A STUDY ON THE DIVERSITY OF ISLAND FLORAS

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'.... all seem to dread the making of Botanical Geography too exact a science; they find it far easier to speculate than to employ the inductive process. The first steps to tracing the progress of the creation of vegetation is to know the proportion in which the groups appear in the different localities, and more particularly the relation which exists between the floras of the localities, a relation which must be expressed in numbers to be at all tangible.'
(J. D. Hooker in a letter to Ch. Darwin). L. Huxley, Life and letters of Sir J. D. Hooker 1 (1918) 439.

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SUMMARY

Of 75 regions, some continental and others insular, the diversity as expressed in the number of Phanerogam genera is compared.

As could be expected it is found that richness in both continental and insular regions is positively correlated with size and with proximity to source areas. In comparable continental and insular regions the former are always richer; increase in the number of genera with increasing size is stronger in the former.

There are various factors disturbing the relations between size/diversity and isolation/diversity. The role of these factors, such as climate, age, topography and the like are discussed.

It is shown that isolated islands are not always poor (New Caledonia, Fiji, Lord Howe I., Rapa, etc.). On the other hand the poverty of islands (e.g. New Zealand) need not be primarily due to the distance from a source area but may be caused by impoverishment of an originally rich flora.

Once isolated, an island flora is much more subject to losses than a continental area where the losses in general may be readily replenished.

It would be wrong therefore to conclude on the basis of poverty that an island has always been as much isolated as it is at present.

Not only are isolated islands in general poorer in genera, there are also less genera per family than in a comparable continental area. This is shown to be caused by a preponderance of families represented by a single genus in the former.

INTRODUCTION

Islands always have received much attention since the early days of biogeography. Following Wallace (1880) islands have as a rule been divided into 'continental' and 'oceanic' ones. The former are those assumed to be situated on a continental platform. They have once been connected with a continent or have made part of it. Their flora and fauna are rich and 'harmonic', i.e. the taxa are represented in about the same numbers and in the same proportions as on corresponding parts of the mother continent. Oceanic islands on the other hand rise steeply out of the depths of the ocean as volcanic formations. They are assumed to have never had any continental connections. Flora and fauna are proportionally poor and 'disharmonic' as they have been dependent on 'random dispersal' to which not all organisms lend themselves. Hence, many taxa found on continents are missing.

This early classification is still generally accepted. But the distinction is not so sharp as originally believed. Axelrod (1960) coined the term 'composite islands' for those islands with a dual history. These were originally the site of large non-volcanic archipelagos or subcontinents which were reduced in size and where later volcanism has taken place.

The poverty of oceanic islands is usually explained by the argument that the closer the island is situated to a continent or other 'source area' the greater the chance that an organism may make a successful landing. By circular reasoning very often the poverty and disharmony of an island's biota are taken as proof for its permanent isolation. It is furthermore curious but at the same time illustrative for the popularity of quoting others in biogeography that the standard example of increasing poverty as a result of increasing isolation is not at all convincing.

In this respect I refer to the series New Guinea, Solomons (or New Caledonia), Fiji, Samoa, Society, Marquesas, and Henderson in the Pacific. The number of species for each area is represented by vertical parallel rods, the length of the rods indicative of the number of species (birds, insect groups). See e.g. Zimmerman (1948). When the ends of the rods are connected the image of a funnel is obtained, hence the effect of isolation is explained as a 'filter effect'.

It is clear that this is a very badly chosen example because the series also shows a strong decrease in size: 800.000, 40.000, 18.500, 3.500, 1.700, 1.300, and 30 sq.km respectively. Although I do not at all deny in general the idea of poverty increasing with isolation, this particular one is to a great extent affected by the decrease in size of the areas. Inclusion of Hawaii would cause a considerable bulge in the filter!

The interpretation of island poverty as a result of a 'filter effect' was strongly rejected by van Steenis (1962, especially pp. 300, 301) who at the same time argued that 'disharmonic island biotas' are fictitious. Decrease in the number of taxa is also found in continental continua when moving away from a centre of development. Representation of families deviating from the average and exceptional endemic development (disharmony) is certainly not a prerogative of island floras.

The problem of island poverty has always had vivid interest from the side of zoogeographers, which has led to numerous papers on this subject. Although botanists were among the first to produce any figures, they have always had more interest in the qualitative aspects of island floras.

During one of the sessions of the 10th Pacific Science Congress, Hawaii, a discussion arose on the issue whether or not island floras are always poorer than comparable parts of continents (Gressitt, 1963, pp. 351—354), but as no pertinent figures were available for a fair appraisal of the situation, it is not surprising that no agreement could be reached.

In order to produce figures I put myself to the task of compiling the number of indigenous Phanerogam genera in some continental regions and on a number of islands partly distinctly continental, partly distinctly oceanic, while some are under dispute as to their category, as for example New Caledonia, New Zealand, the Seychelles & Mascarenes, Juan Fernandez, Galapagos, and some others.

The choice of these floras was random, the only preference being towards islands situated in the warmer regions of the globe. But within that section I have elaborated all those of which the flora seems tolerably well explored and known.

The main theme to be discussed here is the relation between size, isolation, and diversity (or poverty), but it is clear that these relations are affected by a great many factors. These factors not only determine the number of taxa present on any island or continent, they also affect the nature of the plants: their speciation, endemism, habit. These and other aspects such as dispersal capacity, harmony and relationships of the flora, however fascinating especially in connection with islands, will not be discussed here. The interested reader may be referred to Carlquist (1965), Hemsley (1885), Hooker (1867, repr. 1896), Ridley (1930), and van Steenis (1964) to mention but some of the many authors dealing with the qualitative aspects of island floras.

The 'sea of biogeography' in the words of Corner (1963, p. 244) has been flooded by so many ideas, opinions, and controversies that it is becoming increasingly difficult to offer new interpretations. This paper is intended to compile a number of data hitherto concealed in botanical literature and a discussion on their significance for the problem of the quantitative aspects of island floras.

My approach towards richness cq. poverty will be on the generic level. An objection against using genera, or any taxon for that matter, as a unit is their morphological and ecological diversity, especially in the structure and tolerance of their diaspores. In the statistics genera as *Agathis* and *Quercus*, with heavy diaspores, are assigned the same value or weight as *Acaena*, *Barringtonia*, and *Vernonia*, with barbed, buoyant, and plumed diaspores respectively. It is clear that for suggesting, for example, former land connections the presence of a single species with heavy, inedible seeds which are moreover intolerant of submersion in seawater, is more significant than the presence of a score of others whose diaspores are in some way or other fit to cross sea barriers.

Various persons have aided by providing factual information, helpful criticism, or both. For this I feel in particular greatly indebted to Dr L. J. Brass (Cairns), Dr F. R. Fosberg (Washington, D.C.), Mr P. S. Green (Kew), Dr R. D. Hoogland (Canberra), Dr M. Jacobs (Leiden), Mr R. Pullen (Canberra), Dr G. M. Storr (Perth), Dr R. F. Thorne (Rancho Santa Ana, Claremont), Mr W. Vink (Leiden), and especially to Dr C. G. G. J. van Steenis.

SURVEY OF LITERATURE

Already early phytogeographers have written about the numerical relations between insular and continental floras. But their conclusions, being based on too few data, were bound to be contradictory (see e.g. Schouw, 1823).

A. de Candolle in his Géographie Botanique Raisonnée (1855, pp. 1278—1284) was the first botanist to have collected figures on a large scale and to use these figures in an intelligent way for his comparisons and conclusions. According to him large islands are not only floristically as rich and diversified as continental areas, but also as regards the number of vegetation types. His examples (Great Britain, Ceylon, and Sicily) are, however, of undoubted continental nature. He advanced that isolated islands need not be poor (Iceland) and if they are, e.g. Cocos-Keeling, Ascencion, and Falklands, their poverty can be attributed to respectively recent emergence, volcanism, and adverse climate. The poverty of the Azores, Galapagos, and Tahiti he explained by both isolation and volcanism. Small islands, however close to a continent, he found always poor compared with a continental area of similar size.

De Candolle concluded that size is the most important factor determining floristic diversity, but he clearly showed insight in the influence of other factors.

I can not always fully agree with his conclusions. I am not sure whether Iceland is not poor if compared with a corresponding part of Scandinavia. It is also doubtful whether volcanism should be held responsible for the impoverishment of island floras. This is quite feasible in the case of small islands of which Krakatau is the classical example, but also Barceno Volcano is a case in point (Brattstrom, 1963). But the effect is certainly only very local in large islands. Moreover, a volcanic eruption provides new bare soil and ultimately adds to its fertility. It is not clear upon what evidence De Candolle's statement is based that small islands, however close to a continent, are always poor; it is not documented.

W. B. Hemsley (1885) summarized the state of knowledge of insular floras. He gave a list of indigenous and endemic genera and species on various islands and parts of continents. Unfortunately, not much attention is paid to the degree of isolation, size, latitude, or climatic conditions which makes his comparisons rather unjustified. Nevertheless, his is the latest large scale attempt to compare the numbers of genera on islands and continents and his survey is still a mine of information. He stated that poverty of species in relation to size is a general characteristic for islands. Although also to Hemsley the size of the area is the main factor in determining diversity, he acknowledged the importance of isolation.

C. B. Williams (1943) made an extensive study on the relation between size of area and number of species, by plotting the number of species on the ordinate against area (from 1 sq.cm to 10^8 sq.km) on the abcissa. This study, though not especially devoted to island floras, is of sufficient importance to be mentioned here. The areas were divided after their climatic properties into arctic, temperate, subtropical, tropical, desert, and oceanic. This showed that increase of species with area is very much similar in tropical, subtropical, and temperate regions. The dots representing these regions occupy the upper half of the belt of dots, the lower half is occupied by the desert, arctic, and oceanic regions. In these, increase is much less steep. Williams' paper appears to have been much overlooked, as I have rarely seen it cited.

In my phytogeographical analysis of the Pacific (van Balgooy, 1960, p. 429) I dealt briefly with the number of genera on various Pacific islands. I came to the conclusion that 'for ecologically more or less comparable islands the rule seems to be that the distance to a continental flora or other rich plant source and the total number of genera are inversely proportional.'

METHOD

Of 75 areas (fig. 1), mostly insular but some continental, lists were prepared of the indigenous Phanerogam genera. The genus was selected as the working unit, as it is much more reliable taxonomically than the species which is more subject to the personal taste of the authors and besides, a specific account has for many islands not been worked out. Of each of these areas notes were made on the size, altitude, geology, climate, soil, and other factors that may affect the number of genera. This will be discussed in the next chapter.

For several of the areas floras or checklists exist, but of others the information had to be gleaned from various scattered sources, some unpublished. Sources are mentioned after the notes on each of the areas. Many of the data stem from two papers by myself (van Balgooy, 1960, and an unpublished manuscript on the phytogeography of the Pacific) and from Thorne (1963). Data on size, altitude, and distance from source areas have largely been taken from Andree's Handatlas and the Times Atlas. For information on zoological matters I have largely depended on Gressitt (1956, 1961), Darlington (1957), and Mac Arthur & Wilson (1967).

The relations between size, isolation, and the number of genera have been worked out in a number of graphs, followed by a discussion. No lists of genera are here provided.

FACTORS AFFECTING DIVERSITY

When investigating the effect of isolation on the diversity of island floras we should preferably compare islands that are similar as regards size, climate, soil, altitude, age, and all other factors. There are, however, no two islands in the world that meet this condition. At best we can approach this ideal by comparing islands that are not 'too different'. We can not compare Java with Iceland, but Java and Ceylon have much more in common and the same is true for Tasmania and New Zealand. If therefore in the rest of this paper islands are called 'comparable' this should be taken in a very approximate sense.

Let us review some of the factors that may in one way or other influence the diversity of insular floras.

Size

It is conceivable that, all other factors being equal, the number of taxa will increase with increasing area. More space will in general mean more opportunity for speciation, more different habitats, and more possibilities to survive local disasters.

At first sight size may appear one of the easiest factors to measure. But it is not only the present area that matters. An island may have been very much larger or smaller in the past. New Zealand, for example, has had a very chequered geological history with regressions and transgressions (Fleming, 1962). Of many islands we have no clue to their size in the past.

Isolation

As here understood, isolation is the distance in km from the nearest continent or other large land area that can be regarded as the source of the island's flora. Again apparently a rather simple matter of the ruler, but there are many complications. Rapa and Easter I. are approximately equally much isolated. But a glance at the map shows that the isolation of Easter I. is much more absolute. The same holds for Hawaii compared with the Marquesas. The isolation of Fiji is given as the distance to New Guinea, but the sea in between the two is strewn with 'island stepping stones'. What makes matters even more difficult is the fact that so many stepping stones have disappeared; we are never sure about the exact degree of isolation in the past. Lord Howe I. lies about 550 km from Australia, but geological evidence (Standard, 1963) indicates the presence in the past of a more or less continuous series of stepping stones towards New Zealand which is today 1400 km distant, and none towards Australia.

In many zoogeographical papers we find that the poverty of island faunae is due to decreased accessibility. It is said that an isolated island is dependent on 'random dispersal'. It is at the same time tacitly assumed that isolation is permanent, the island being at the start a bare piece of land. Although this may be true in many cases — new islands are being formed to the present day — it is wrong to reverse the thesis and to accept faunistic (or floristic) poverty as proof for 'oceanicity'.

Suppose that we have a land area at the end of a peninsula, an island chain, or an archipelago, in short an area not separated from a continent by broad sea barriers. Suppose that all of this more or less continuous peninsular land subsides or is transgressed by the sea, except the terminal land area. We would then have a continental island by definition. Originally the flora of our island would probably not be much different from that of the 'mother continent', though somewhat poorer on account of its smaller size. What would happen next?

Probably some of the species would become restricted to either the continent or the island. This and independent speciation (as mixing of populations would be minimized) in the two would lead to increased endemism and floristic dissimilarity. Speciation again would depend on the genetic potential of the original stock, available niches, and time. Any changes for the worse in the conditions on the island, e.g. increased aridity, decrease in temperature, volcanic eruptions, hurricanes etc. may lead to the extinction of species. Replenishment by the continental stock being rendered difficult, the losses on the island would probably be greater than the gains.

The tentative expectation is that whether an island starts as bare land and obtains its flora by 'random dispersal' or as a continental floristic sample impoverished by 'random extinction', the net result may ultimately be the same: a poor and 'disharmonic' flora.

It might be possible to discriminate between these two different origins by an analysis of the dispersal spectra of the floras. In the first case there should be a preponderance of species with diaspores fit for overseas dispersal. Anyhow, other factors being equal, isolation will have a negative effect on diversity.

Source area

The problem of isolation leads us to a closely connected factor: the source area. As *source area* I have accepted the continent or large island with which the island is floristically closest allied and that has presumably acted as the most important source of the island's flora. It must, however, not be forgotten that through the ages source areas may have disappeared.

In some cases the source area is rather evident. The islands in the Gulf of Guinea have a flora derived from tropical West Africa, the only nearby rich flora for Cocos Island is Central America, for Christmas Island (Indian Ocean) it is Java. But for Lord Howe I. there are 3 possible source areas: Australia, New Caledonia, and New Zealand. That they have all three contributed to the peopling of Lord Howe I. is borne out by the floristic relationship. As source I have now taken New Zealand as relationships are slightly stronger with this than with the other two. For Hawaii I have taken Malesia as the source area on floristic grounds, although geographically it is closer to North America.

The presence of stepping stones and secondary source areas complicates matters, but it can be agreed that the richer the source area the richer the recipient island may potentially be.

It is always accepted that an island has obtained its flora from a continental source, but could it not be that there are islands that, at least in part, have an original stock, developed on the spot and not 'imported' from somewhere else?

Age

It is easy to visualize that, again all other factors being equal, the older of two islands will have the richer flora. The age of an island is very difficult to establish even in an approximate way. The age of the oldest geological formation on an island is of relatively little importance. It is not the geological age of the island that matters but the age of the island's flora. The basic rock of Fiji dates from the Precambrian, but was the land continuously above water since that time and does the present day flora date from that era? St Catalina is geologically an old island, but it was almost completely submerged in the Pleistocene, so that at least part of the flora must be young.

Krakatau is a similar case. Although doubts have been expressed concerning the complete annihilation of the flora during the eruption in 1883 (Backer, 1929) it is certain that the majority of the species on the island has arrived through oversea dispersal after the disaster. This flora then is not yet a century old! It must be borne in mind that the distances for this overseas dispersal are proportionally extremely small, as besides South Sumatra and West Java, also adjacent islets in Sunda Straits acted as source areas, and overseas distances do not exceed a dozen kilometers.

Climate and soil

Climatic and edaphic conditions also play an important role in determining the number of taxa present. A region with evenly distributed high rainfall and fertile soil will be richer than a desert region. Islands in the tropics subject to the trade winds are moist on the windward and dry on the leeward side. It is clear that, as with the other factors so far discussed, climate and soil are very complicated factors, difficult to evaluate and unfit to express in figures. The amount and annual distribution of rainfall, temperature fluctuations, and the kinds of soil makes but a very superficial presentation.

Altitude

A high island will in general be more diversified ecologically than a low one of the same size. It has been shown e.g. by Kroeber (1916) for the Galapagos, by Szymkiewicz (1938) for the Canaries, Galapagos, and Hawaii, and by Kalkman (1955) for the Lesser Sunda Islands, that within the same island group floristic diversity and endemism are correlated with the height of the island. Altitude as here understood is the highest point above sealevel in meters of any part of the region. In a number of continental areas the total altitudinal range has been given, e.g. Pindunde Valley (3300—4000 m).

Latitude

The position of a region in respect to the equator is another factor affecting diversity. The farther away from the equator the less favourable the climate, the less species will be able to maintain themselves.

This again is only true in a general way. Yakusima lies relatively far north but enjoys a very favourable climate due to the Kuro Shyo current, in contrast to St Catalina at about the same latitude; besides, Yakusima is much higher.

Human influence

The influence of man on the flora of a region is mostly of a negative kind. Especially man's destruction of island floras is notorious.

If the island is large (Hawaii) or of steep topography (Lord Howe I.) destruction may be retarded, so that much of the original flora may become known scientifically. But on small and flat islands much was lost before a complete inventory was made.

Not only destruction by man proper falls under this heading, also that caused by man-introduced animals (rabbits, goats, pigs) and pests.

Man also enriches the flora by the introduction of crops, weeds, and aliens. But this is of no importance for the present study which is based only on the indigenous flora.

How many species may have become extinct by man's action before collected is hard to establish.

Exploration

How much exploration is needed to make the inventory of a flora complete or nearly complete is difficult to say and will of course vary from case to case. It is a matter of experience that the amount of new taxa for a certain region decreases with increased exploration. Not much in the way of new genera are to be expected from Hawaii, Java, or New Zealand, but Batan I., Fernando Po, and NE. Queensland are certainly under-explored. For many islands it is impossible to say how much of its flora is at present known.

Summary

We may express the effect on diversity of the factors just discussed into a formula:

$$\text{Diversity} = \frac{\text{Size} + \text{Age} + \text{Richness of source} + \text{Altitude} + \text{Exploration}}{\text{Isolation} + \text{Latitude} + \text{Adverse climate} + \text{Poor soil} + \text{Human influence}}$$

This formula has no mathematical meaning, nor does it pretend to be complete, but it may serve a summarizing purpose. Factors above the line have a positive, those below a negative effect on diversity. It will be realized that some of these factors may overlap or antagonize each other. Climate is affected by latitude; at high latitudes high altitude may play no role as all the land above a certain limit is permanently snow- or ice-capped. Also factors generally of positive effect may in certain cases become negative, or the other way round. As pointed out before, prolonged isolation (i.e. great age) may lead to the extinction of species but on the other hand may also promote speciation, especially in large islands.

Diversity is, hence, determined by a multitude of factors most of which do not lend themselves to precise formulation and evaluation. This whole discussion ultimately boils down to the conclusion that diversity, or the number of taxa, in any region is determined by the diversity and number of available niches.

CONCISE DESCRIPTION OF AREAS STUDIED

The islands and continental areas are listed in alphabetical order. Numbers correspond to the numbers on the accompanying map (fig. 1).

1. Annobon

Location: Atlantic, Gulf of Guinea; 1° 30′ S, 5° 30′ E.
Isolation: 350 km from Gabon, 180 km from S. Tomé.
Area: 16 sq.km. *Altitude:* 650 m. *Fam./Gen.:* 54/141.
Remarks: Most distant and smallest of a series of 4 islands. Climate equatorial, hotter and drier than on S. Tomé (no. 62), more pronounced seasons. Probably originally well forested. Rather well explored.
Sources: Exell (1944, 1956, 1963).

2. Ascension

Location: Atlantic Ocean; 8° S, 14° 30′ W.
Isolation: 1600 km from W. Africa, 2200 km from S. America.
Area: 90 sq.km. *Altitude:* 850 m. *Fam./Gen.:* 6/6.

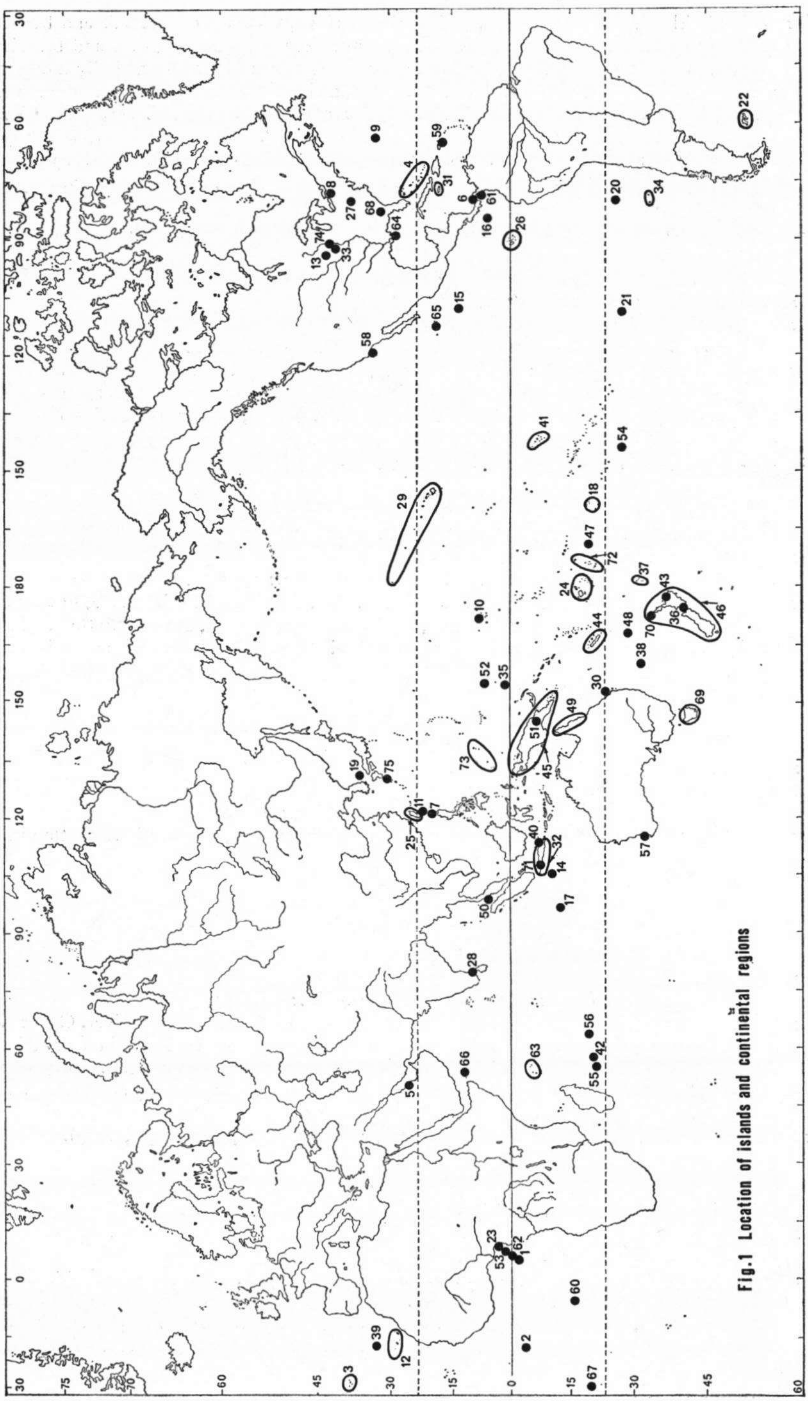

Fig.1 Location of islands and continental regions

Remarks: Volcanic island, base of cone near mid-Atlantic ridge, built up of lavabeds and basaltic and trachytic domes, fragments of plutonic rock have been found among tuffs and breccias. Soil porous, preventing formation of streams or stagnant water; lowland practically a desert, only the cloud-zone (above 600 m), where the soil is enriched by guano from the numerous terns nesting there, supports a rather rich vegetation of shrubs and herbs. Mean annual rainfall *c.* 500 mm, mostly falling in March/April in 'cloud bursts'. Daly gives mean (monthly?) temp. at shore 30° C, at 600 m 24° C. Constancy of temperature and dryness have left the rocks almost unweathered. Present day flora comprises *c.* 40 species; only six, belonging to as many genera, can be considered native with any certainty.

Sources: Daly (1925), Hemsley (1885), Rudmose Brown (1906), Watson (1891).

3. Azores

Location: Atlantic Ocean; 37°—39° 45′ N, 25°—31° 30′ W.
Isolation: 1300 km from Portugal, 1200 km from Canaries.
Area: 2400 sq.km. *Altitude:* 2300 m. *Fam./Gen.:* 70/221.
Remarks: Group of 9 volcanic islands; warm-temperate, humid climate. In lowland mean annual temp. 17° C, monthly means 14—22° C; rainfall fairly equally distributed over the year, 850—1000 mm. Soil very fertile permitting luxurious forest up to *c.* 900 m, higher up grading into shrubby and eventually alpine vegetation. Flora well known.
Sources: Dansereau (1965), Palhinha (1966), Rikli (1912).

4. Bahamas

Location: Carribean; 21°—27° 30′ N, 71°—79° 30′ W.
Isolation: 60 km from Florida, 50 km from Cuba.
Area: 11300 sq.km. *Altitude:* 60 m. *Fam./Gen.:* 104/290.
Remarks: Group of 29 larger islands, 661 cays, and 2387 rocks. Soil is aeolian limestone, greatly eroded to dogtooth projections, many sinkholes, in places deep sandy soil, but mostly thin and meagre 'redlands'. The most widespread vegetation type is 'scrub'. In places Pine and mixed forests occur.
Source: Britton & Millspaugh (1920).

5. Bahrain

Location: Gulf of Persia; 25° 45′ N, 50° 30′ E.
Isolation: 35 km from Arabia.
Area: 530 sq.km. *Altitude:* 115 m. *Fam./Gen.:* 41/123.
Remarks: Treeless island (but for planted date palms). Climate desert-like, halophytic vegetation in lower marshy portions. Somewhat underexplored.
Source: Good in Dickson (1955).

6. Barro Colorado

Location: Panama Canal Zone; 9° N, 79° 30′ W.
Isolation: 1—2 km.
Area: 15 sq.km. *Altitude:* 160 m. *Fam./Gen.:* 108/445.
Remarks: An island formed in 1914 in artificial lake Gatun by dam built in Chagres River. Covered with luxuriant primeval forest intermediate between monsoon and tropical rain forest, in parts with secondary vegetation. Rainfall 2800 mm/year, 4 dry months; temp. fairly constant: 21—32° C. All weeds and ubiquists deleted from the totals, though some are perhaps native. Some new finds still to be expected.
Sources: Kenoyer (1929), Kenoyer & Standley (1929), Standley (1927, 1928, 1930, 1933).

7. Batan I.

Location: Philippine Sea; 20° 30′ N, 122° E.
Isolation: 200 km from Formosa and Luzon.
Area: 65 sq.km. *Altitude:* 1000 m. *Fam./Gen.:* 85/273.
Remarks: Island built up by sandstone, slate, and conglomerate layers, probably of mid-Tertiary age, highest peak is a volcano, recently active. Part of island consists of uplifted coral limestone. Climate tropical, mean monthly temp. 22.3° C in January to 28.4° C in June. Rainfall high throughout the year: 3300 mm, most in Aug.—Nov.; driest months Febr.—April. Underexplored.
Source: Hatusima (1966).

8. Bergen Swamp

Location: State of New York, U.S.A.; 43° N, 78° W.
Isolation: Continental area.
Area: 13 sq.km. *Altitude:* 100 m. *Fam./Gen.:* 83/272.
Remarks: A track of lowland country with very little variation in elevation, but great variety of habitats: fens and bogs, alluvial swamps, upland oakwoods, maple-beech forest, and hemlock (*Tsuga*) knolls. Climate temperate. Well explored.
Source: Thorne (letter 1967).

9. Bermudas

Location: Atlantic Ocean; 32° 15′ N, 60° 45′ W.
Isolation: 1000 km from New Orleans, U.S.A.
Area: 50 sq.km. *Altitude:* 75 m. *Fam./Gen.:* 55/102.
Remarks: One main island in an irregular chain of *c.* 100 islets situated on a submarine plateau, subject to alternative vertical movements in the past, has been much larger formerly. Soil aeolian limestone and sand resting on volcanic substratum; topography hilly, broad valleys, marshes, mangroves, moving sand dunes. Mean monthly temp. 17° C in Febr., 28° C in August. Climate favourable for a subtropical to warm temperate flora. Flora well explored.
Sources: Britton (1918), Hemsley (1885).

10. Bikini I.

Location: Pacific, Marshall Is.; 11° 40′ N, 165° 20′ E.
Isolation: 2700 km from New Guinea, 2000 km from Bismarcks.
Area: 25 sq.km. *Altitude:* 5 m. *Fam./Gen.:* 22/29.
Remarks: Coral atoll, belonging to the Northern Marshalls. Forming a ring enclosing a large lagoon, open on the South. Soil consists of consolidated sandstone and limestone rock bordered by sandy shores. The island lies in the westward bound N. equatorial current. No data on climate available. Vegetation a marginal closed thicket of strandplants and an inner scrub. Well explored.
Sources: St. John & Mason (1953), Taylor (1950).

11. Botel Tobago (Lanyu, Koto Sho)

Location: Philippine Sea; 22° N, 121° 30′ E.
Isolation: 60 km from Formosa, 350 km from Luzon.
Area: 140 sq.km. *Altitude:* 530 m. *Fam./Gen.:* 115/358.
Remarks: Volcanic island belonging to the same chain as Batan I. No climatic and geologic data obtained, but probably comparable to Formosa (no. 25) and Batan I. (no. 7). Well forested. Fairly well but not exhaustively explored.
Sources: Kanehira (1935b), Liu, Sasaki & Keng (1955, 1957), Sasaki (1932).

12. Canaries

Location: Atlantic; 27° 45′—29° 30′ N, 15° 45′—20° 30′ W.
Isolation: Easternmost island 100 km from Rio de Oro (N. Africa).
Area: 7500 sq.km. *Altitude:* 3700 m. *Fam./Gen.:* 91/400.
Remarks: Group of 7 large and 5 small islands on submarine plateau connected with N. Africa and Mediterranean. The two islands closest to Africa are low and have a semi-desert climate. They support mainly a steppe-like vegetation. The five western islands are high, temp. equable, monthly mean 17° C in winter to 24° C in summer. Rainfall low: *c.* 300 mm/year at sealevel of which half in Nov., but increasingly higher at higher altitudes. Much cloud formation above 2000 m. The mountain peaks snow-clad in winter. There are three main vegetation zones: up to *c.* 700 m a steppe-like vegetation, now mostly under cultivation, up to *c.* 2000 m montane forest, and above 2000 m an alpine vegetation. Very few generic novelties to be expected.
Sources: Ceballos & Ortuno (1951), Lems (1960), Pitard & Proust (1908), Rikli (1912).

13. Cayler Prairie

Location: Iowa, U.S.A.; 42° 30′ N, 95° 30′ W.
Isolation: Continental area.
Area: 0.6 sq.km. *Altitude:* *c.* 400 m. *Fam./Gen.:* 46/127.
Remarks: Small piece of rolling prairie grassland, little disturbed lately. Soils of glacial origin, the ridges composed of sandy loam, lower parts peaty. Climate temperate continental.
Sources: Aikman & Thorne (1956), Thorne (letter 1967).

14. Christmas I.

Location: Indian Ocean; 10° 30′ S, 115° 30′ E.
Isolation: 300 km S. of Java.
Area: 150 sq.km. *Altitude:* 330 m. *Fam./Gen.:* 52/107.
Remarks: Emergent top of submarine volcano with steep slopes, thick limestone deposits enriched by guano upon volcanic base. The island is said to date at least from Eocene. Climate mild tropical, temp. ± constant throughout the year. Rainfall rather high, running water present. Well forested. Underexplored, some new genera to be expected.
Sources: Andrews (1900), Ridley (1905, 1907, 1930 p. 675—679).

15. Clipperton

Location: Pacific Ocean; 10° 18′ N, 109° 13′ W.
Isolation: 1100 km W. of Mexico.
Area: 2 sq.km. *Altitude:* 30 m. *Fam./Gen.:* 12/19.
Remarks: Low closed ring of coral limestone, small volcanic peak on one side. Climate oceanic, tropical, little variation in temperature which is *c.* 27° C all year round, minima and maxima 23.9—30.6° C. Rainfall slightly seasonal, *c.* 5000 mm/year. In winter NE. trades; from Aug.—Oct. SW. winds prevail, these include occasional cyclones. Vegetation consists of low shrubs and herbs, marshes round the lagoons; no trees except planted coconutpalms.
Sources: Sachet (1962a, b).

16. Cocos I.

Location: Pacific Ocean; 5° 30′ N, 87° W.
Isolation: 500 km from Costa Rica.
Area: 25 sq.km. *Altitude:* 825 m. *Fam./Gen.:* 33/59.
Remarks: Volcanic island, rising steeply out of the ocean, topography very rough, in places inaccessible. Rocks built up of agglomerates, tuffs, and andesitic lava flows. Steep topography causes frequent landslides. Rainfall 'several feet a year' (Stewart), 3 dry months. Temp. fairly constant: 20—33° C. Densely forested island, tall trees, abundance of lianas and epiphytes, vegetation is a 'tropical jungle composed of selected species' (Fournier, p. 184). It is little affected by man. Reasonably well explored but some novelties still to be expected.
Sources: Fosberg & Klawe (1966), Fournier (1966), Hertlein (1963), Stewart (1912), Svenson (1935).

17. Cocos Keeling

Location: Indian Ocean; 12° 10′ S, 97° E.
Isolation: 1100 km from Sumatra and Java.
Area: *c.* 5 sq.km. *Altitude:* *c.* 10 m. *Fam./Gen.:* 17/20.
Remarks: An isolated coral atoll, no stagnant water or marshes present. No data on climate available. Ocean currents from New Guinea and the Moluccas pass the island. Cyclones take place occasionally.
Sources: Forbes (1885), Henslow (1838), Ridley (1930, p. 675—679).

18. Cook Is

Location: Pacific Ocean; 19°—22° S, 157°—160° W.
Isolation: 4700 km from Australia, *c.* 3000 km from New Zealand, *c.* 2000 km from Fiji, 1250 km from Samoa, 1000 km from the Society Is.
Area: 250 sq.km. *Altitude:* 660 m. *Fam./Gen.:* 63/128.
Remarks: Group of volcanic islands, some very rugged and deeply eroded. Rainy season Nov.—April coincides with the hottest months of the year, rainfall 40—400 mm/month, 2250 mm/year. Temp. ranges between 15.5°—32° C. Hurricanes are rare. Only one island (Rarotonga) well explored, but not many new generic records to be expected.
Sources: Cheeseman (1903), Wilder (1931).

19. Dagelet I. (Ooryong To, Ullung Do)

Location: Sea of Japan; 37° 30′ N, 130° 45′ E.
Isolation: 135 km from Korea, 250 km from Japan.
Area: 20 sq.km. *Altitude:* 900 m. *Fam./Gen.:* 80/230.

Remarks: Rocky, volcanic island gradually sinking, formerly probably larger and connected with mainland. Once densely forested. Climate mild, despite latitude, due to warm ocean current. Rather well explored.
Sources: Nakai (1919, 1928).

20. Desventuradas

Location: Pacific Ocean; 26° S, 80° W.
Isolation: 1000 km from Chile.
Area: 7 sq.km. *Altitude:* 450 m. *Fam./Gen.:* 12/17.
Remarks: Two small, rocky islets situated on same submarine ridge as Juan Fernandez, remnants of a disrupted crater, lower islet (San Felix, 180 m) consists of 2 layers: a tuff layer covered with basalt, and is desert-like, the other (San Ambrosio) consists of tilted basaltic layers, much dissected by ravines, is often foggy and moister. No novelties to be expected.
Sources: Johnston (1935), Kuschel (1961), Skottsberg (1937, 1957).

21. Easter I.

Location: Pacific Ocean; 27° S, 109° 30′ W.
Isolation: 4000 km from Chile, 3500 km from Rapa, *c.* 7000 km from New Zealand.
Area: 120 sq.km. *Altitude:* 530 m. *Fam./Gen.:* 15/22.
Remarks: Volcanic almost treeless island, low undulating plateau with three large craterlakes; porousness of soil prevents formation of streams, little erosion; mean monthly temp. 17—23° C, annual rainfall variable, 700—2000 mm/year, fairly evenly distributed, but most in March—June. SE. trades in summer, W. and N. winds in winter, storms rare. Exhaustively explored, but possibly some species extinct before collecting started.
Sources: Guillaumin, Camus & Tardieu Blot (1936), Skottsberg (1922, 1927, 1956).

22. Falkland Is

Location: Atlantic Ocean; 52°—54° S, 57° 30′—61° 30′ W.
Isolation: 500 km E. of Patagonia.
Area: 16500 sq.km. *Altitude:* 700 m. *Fam./Gen.:* 36/98.
Remarks: Group of two large and numerous smaller islands, situated on shallow submarine bank. Precambrian core, overlain by Devonian and Permo-Carboniferous sandstones and quartzite. No Tertiary deposits. No signs of Quarternary glaciation despite latitude. Climate oceanic: cool summers (average temp. 9.7° C) and mild winters (average temp. 2.5° C), frosts are common. Annual precipitation 600—700 mm. Rain or snow falls during 250 days of the year, but snow never remaining very long. Gales frequent, preventing growth of trees unless well protected. Vegetation of shrubs and herbs, forming extensive peat formations.
Sources: Skottsberg (1913, 1942), Valentin & Cotton (1921).

23. Fernando Po

Location: Atlantic, Gulf of Guinea; 3° 30′ N, 8° 45′ E.
Isolation: 35 km from Cameroon.
Area: 2000 sq.km. *Altitude:* 3000 m. *Fam./Gen.:* 100/470.
Remarks: One of a series of 4 volcanic islands. Climate similar to that of S. Tomé (no. 62) but more rainy, with a dry season in January. There is a broad zone of tropical rain forest in the lowland, now largely cultivated, merging into monsoon forest in the South and into mossy forest upwards and ultimately into alpine vegetation and grassland on the mountain tops. The flora is certainly underexplored.
Sources: Exell (1944), Guinea (1968), Hutchinson & Dalziel (1927, 1928, 1931, 1936).

24. Fiji Is

Location: Pacific Ocean; 15°—20° S, 177° E—179° W.
Isolation: 2500 km from New Guinea and Australia, 1250 km from New Caledonia, 800 km from New Hebrides, 1750 km from New Zealand.
Area: 18500 sq.km. *Altitude* 1300 m. *Fam./Gen.:* 119/452.
Remarks: A group of *c.* 500 islands the bulk formed by Viti Levu (10388 sq.km) and Vanua Levu (6000 sq.km). The eastern islands are volcanic and consist of andesite or tuffs and raised coral. The large islands are underlain by a core of plutonic rock of possibly Pre-Cambrian age, associated with sedimentary rocks of quartz and slates. This is overlain by younger tuffs — especially in the coastal areas — lavabeds and agglomerates. At various points this layer is broken

by outcrops of older rock. There is a great unconformity between the two. It is probably either an area of gradual subsidence, Cambrian to Tertiary deposits piling up on the sinking land, or the land may have been stable, subsidence not taking place until early Tertiary, followed by a recent uplift at the end of the Tertiary. Climate is oceanic, mild, but with distinct hot/wet and dry/cool seasons. Annual precipitation ranges from 1500 mm in the W. (leeward side) to 2500 mm in the E. and *c.* 5000 mm in the interior. The temperature is fairly constant, rarely rising above 32° C. Most of the islands once carried a dense rain forest, much of it has been changed into secondary wood and grassland or cultivated areas. Reasonably well explored, few generic novelties to be expected.

Sources: Gillespie (1930, 1931, 1932), Parham (1964), Seemann (1865—1873), Smith (1936, 1942, 1955), Woolnough (1903).

25. Formosa (Taiwan)

Location: 21° 45′—25° 40′ N, 119° 20′—122° 5′ E.
Isolation: 150 km from China, 350 km from the Philippines.
Area: 36000 sq.km. *Altitude:* 3950 m. *Fam./Gen.:* 175/1080.
Remarks: Large island situated on geologically unstable continental border. There are strong indications for prolonged connections with continental Asia until relatively recent. Extremely rugged interior, 3 mountain systems running North-South. Highest peaks temporarily snow-covered. Both NW. (winter) and SE. (summer) monsoon winds bring abundant rainfall ranging from 2000—11000 mm/year. Winter is mild, summer long. In lowland monthly mean temp. from 15° C in Jan. to 28° C in July. Frost is rare. The island is largely covered with luxuriant tropical rain forest, of which untouched portions still exist on the mountain slopes. At higher altitudes a temperate type of forest occurs, the tree limit formed by conifers, above this an alpine shrub and herb vegetation. Reasonably well explored but generic novelties still to be expected.
Source: Li (1963).

26. Galapagos Is

Location: Pacific Ocean; 1° N—2° S, 89°—93° W.
Isolation: 1000 km W. of Ecuador.
Area: 7700 sq.km. *Altitude:* 1500 m. *Fam./Gen.:* 67/189.
Remarks: Volcanic islands, soil built up of basaltic lavas and other volcanic products. Precipitation ranges between extremes, lower slopes often very dry, upper parts moist, on many islands no running or stagnant water. Temp. rather cool despite latitude due to Humboldt Current: 21—27° C. A xerophytic type of vegetation in the lowland, (low) forests only developed on the wet mountain slopes. Rather well explored, few novelties expected.
Sources: Bowman (1966), Kuschel (1963), Robinson (1902), Stewart (1911), Svenson (1935, 1946).

27. Giles County

Location: West Virginia, U.S.A.; 38°—39° N, 80° W.
Isolation: Continental area.
Area: 940 sq.km. *Altitude:* 450—865 m. *Fam./Gen.:* 105/369.
Remarks: A region of narrow ridges and valleys in the Appalachian Highlands. Stony, alluvial soil, with limestone, dolomite, sandstone, and shale exposures. Climate continental temperate. Average temperature in July 18—24° C, recorded extremes 33 and 36° C. Annual rainfall 900—1500 mm. Growing season 150—176 days. Original vegetation probably deciduous and conifer forests, now mostly secondary woodland, some sphagnum bogs. Only small tracts of virgin forest left. Well explored.
Sources: Thorne & Cooperrider (1960, 1964).

28. Hare I. (Pandiyan Theevu)

Location: S. India; 8° 48′ N, 78° 11′ E.
Isolation: 1 km from coast, but connected with it at low tide by narrow strip of sand.
Area: 0.6 sq.km. *Altitude:* *c.* 10 m. *Fam./Gen.:* 35/75.
Remarks: Flat island, built up of sandy loam and calcareous rocks. Rainfall 950 mm/year, highest during NE. monsoon in Oct.—Nov. Strong SW. winds prevail in June—July. Temperature minima: 20—25° C, maxima: 28—39° C. Vegetation is chiefly an open scrub. Rather well explored.
Source: Sundararay & Nagarayan (1964).

29. Hawaiian Is

Location: Pacific Ocean; 18°—28° 30′ N, 155°—178° 30′ W.
Isolation: 3800 km from N. America, 6000 km from New Guinea and Japan, 5000 km from Fiji, 4000 km from Marquesas.
Area: 16000 sq.km. *Altitude:* 4100 m. *Fam./Gen.:* 83/221.
Remarks: A long chain of volcanic islands, decreasing in age from West to East. The easternmost 8 support a luxuriant vegetation, the other islands of the group are very much worn down and have a very meagre flora. Topography is very varied: deep valleys, rugged mountain ridges, alluvial plains, and montane bogs. Very steep rainfall gradients even on the same island, with extremes of 160—11.500 mm/year. Temp. extremes of 38° C in the lowland to —8° C on mountain tops; these occasionally snow-covered. In lowland below 600 m equable temp., monthly averages of 23—25.5° C in May—Sept. and 21—24° C from Oct.—April; NE. trade winds prevail, cyclones common. Botanically well explored.
Sources: Fosberg (1948), Hillebrand (1888), Water Resources of Hawaii (1959).

30. Heron I.

Location: Pacific, Coral Sea; 23° 30′ S, 152° E.
Isolation: 65 km E. of Queensland.
Area: 0.2 sq.km. *Altitude:* 4 m. *Fam./Gen.:* 18/27.
Remarks: Flat, sandy, coral island at southern end of Great Barrier Reef. Interior much disturbed by shearwaters *(Puffinus pacificus)*, part of the island was recently swept away by a hurricane. It is difficult to assess which species are introduced and which are indigenous. Flora is reasonably well known.
Source: Fosberg, Thorne & Moulton (1961).

31. Jamaica

Location: Caribbean; 17° 15′—18° 30′ N, 76° 10′—78° 25′ W.
Isolation: 150 km from Cuba, 180 km from Haiti, 650 km from Honduras.
Area: 11400 sq.km. *Altitude:* 2250 m. *Fam./Gen.:* 154/810.
Remarks: Mountainous island, mostly built up of limestone rock, but in places outcrops of shales, marbles, and granite and raised coral. NE. trade winds bring rain throughout the year in the eastern mountainous part with annual precipitation of *c.* 5000 mm. Rainfall gradually diminishes towards the west to *c.* 750 mm/year. Tropical rain forest dominates but a xerophytic vegetation is found in the drier parts. Exploration insufficient.
Sources: Fawcett (1893), Fawcett & Rendle (1910—1936), Proctor (1967).

32. Java

Location: 6° 10′—8° 45′ S, 105° 10′—114° 40′ E.
Isolation: Continental island.
Area: 125000 sq.km. *Altitude:* 3600 m. *Fam./Gen.:* 182/1320.
Remarks: Southernmost of the Greater Sunda Islands. Elongated mountainous country with broad stretches of largely alluvial lowland. An irregular chain of volcanoes, some still active, running the length of the island, extensive limestone formations in the S. Situated on Sunda shelf which was emerged during Tertiary until as late as Pleistocene and connected Java to other Sunda Is and SE. Asia. Much of original vegetation destroyed: rain forest remnants in everwet W. Java, monsoon forest in seasonal to semi-arid E. Java. By far the best explored island of Malesia.
Sources: Backer & Bakhuizen van den Brink Jr (1963, 1965, 1968), Van Steenis (1965).

33. Johnson County

Location: Iowa, U.S.A.; 41° 30′ N, 91° 30′ W.
Isolation: Continental area.
Area: 1600 sq.km. *Altitude:* 200—250 m. *Fam./Gen.:* 95/344.
Remarks: An area heavily subjected to Quarternary glaciation. Much of the soil consists of loess or is of drift origin. Along some of the streams outcrops of Carboniferous to Silurian limestone rocks. Climate temperate, continental with recorded extremes in temp. of —36° C and 43° C. Annual rainfall 635 mm, most of it falling during the summer. The area is situated on the deciduous forest/prairie ecotone. Much of the original vegetation has been destroyed by cultivation.
Sources: Thorne (1955, letter 1967).

34. Juan Fernandez

Location: Pacific Ocean; 33° 30′ S, 80° W.
Isolation: Masatiera lies 650 and Masafuera at 800 km W. of Chile.
Area: 150 sq.km. *Altitude:* 1500 m. *Fam./Gen.:* 43/90.
Remarks: Very rugged volcanic islands, the two large ones 150 km apart, one satellite islet, on submarine North—South running ridge. Masatiera is a deeply eroded island, with many bays, is less high (915 m). Masafuera has no bays, rises steeply, especially on W. side, has many deeply eroded valleys. Both built up of thick lava beds. Climate: warm temperate; rainfall in lowland 400—1700 mm/year, average 1000 mm/year, mountains often clouded, moister. Maximum rain in winter months: May—August. Temp. monthly means at 10 m 12.4° C in August to 19° C in Febr., at 350 m 9.5° C and 16.7° C respectively. SE. trade winds prevail. Formerly heavily forested all over but much of original vegetation cleared or damaged by goats. Well explored.
Sources: Skottsberg (1922, 1953, 1954, 1956).

35. Kapingamarangi

Location: Pacific, E. Carolines; 1° N, 154° 45′ E.
Isolation: 1100 km from New Guinea, 550 km from New Ireland, 750 km from Ponape, 800 km from Truk.
Area: 1.1 sq.km. *Altitude:* 5 m. *Fam./Gen.:* 23/33.
Remarks: Rather isolated atoll, forming a nearly closed ring of reef with 33 islets on the eastern windward side. Soil limestone rock and sand in places enriched by guano. Geologic evidence points to greater elevation and land area in the past. Rainfall in July—August *c.* 125 mm, minimum and maximum temp. for June—July 28° C and 32° C. Vegetation of strand plants, supplemented with foodplants as *Cyrtosperma* and breadfruit. Well explored.
Sources: McKee (1956), Niering (1956, 1963), Wiens (1956).

36. Kapiti I.

Location: Cook Strait, New Zealand; 41° S, 175° E.
Isolation: 6 km from North I.
Area: 20 sq.km. *Altitude:* 525 m. *Fam./Gen.:* 68/121.
Remarks: Oblong, steeply rising island, much worn down and dissected by gullies. Built up of sedimentary rocks: shales and sandstones. Soil mostly a poor clayey loam. No details of climate known, winters mild, much rain, strong gales common. Great part of island covered by dense low forest and shrubbery, and where most affected by gales, meadows. List of plants certainly incomplete.
Source: Cockayne (1907).

37. Kermadecs

Location: Pacific Ocean; 29°—32° S, 178° 30′ W.
Isolation: 900 km from North I. (New Zealand), 950 km from Tonga, 2500 km from Australia.
Area: 32 sq.km. *Altitude:* 520 m. *Fam./Gen.:* 40/62.
Remarks: Volcanic group of islands, the bulk formed by Sunday I. (29 sq.km). Soil tuffaceous, very fertile, supporting luxurious vegetation. Climate subtropical, mean annual temp. 19° C with a range of 6°; rainfall 2000 mm/year, evenly distributed but maximum in winter. Well explored.
Sources: Allan (1961), Oliver (1909).

38. Lord Howe I.

Location: Tasman Sea; 31° 30′ S, 159° E.
Isolation: 550 km from Australia, 1300 km from New Caledonia, 1400 km from New Zealand.
Area: 13 sq.km. *Altitude:* 850 m. *Fam./Gen.:* 69/134.
Remarks: Volcanic island, situated on submarine plateau stretching to New Zealand. The island most likely was much larger in Pleistocene. Topography very rugged, soil basaltic, in places mixed with raised coral. Climate subtropical; rainfall rather evenly distributed but most in winter: 1250 mm/year. Mean monthly temp. 14—23° C. Strong winds especially in winter. Numerous burrowing petrels *(Puffinus)* and other seabirds nest on the island. Flora reasonably well known.
Sources: Green (letter 1967), Hoogland (letter 1967), Oliver (1917), Standard (1963).

39. Madeira

Location: Atlantic Ocean; 32° 30′ N, 17° W.
Isolation: 650 km from Morocco, 450 km from Canaries.

Area: 725 sq.km. *Altitude:* 1850 m. *Fam./Gen.:* 71/290.
Remarks: Volcanic island at the margin of submarine plateau, which extends to the Iberian Peninsula. Mainly built up of basaltic lava. Climate subtropical, monthly mean temp. range from 5—16° C in Jan. to 13—22° C in June—July, depending on altitude. Rainfall 250 mm/year in lowland to over 3000 mm in the mountains. Maximum rain in June—July, minimum in Febr.—April. Originally well forested between 400—1300 m, where much cloud formation takes place. A kind of 'macquis' above and below these limits. Many adventives, often difficult to distinguish between native and alien species. Flora well known.
Sources: Lowe (1868), de Meneses (1914), Rikli (1912), Tavares (1965).

40. Madura

Location: NE. of Java; 6° 50′—7° 15′ S, 112° 45′—114° 10′ E.
Isolation: 3 km.
Area: 5000 sq.km. *Altitude:* 470 m. *Fam./Gen.:* 104/380.
Remarks: Rather flat island. Soils mostly Quarternary to Mid-Tertiary sediments derived from limestone and marls, some alluvial deposits. Climate dry monsoonal. Probably originally largely covered by monsoon forest, which was long ago nearly completely destroyed.
Sources: Backer & Bakhuizen van den Brink Jr (1963, 1965, 1968).

41. Marquesas

Location: Pacific Ocean; 8°—10° 30′ S, 138° 30′—141° W.
Isolation: 7500 km from Australia and New Guinea, 5000 km from America, 4500 km from Fiji, 4000 km from Hawaii, 3500 km from Samoa, 1300 km from Tahiti.
Area: 1300 sq.km. *Altitude:* 1200 m. *Fam./Gen.:* 58/111.
Remarks: Group of 9 volcanic islands on shallow submarine plateau which was probably at one time partly emerged. Topography very rough, rugged steep mountains and deep valleys. Soil fertile, rainfall heavy, cloud caps formed almost daily round peaks. Densely forested except where disturbed by man. Reasonably well, but not exhaustively explored.
Sources: Brown (1931, 1935), Drake del Castillo (1893).

42. Mauritius

Location: Indian Ocean; 20° S, 57° 30′ E.
Isolation: 800 km from Madagascar, 150 km from Réunion.
Area: 1800 sq.km. *Altitude:* 825 m. *Fam./Gen.:* 102/299.
Remarks: Volcanic mountainous island, surrounded by a few satellite islets. Together with Réunion and Rodriguez situated on the Seychelles—Mauritius ridge. Deeply excavated valleys; soil basaltic with raised coral and sandstone in places. Rainfall varies locally and from year to year: 1000—4200 mm/year and is mainly brought by the SE. trade winds. Warm/wet season from Nov.—April, cool/dry season from May—Oct. Reasonably well explored but doubtful whether sufficiently collected before devastation of original vegetation started.
Sources: Baker (1877), Johnston (1894), Vaughan (1968).

43. Mayor I.

Location: New Zealand; 37° 15′ S, 176° 20′ E.
Isolation: 35 km from North I.
Area: 13 sq.km. *Altitude:* 400 m. *Fam./Gen.* 45/65.
Remarks: Volcanic island, two great crater lakes in centre, many dry gullies run down the main ridges, some small swampy areas round the craters. Covered with forest and scrub composed of few dominant species and rather poor undergrowth. List compiled from two visits, therefore likely incomplete.
Source: Allan & Dalrymple (1926).

44. New Caledonia and Loyalties

Location: Pacific Ocean; 19°—23° S, 163°—170° E.
Isolation: 1800 km from New Guinea, 1600 km from New Zealand, 1250 km from Fiji, 1200 km from Queensland, 350 km from New Hebrides.
Area: 25000 sq.km. *Altitude:* 1600 m. *Fam./Gen.:* 142/624.
Remarks: Main island elongated, mountainous, geologically unstable in the past, volcanism ceased in Oligocene. Built up largely of serpentine and peridotite, in places calcareous rocks, schists,

tuffs etc. Climate is mild, rainfall evenly distributed over the year: *c.* 1000 mm on the W. coast to 2000 mm on the E. coast and over 3000 mm in the interior. Mean monthly temp. 20—27° C. In warm season (Dec.—March) varying from 21—30° C; in cool season *c.* 7° C lower. Cyclones occasionally strike the island, prevailing winds E. and SE. Rather well explored but novelties can be expected, a number of genera likely native have been deleted. The Loyalties form a chain of low-lying (60 m) raised coral islands at *c.* 100 km from the main island. Most of the characteristic New Caledonian genera missing.

Sources: Guillaumin (1948), Thorne (1965).

45. New Guinea

Location: 0°—11° S, 131°—151° E.

Isolation: Continental island.

Area: 800.000 sq.km. *Altitude:* 5000 m. *Fam./Gen.:* 192/1420.

Remarks: Largest tropical island in the world. Situated on Australian Shield (Sahul Shelf). Huge mountain ranges running the length of the island, some of the peaks permanently snow-covered. Permanent emergence since Eocene, starting as insular area, progressing through Miocene to form continuous landmasses, present configuration attained in Plio-Pleistocene. Pleistocene to recent volcanism locally. Intrusives, metamorphics, and limestone widespread. Soils generally of lateritic types, alluvial sediments widespread, podsols in the mountainous areas, volcanic soils of little extent. Climate tropical, distribution of rainfall and temperature strongly modified by topography; monsoonal in the S., slightly seasonal with NW. monsoon and SE. trade winds elsewhere. Vegetation depends on topography and climate. Extensive tropical lowland rain forests, swamp and mangrove forest, in the monsoonal regions savannah woodland prevails. Montane forest merges into subalpine grasslands on the mountain ranges. Shifting cultivation has affected the vegetation to various degrees, especially below 2000 m, but large stretches of untouched lowland rain forest still exist. Genera new to the island are still being discovered.

Sources: Good (1960, 1963), Klein (1953—1954), Lam (1945), van Royen (1959), Visser & Hermes (1962), Resources of Papua and New Guinea (1951).

46. New Zealand

Location: 34° 30′—47° S, 166° 30′—178° 30′ E.

Isolation: 1500 km from Tasmania, 1650 km from N.S.W., 1600 km from New Caledonia, 8000 km from S. America.

Area: 265.000 sq.km. *Altitude:* 3750 m. *Fam./Gen.:* 102/328.

Remarks: Extremely mountainous island group, the bulk formed by North and South Island. Many peaks permanently covered by snow and glaciers, many lakes and rivers, several volcanoes, some still active. Geological history traced back to Precambrian. A large subcontinent (Tasmantis) bordered on the North by a geosyncline stretching to New Caledonia lasted at least till Jurassic. It gradually foundered, transgression reaching its greatest extent in Oligocene, when New Zealand was a chain of low islands. Uplift took place in Miocene accompanied by cooling and followed by increased volcanism in Pliocene. Land surface much enlarged in Pleistocene, and extensive glaciation in South I. Soils are in great part of alluvial and volcanic origin, podsols are extensive in the mountainous and semi-arid regions, dune sands pumice soils and other calcareous soils occur locally. Climate temperate oceanic, modified by latitude and altitude. Rainfall seasonal in North I. with a winter maximum, evenly distributed in South I., very high on W. side (up to *c.* 7000 mm/year), relatively dry in the eastern part (in places 330 mm/year).

Sources: Allan (1961), Cheeseman (1925), Cockayne (1921), Fleming (1962, 1963).

47. Niue I.

Location: Pacific Ocean; 19° S, 170° W.

Isolation: 4250 km from New Guinea and Australia, 500 km from Tonga and Samoa.

Area: 260 sq.km. *Altitude:* 70 m. *Fam./Gen.:* 55/113.

Remarks: Raised coral atoll, limestone soil, deeply fissured. Monthly mean temp. 23—27° C; rainfall 2000 mm/year, highest in Jan.—March, lowest in June—Sept. The island was densely forested, but much of the arable land has been cleared and planted with coconutpalms. Rather well explored.

Source: Yuncker (1945).

48. Norfolk I.

Location: SW. Pacific; 29° S, 168° E.
Isolation: 750 km from New Zealand, 675 km from New Caledonia, 1350 km from Australia, 1000 km from Lord Howe I.
Area: 40 sq.km. *Altitude:* 310 m. *Fam./Gen.:* 53/101.
Remarks: Volcanic island, bounded by precipitous cliffs of basalt and tuffs. Soil is fertile. Two satellite islets once as densely forested as main island, now denuded. Most of original vegetation destroyed. Climate subtropical oceanic, temp. varying between extremes of 7—33° C. Rainfall 1325 mm/year with winter maximum. Flora rather completely recorded, but distinction between native and alien species in many cases uncertain.
Sources: Green (letter 1967), Laing (1915), Maiden (1903), Turner, Smithers & Hoogland (1968).

49. NE. Queensland

Location: Australia; 11°—19° S, 142°—147° E.
Isolation: Continental area.
Area: c. 75000 sq.km. *Altitude:* 1650 m. *Fam./Gen.:* 157/870.
Remarks: Easternpart of Cape York Peninsula, exact limits cannot be precisely given. A stretch of country with little variation in elevation except in the Atherton tableland, which is part of a North—South running granitic massif: the Great Dividing Range. Soils are mainly podsols, red loams in Atherton tableland, some outcrops of laterite in the N. and sandy soils locally. Temperatures uniformly high except were modified by altitude; annual mean temp. at Cape York (11° S) 26.5° C, at Cairns (17° S) 24.5° C, with mean monthly temp. of 21° C in July to 28° C in Jan. Rainfall is highest of Australia: 4500 mm/year locally but much less elsewhere. Storms and hurricanes occur regularly. Rain forest is developed where rainfall is sufficiently high; in places it merges with monsoon forest. Main vegetation type is an open savannah-like forest, low scrub is especially found in the N. Many genera probably await recording, especially in the arid areas.
Sources: Brass (1953), Burbidge (1960, 1966).

50. Penang

Location: Strait of Malacca; 5° 30′ N, 100° 20′ E.
Isolation: 10 km from Malaya.
Area: 270 sq.km. *Altitude:* 825 m. *Fam./Gen.:* 136/633.
Remarks: Hilly island much dissected by deep ravines, well watered. Basic rock granite. Once supporting rich tropical rain forest. Mean (daily?) temp. 27° C with a range of 8° C. Rainfall 3000 mm/year, evenly distributed. Reasonably explored.
Source: Curtis (1894).

51. Pindunde Valley

Location: New Guinea; 5° 45′ S, 145° 5′ E.
Isolation: None.
Area: 5 sq.km. *Altitude:* 3300—4000 m. *Fam./Gen.:* 55/118.
Remarks: Valley on E. slope of Mt Wilhelm. Glaciated in Pleistocene. Scree slopes and three oligotrophic lakes in upper part. Valley base filled with swampy tussock grass with scattered shrubs, the slopes covered with patches of subalpine forest. Rainfall high throughout the year. Daily mean temp. *c.* 10° C, frost occurs regularly, recorded extremes near ground —3° and 33° C. Hardly any new generic records to be expected.
Sources: van Balgooy (1965), Brass (1959), Hoogland (1958), Thomasson (1967), Walker (1968).

52. Ponape

Location: Pacific, Carolines; 7° N, 158° E.
Isolation: 1300 km from Bismarcks, 1800 km from New Guinea, 3000 km from Philippines.
Area: 380 sq.km. *Altitude:* 750 m. *Fam./Gen.:* 65/168.
Remarks: Volcanic mountainous island in a group of mainly coral islands, basic rock of Eocene/Oligocene age. Climate tropical, rainfall high throughout the year: 4600 mm/year, ranging from 490 mm in May to 205 mm in Febr. Rainfall higher in the mountains; over 6000 mm at 450 m. Minimum and maximum temp. recorded 20° and 33° C. Strong SE. winds in May—Dec. Vegetation chiefly a luxuriant rainforest. Well explored.
Sources: Glassman (1952), Hosokawa (1954).

53. Principe

Location: Atlantic, Gulf of Guinea; 1° 30′ N, 7° 30′ E.
Isolation: 200 km from Rio Muni, 135 km from S. Tomé (no. 62) and 200 km from Fernando Po (no. 23).
Area: 125 sq.km. *Altitude:* 950 m. *Fam./Gen.:* 64/198.
Remarks: One of a series of four volcanic islands. Sharp little eroded contours. Rainy season Sept.—May, driest month July. Rainfall 2000—4000 mm/year. Mean annual temp. 24° C. Originally densely forested, now the flat parts entirely cultivated. Well explored except above 650 m, where some novelties are still expected.
Sources: Exell (1944, 1956, 1959, 1968).

54. Rapa I.

Location: S. Pacific; 27° 30′ S, 144° W.
Isolation: Southernmost island of SE. Polynesia, 1200 km from Tahiti, 1400 km from Cook Is., 4000 km from New Zealand, 6000 km from Australia, 6500 km from S. America.
Area: 40 sq.km. *Altitude:* 660 m. *Fam./Gen.:* 49/90.
Remarks: Crescent shaped, irregular, volcanic island very much worn down, with many steep inaccessible crags, swampy in the lowland. The only Pacific island where a coal deposit has been found. Soil very fertile, supporting luxuriant vegetation. No data on climate but probably not much different from Norfolk or Lord Howe. Reasonably well explored, but novelties still to be expected.
Sources: Brown (1931, 1935), Cranwell (1964), Fosberg (letter 1967), Riley (1926).

55. Réunion

Location: Indian Ocean; 21° S, 55° 30′ E.
Isolation: 700 km E. of Madagascar.
Area: 2500 sq.km. *Altitude:* 3050 m. *Fam./Gen.:* 92/316.
Remarks: Rugged, deeply eroded volcanic island. Hot/wet season: Nov.—April, cool/dry season: May—Oct. Trade winds bring much rain to the S. and E. parts and the mountains. Temp. fairly constant with minima and maxima of 16° and 32° C in the lowland. Highest peak temporarily snow-capped. Once supporting extremely rich forest, now largely devastated, especially the NW. dry sector. Reasonably well explored but probably several species became extinct before collected.
Sources: de Cordemoy (1895), Rivals (1968).

56. Rodriguez I.

Location: Indian Ocean; 19° 45′ S, 63° 30′ E.
Isolation: 1400 km from Madagascar, 600 km from Mauritius.
Area: 110 sq.km. *Altitude:* 400 m. *Fam./Gen.:* 57/119.
Remarks: Smallest and most remote of the Mascarenes, situated on the Seychelles—Mauritius submarine ridge. A basaltic ridge runs the length of the island, deeply dissected on all sides by ravines. Annual rainfall 1000—1500 mm, wettest months Jan.—May; temp. fairly constant, mean monthly temp. 21.7° C in Aug. and 26.8° C in Febr.; extremes on record 33.7° C and 15.2° C. SE. trade winds prevail throughout most of the year. Originally densely covered with thickets and forests but now practically denuded. Some species probably never collected.
Sources: Balfour (1879), Wiehe (1949).

57. Rottnest I.

Location: Indian Ocean; 32° S, 115° 30′ E.
Isolation: 20 km from W. Australia.
Area: 19 sq.km. *Altitude:* 35 m. *Fam./Gen.:* 49/99.
Remarks: Very arid, exposed island, separated from mainland only *c.* 7000 years ago. Soil a consolidated calcareous sandstone. Many saline lakes and interdunal fresh to brackish ponds. Climate maritime mediterranean. Rainfall 750 mm/year, driest month Jan.: 6 mm, wettest June: 165 mm. Monthly mean temp. 14.5° C in July to 22° C in Febr. Overbrowsing by Quokkas *(Setonix brachyurus)*, deterioration of climate, and recent erosion have impoverished the flora. Fossil evidence indicates that the original vegetation consisted of woodland, now replaced by coastal and marsh vegetation. Present day flora well explored.
Sources: Hodgkin & Sheard (1959), Storr (1962, letter 1964).

58. S. Catalina

Location: Pacific; 33° N, 118° W.
Isolation: 35 km from California, U.S.A.
Area: 195 sq.km. *Altitude:* 620 m. *Fam./Gen.* 74/236.
Remarks: Mountainous island, built up of metamorphic rocks, partly covered by lava flows. Continental in origin, but largely submerged in Pleistocene. Semi-arid mediterranean type of climate, mean annual temp. 16° C with range of 6.5° C. Vegetation rather sparse, scattered patches of forest, but mostly savannah. Well explored.
Source: Thorne (1967).

59. S. Croix

Location: Caribbean; 17° 30′ N, 64° 30′ W.
Isolation: 100 km from Porto Rico, 800 km from Venezuela.
Area: 150 sq.km. *Altitude:* 350 m. *Fam./Gen.:* 89/394.
Remarks: One of the northernmost islands of the Lesser Antilles. Topography hilly in places, elsewhere sandy flats and lakes. Soil fertile. Rainfall 750—1800 mm/year, well distributed, comparatively dry from Dec.—April, monthly average 42—175 mm; temp. nearly uniform, monthly average from 25.5° C in Febr. to 29° C in Sept. Trade winds in Oct.—June. Exploration reasonably good.
Sources: Britton & Wilson (1923, 1925), Millspaugh (1902).

60. S. Helena

Location: Atlantic Ocean; 16° S, 5° 45′ W.
Isolation: 1800 km from Angola (Afr.), 2000 km from S. America.
Area: 125 sq.km. *Altitude:* 800 m. *Fam./Gen.:* 18/34.
Remarks: Top of large volcanic cone, diameter 130 km at the base which is at a depth of 4000 m; 900 km E. of Mid-Atlantic Ridge. Emerged part of cone largely built up of basaltic lava flows, in places cut by intrusions and extrusions of basaltic dykes and masses of alkaline rock. Calcareous sand dunes are developed along the shore. No granitic fragments as on Ascension (no. 2). Topography rough. Climate equable, no storms or hurricanes. SE. trade winds dominate throughout the year, southern fringe of S. Equatorial Current passes the island. Temp. at sealevel 20—29° C in summer, 14—21° C in winter, in the interior *c.* 5° lower. Annual rainfall at sealevel 250 mm, at 500 m 1100 mm. Formerly densely forested, original vegetation now largely replaced by aliens, possibly some species became extinct before collected. Hemsley accepted only 28 genera with endemic species as native. I have accepted a few of his 'doubtfuls' as indigenous.
Sources: Daly (1927), Hemsley (1885).

61. S. José

Location: Pacific; 8° 15′ N, 79° W.
Isolation: 65 km from Pacific coast of Panama.
Area: 40 sq.km. *Altitude:* 135 m. *Fam./Gen.:* 90/335.
Remarks: Irregular hilly island, undisturbed until 1944. Composed of bedded, consolidated, sedimentary rock of volcanic origin, faulted and cut by dikes and sills of basalt and andesite. Probably emerged since Oligocene. Situated on shallow submarine bank, probably connected with mainland in early Pleistocene. Many streams, but no marshes and ponds. Climate seasonal, annual rainfall 2100—2500 mm, mostly falling in Aug.—Nov., Jan.—March almost rainless. Recorded temp. extremes 19° and 32° C, monthly means 24.5—26.5° C. Wind prevailingly from the North, but in rainy season variable. Covered with forest and thickets, some grassland. State of exploration reasonable.
Source: Johnston (1949).

62. S. Tomé

Location: Atlantic, Gulf of Guinea; 0° 15′ N, 6° 30′ E.
Isolation: 250 km from Gabon.
Area: 1000 sq.km. *Altitude:* 2000 m. *Fam./Gen.:* 94/354.
Remarks: Volcanic island, one of a series of four. Presumably of mid-Tertiary age. Climate equatorial, temp. range 22° C (mean minimum) to 30° C (mean maximum); mean monthly temp. from 24° C in August to 27° C in March, at 650 m 5—6° C lower. Annual rainfall 1000—5000 mm, heavy rains in Nov.—April, dry period from June—Sept. Formerly a dense tropical rain forest covered the whole island, only small remnants now remain. Rather well explored.
Sources: Exell (1944, 1956, 1959, 1968).

63. Seychelles

Location: Indian Ocean; 3°—7° S, 53°—57° E.
Isolation: 900 km from Madagascar, 1750 km E. of Africa, 2400 km from India.
Area: 235 sq.km. *Altitude:* 900 m. *Fam./Gen.:* 81/214.
Remarks: A group of *c.* 30 rugged islands, the bulk formed by Mahé, situated on a broad submarine bank stretching S. to the Mascarenes. They are built up of granitic (Precambrian) and syenitic (early Tertiary) rocks, cut by dikes of basalt. It is the only granitic island group so much isolated. During Pleistocene lowering of sealevel most islands must have been connected. The soil is generally poor except were alluvial deposits are formed. Climate equatorial oceanic, seasonal: dry SE. monsoon in Apr.—Sept., wet NW. monsoon in Oct.—March. Rainfall 1750—3000 mm/year. Temperature round 27° C throughout the year with fluctuations not exceeding 5° C. Originally covered with a luxuriant forest, now practically destroyed. State of exploration reasonably good.
Sources: Baker (1877), Jeffrey (1968), Sauer (1967), Stanley Gardiner (1907), Summerhayes (1931).

64. Ship I.

Location: Mouth of Mississippi River, U.S.A.; 30° N, 89° W.
Isolation: 30 km from coast.
Area: 6 sq.km. *Altitude:* 30 m. *Fam./Gen.:* 71/199.
Remarks: Sandy strip of land, composed of shifting dunes, with some marshes locally. Species apparently not permanently established were left out.
Source: Miller & Jones (1967).

65. Socorro

Location: Pacific Ocean; 19° N, 111° W.
Isolation: 500 km from Baya California, Mexico.
Area: 170 sq.km. *Altitude:* 1150 m. *Fam./Gen.:* 38/77.
Remarks: Volcanic island rising steeply out of the ocean. Climate arid, occasional torrential storms yearly, peak often clouded. Although not exhaustively explored, not many novelties expected.
Source: Johnston (1931).

66. Socotra

Location: Indian Ocean; 12° 30′ N, 54° E.
Isolation: 225 km from Cape Guardafui, Somalia.
Area: 3650 sq.km. *Altitude:* 1500 m. *Fam./Gen.:* 85/313.
Remarks: Island situated on continental plateau, same geological structure as adjacent E. Africa. Most of the is'and occupied by limestone plateau, the Haggier range is a granitic massif. Basement rocks formed by Archean gneisses and schists, these overlain by Cretaceous lime and sandstones and Eocene limestones, in places pierced by basaltic and trachytic dykes. In the mountains redsoils as result of granitic decomposition widespread, clayey soils on the plateau, the alluvial plains filled with stones, gravel, and sand. Climate monsoonal, arid, less torrid than on adjacent mainland, due to monsoon-winds. Coastal temp. 15—32° C in spring, hotter during calms between monsoons, considerably cooler on the mountains but frosts unknown. Rainfall *c.* 150 mm/year and up to *c.* 500 mm in the mountains, mostly falling during the NW. monsoon (Nov.—March). The SW. monsoon (May—Sept.) extremely dry. Permanent streams in the upper parts only. The island is largely covered with subdesert shrub vegetation and grass steppe, montane thickets in the Haggier massif. Novelties still to be expected.
Sources: Balfour (1888), Gwynne (1968), Popov (1957).

67. S. Trinidad (Trinidade)

Location: Atlantic Ocean; 20° 30′ S, 29° 20′ W.
Isolation: 1000 km E. of Brazil.
Area: 10 sq.km. *Altitude:* 600 m. *Fam./Gen.:* 8/9.
Remarks: Volcanic rocky island, hardly accessible. No data on climate available. In places a dense vegetation of few species occurs. One tree species became extinct in the middle of the 19th century before identified. Perhaps some more species exterminated by goats released on the island. Popular nesting ground for frigate birds.
Source: Hemsley (1885).

68. SW. Georgia

Location: Georgia, U.S.A.; 30° 42′—32° 13′ N, 83° 56′—85° 08′ W.
Isolation: Continental area.
Area: 13000 sq.km. *Altitude:* 15—200 m. *Fam./Gen.:* 134/532.
Remarks: Flat area on the inner Gulf Coastal Plain. Sandy plains, often excessively or poorly drained, sandy and clayey hills. Soils red or yellow podsols, laterized, low in mineral nutrients, often strongly leached and acid. Warm temperate climate, frost free period of 233—250 days. Annual rainfall 1175—1350 mm, well distributed. Flora well known.
Source: Thorne (1954).

69. Tasmania

Location: 40° 30′—43° 30′ S, 144° 20′—148° 10′ E.
Isolation: 250 km from Victoria, SE. Australia.
Area: 68000 sq.km. *Altitude:* 1550 m. *Fam./Gen.:* 94/401.
Remarks: Mountainous island with extensive tableland, many lakes and rivers. Built up of granitic core covered by metamorphic rocks of Cambrian to Tertiary age. Volcanoes were active in Tertiary but not in recent time. The island has been connected with Australia during most of the Tertiary. Climate is temperate. The 'Westerlies' bring rain almost throughout the year. Annual rainfall ranges from 1500 mm on the W. coast to 3500 mm inland down to 750 mm on the E. coast and 500 mm in the rainshadow. Snow covers the mountain tops for 3—6 months of the year. *Nothofagus* forest dominates in the W. and *Eucalyptus* forest in the E. Heath and bog formations also widespread.
Sources: Burbidge (1960, 1966), Curtis (1956, 1963, 1967), Hooker (1860), Rodway (1903), Tennison-Woods (1882).

70. Three Kings Is

Location: New Zealand; 34° S, 172° E.
Isolation: 60 km from Cape Maria van Diemen, North I.
Area: 7 sq.km. *Altitude:* 300 m. *Fam./Gen.:* 60/113.
Remarks: Group of tiny islets on submarine plateau connected with New Zealand. Igneous basement rock of graywackes supplemented with andesitic lava streams. The largest island (Great I.) has an undulating surface, surrounded on all sides by precipitous cliffs. Much of the original dense forest destroyed by early Maori occupants and later by goats. The human inhabitants left in 1840, the goats were recently exterminated. The vegetation now rapidly recovers but it is possible that some species were never collected. Present-day flora well known.
Sources: Baylis (1948, 1951, 1958), Buddle (1948), Cranwell (1962), Holdsworth & Baylis (1967), Oliver (1948, 1951), Turbott (1963).

71. Tjibodas

Location: Java; 6° 45′ S, 107° E.
Isolation: None.
Area: 12 sq.km. *Altitude:* 1400—3000 m. *Fam./Gen.:* 103/374.
Remarks: Nature reserve on the NE. slope of the volcanic Gedeh-Pangrango complex. Rainfall rather evenly distributed 3000—3500 mm/year with a maximum in Dec.—Febr. and a minimum in June—August. Daily temp. range *c.* 13—22° C at 1500 m and *c.* 6—13° C at 3000 m. Frost occasionally recorded in depressions. Vegetation consists of dense montane rain-forest, gradually merging into subalpine forest, grassland, and shrubbery towards the summits of the two peaks, one of which is an active crater. Very well explored.
Sources: Docters van Leeuwen (1933), Koorders (1918, 1923).

72. Tonga Is

Location: Pacific Ocean; 18°—22° S, 174°—175° W.
Isolation: 3750 km from Australia and New Guinea, 500 km from Fiji and Samoa.
Area: 650 sq.km. *Altitude:* 1000 m. *Fam./Gen.:* 87/246.
Remarks: Group of *c.* 150 islands (Niue is not included), both of volcanic and coral formation, the former supporting a rich forest which is preserved on some of the uninhabited islands. Monthly mean temp. *c.* 25° C in July—Aug. and *c.* 32° C in Jan.—March. Rainfall *c.* 2200 mm/year, mainly falling in the first half of the year. Reasonably well explored.
Sources: Hemsley (1894), Hotta (1963, 1965), Hürlimann (1967), Yuncker (1959).

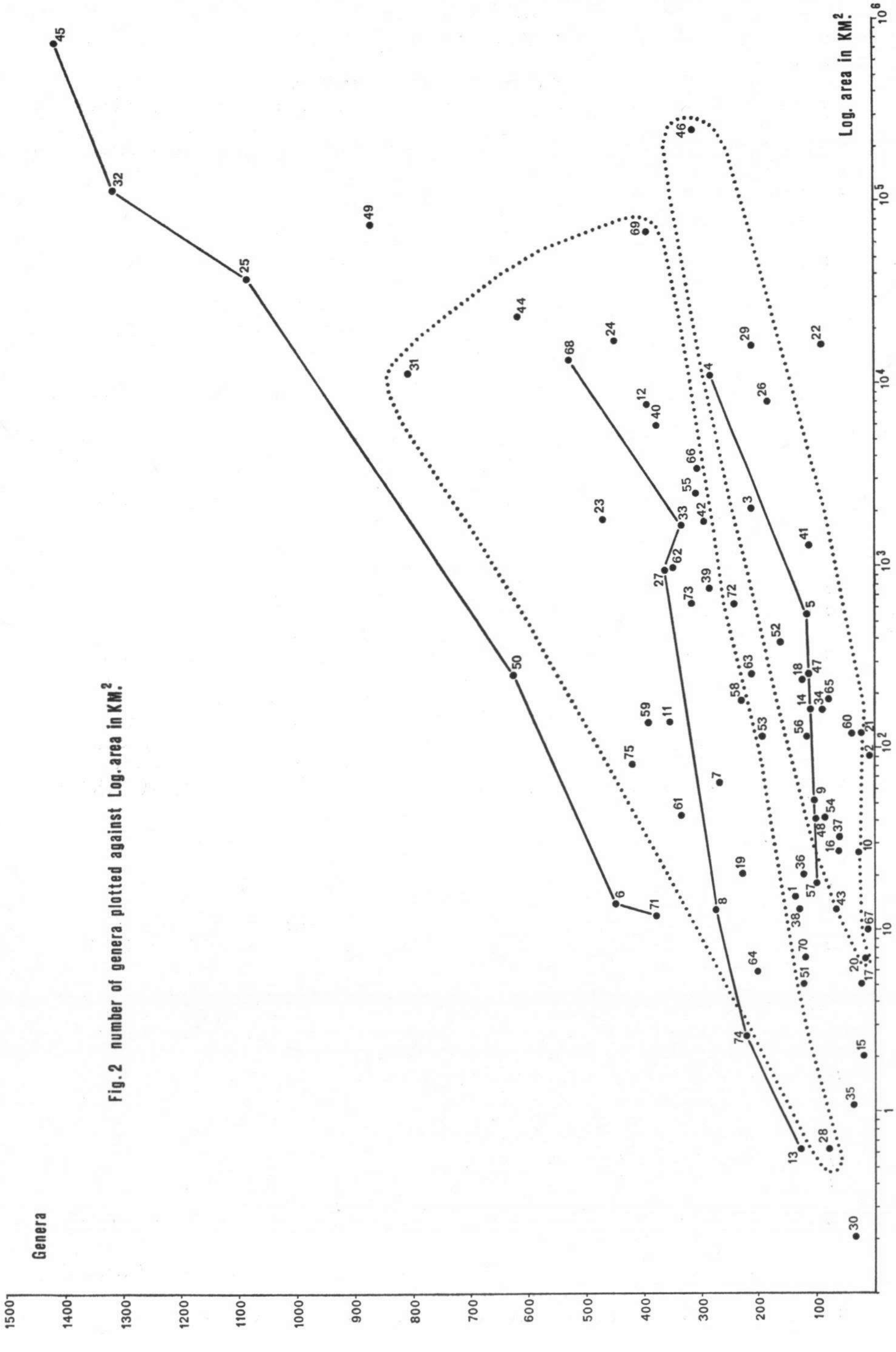

Fig. 2 number of genera plotted against Log. area in KM².

73. W. Carolines

Location: W. Pacific; 7°—10° N, 134°—145° E.
Isolation: Palau *c.* 900 km from Mindanao and Vogelkop (New Guinea).
Area: 650 sq.km. *Altitude:* 240 m. *Fam./Gen.:* 95/320.
Remarks: A great number of islands mostly of coral formation, but the bulk made up by volcanic Palau (378 sq.km) and plutonic Yap (216 sq.km). Both islands (originally) covered all over with dense rain forest, some marshy spots on Yap. Rainfall *c.* 3000 mm/year, wet period July—Sept., dry period Febr.—April. Temp. fairly constant all over the year, monthly average *c.* 27° C. NE. trade winds prevail from Nov.—May. At beginning and end of this period cyclones occur. Insufficiently explored but many new generic records unlikely.
Sources: Hosokawa (1954), Kanehira (1935a), Volkens (1901).

74. White Pine Hollow

Location: Iowa, U.S.A.; 42° 38′ N, 91° 07′ W.
Isolation: Continental area.
Area: 2.5 sq.km. *Altitude:* 250—340 m. *Fam./Gen.:* 70/224.
Remarks: Much dissected area, loess covered uplands, many limestone bluffs, crags, and pinnacles, and alluvial flats, offering rich diversity of habitats; densely forested. Climate mid-continental, very cold in winter, hot in summer. Rainfall 775 mm/year, rather equally distributed but mostly falling in April—Sept. Monthly mean temp. — 8°—23° C. Thoroughly explored.
Source: Thorne (1964).

75. Yakusima

Location: S. Japan; 30° N, 130° E.
Isolation: 60 km from Kyu Shu.
Area: 80 sq.km. *Altitude:* 1950 m. *Fam./Gen.:* 128/420.
Remarks: One of the northernmost islands of the Ryu Kyu Archipelago. The island consists of a granitic batholith, partly overlain by layers of sandstone and slate and locally by volcanic products. Soil fertile. Climate mild as result of Kuro Shyo Current; mean monthly temp. from 11° C in Jan. to 29° C in Aug. at sealevel, and resp. 7° and 26° C at 650 m. Rainfall high all over the year, 3300 mm at sealevel and 7500 mm at 650 m, with a summer maximum. Covered all over with luxuriant forest. Reasonably well explored but additions can be expected.
Source: Masamune (1938).

TABULATED SUMMARY OF DATA

The data on size, altitude, isolation, and number of genera and families are summarized in table 1. In the column 'isolation' the figure indicates the distance to the nearest continent or other big source area. The figure in brackets represents the nearest island source ('stepping stone'), e.g. for Cook Is the distance to Australia is 4700 km and the distance to Samoa is 1250 km. The latitude is given in single round figures, except in cases of considerable North—South extension. In the column 'Fam./Gen.' the figure in brackets represents the average number of genera per family.

DISCUSSION

In fig. 2 the number of genera has been plotted against (log.) area in sq.km.

A broad belt of dots is obtained, showing on the whole a positive tendency: the larger the area the more genera.

Table 1

No.	Island(-group) or continental area	Area in sq.km	Alt. in m	Isolation in km	Latitude	Fam./Gen.
1	Annobon	16	650	350	2°	54/141 (2.6)
2	Ascension	90	850	1600	8°	6/6 (1.0)
3	Azores	2300	2250	1300	38°	70/221 (3.2)
4	Bahamas	11300	60	60	21—28°	104/290 (2.8)
5	Bahrain	530	115	35	26°	41/123 (3.0)
6	Barro Colorado	15	160	1	9°	108/445 (4.1)
7	Batan I.	65	1000	200	21°	85/273 (3.2)
8	Bergen Swamp	13	100	0	43°	83/272 (3.3)
9	Bermudas	50	75	1000	32°	55/102 (1.9)
10	Bikini I.	25	5	2500	12°	22/29 (1.3)
11	Botel Tobago	140	530	60	22°	115/358 (3.1)
12	Canaries	7500	3700	100	28°	91/400 (4.4)
13	Cayler Prairie	0.6	400	0	43°	46/127 (2.8)
14	Christmas I.	150	350	300	10°	52/107 (2.1)
15	Clipperton	2	30	1100	10°	12/19 (1.6)
16	Cocos I.	25	825	500	6°	33/59 (1.6)
17	Cocos Keeling	5	10	1100	12°	17/20 (1.2)
18	Cook Is	250	660	4700(1250)	21°	63/128 (2.0)
19	Dagelet I.	20	900	135	38°	80/230 (2.9)
20	Desventuradas	7	450	1000	26°	12/17 (1.4)
21	Easter I.	120	530	4000	27°	15/22 (1.5)
22	Falkland Is	16500	700	500	53°	36/98 (2.7)
23	Fernando Po	2000	3000	35	4°	100/470 (4.7)
24	Fiji Is	18500	1300	2500(1500)	15—20°	119/452 (3.8)
25	Formosa	36000	3950	150	22—26°	175/1080 (6.2)
26	Galapagos Is	7700	1500	1000	0°	67/189 (2.8)
27	Giles County	940	450—865	0	39°	105/369 (3.5)
28	Hare I.	0.6	10	1	9°	35/75 (2.1)
29	Hawaiian Is	16000	4100	6000(3750)	18—28°	83/221 (2.6)
30	Heron I.	0.2	4	65	23°	18/27 (1.5)
31	Jamaica	11400	2250	150	18°	154/810 (5.3)
32	Java	125000	3600	0	6—9°	182/1320 (7.3)
33	Johnson County	1600	200—250	0	42°	95/344 (3.6)
34	Juan Fernandez	150	1500	650	34°	43/90 (2.1)
35	Kapingamarangi	1.1	5	1100(550)	1°	23/33 (1.4)
36	Kapiti I.	20	525	6	41°	68/121 (1.8)
37	Kermadecs	32	520	900	30°	40/62 (1.6)
38	Lord Howe I.	13	850	1400(550)	32°	69/134 (2.0)

In order to rule out as many factors as possible affecting the size/diversity relation dots representing regions more or less comparable except in size have been connected by lines. This clearly illustrates the general tendency.

Taking first the continental regions with a tropical everwet climate where tropical rain forest is the climax vegetation, in other words regions with optimal conditions for plant life, we have the following series: 71 Tjibodas, 6 Barro Colorado, 50 Penang, 25 Formosa, 32 Java, 45 New Guinea. The dots lie almost in a straight line. Barro Colorado, despite its low elevation, is richer than Tjibodas which is only slightly smaller. Although it would have been more conclusive if the two regions were situated on the

No.	Island (-group) or continental area	Area in sq.km	Alt. in m	Isolation in km	Latitude	Fam./Gen.
39	Madeira	725	1850	650	33°	71/290 (4.1)
40	Madura	5000	470	3	7°	104/380 (3.7)
41	Marquesas	1300	1200	7000(1300)	9°	58/111 (1.9)
42	Mauritius	1800	825	800	20°	102/299 (2.9)
43	Mayor I.	13	400	35	37°	45/65 (1.5)
44	New Caledonia and Loyalties	25000	1600	1200	19—23°	142/624 (4.4)
45	New Guinea	800000	5000	0	0—11°	192/1420 (7.4)
46	New Zealand	265000	3750	1500	35—47°	102/328 (3.2)
47	Niue I.	260	70	3500(500)	19°	55/113 (2.0)
48	Norfolk I.	40	310	750	29°	53/101 (1.9)
49	NE. Queensland	75000	1650	0	10—19°	157/870 (5.5)
50	Penang	270	825	10	5°	136/634 (4.7)
51	Pindunde Valley	5	3300—4000	0	6°	55/118 (2.1)
52	Ponape	380	750	1800	7°	65/168 (2.6)
53	Principe	125	950	200	2°	64/198 (3.1)
54	Rapa I.	40	660	5500(1200)	28°	49/90 (1.8)
55	Réunion	2500	3050	700	21°	92/316 (3.4)
56	Rodriguez I.	110	400	1400	20°	57/119 (2.1)
57	Rottnest I.	19	35	20	32°	49/99 (2.0)
58	S. Catalina	195	620	35	33°	74/236 (3.2)
59	S. Croix	150	350	800(60)	18°	89/394 (4.4)
60	S. Helena	125	800	1800	16°	18/34 (1.9)
61	S. José	40	135	65	8°	90/335 (3.7)
62	S. Tomé	1000	2000	250	0°	94/354 (3.8)
63	Seychelles	250	1000	900	5°	81/214 (2.6)
64	Ship I.	6	30	30	30°	71/199 (2.8)
65	Socorro	170	1150	500	19°	38/77 (2.0)
66	Socotra	3650	1500	225	13°	85/313 (3.7)
67	S. Trinidad	10	600	1000	21°	8/9 (1.1)
68	SW. Georgia	13000	200	0	32°	134/532 (4.0)
69	Tasmania	68000	1550	250	42°	94/401 (4.3)
70	Three Kings Is	7	300	60	34°	60/113 (1.9)
71	Tjibodas	12	1500—3000	0	7°	103/374 (3.6)
72	Tonga Is	650	1000	3000(500)	15—23°	87/246 (2.8)
73	W. Carolines	650	240	900	5—10°	95/320 (3.4)
74	White Pine Hollow	2.5	340	0	43°	70/224 (3.2)
75	Yakusima	80	1950	60	30°	128/420 (3.3)

same continent, I think the most plausible explanation is that lowland rain forest is richer than montane forest. Moreover much of the higher parts of Tjibodas are covered by a relatively poor alpine and crater vegetation.

I have not included in this series 23 Fernando Po, 31 Jamaica, and 49 NE. Queensland, the first two because they are certainly underexplored, the latter because it is both underexplored and is only partially covered with tropical rain forest.

The next series comprises: 13 Cayler Prairie, 74 White Pine Hollow, 8 Bergen Swamp, 27 Giles County, 33 Johnson County, 68 SW. Georgia. These regions are all situated in North America and have a temperate climate. Again the dots lie almost in a straight line, except Johnson County which is most affected by man. Inclusion of two islands with approximately the same climate, 19 Dagelet I. and 69 Tasmania, would disturb the picture by deflecting the line downward, in other words there are less genera than expected. This is probably due to the insular character of Dagelet and, in the case of Tasmania, both isolation and the general poverty of Southern Australia compared with North America.

The third series consists of continental islands where conditions for plant life are distinctly unfavourable: 57 Rottnest I., 5 Bahrain, 4 Bahamas. They lie far apart and the reasons for poverty are not the same, nevertheless they illustrate the poverty of some continental regions.

I have not included 66 Socotra here. Although this island lies opposite desert areas (Arabia and Somalia) its climate, at least in the mountainous parts, is ameliorated by monsoon winds.

From these 'continental' series it appears that there is an increase in the number of genera correlated with size. The increase is strongest in the tropical rain forest regions which are also by far the richest in genera when compared with other regions of equal size.

The following islands with fair to good conditions for plant life can through their proximity to continents and on geological grounds be considered (sub)continental: 7 Batan I., 11 Botel Tobago, 12 Canaries, 19 Dagelet I., 23 Fernando Po, 28 Hare I., 31 Jamaica, 40 Madura, 58 S. Catalina, 61 S. José, 64 Ship I., 66 Socotra, 69 Tasmania, and 75 Yakusima. I have drawn a broken line round the dots representing these regions. Islands falling within this line include: 73 W. Carolines, 24 Fiji Is, 44 New Caledonia, 39 Madeira, 42 Mauritius, 55 Réunion, and 62 S. Tomé, of which the first three are now widely isolated, but in their number of genera 'behave' like continental islands.

Falling just outside this line are: 1 Annobon, 38 Lord Howe I., 51 Pindunde Valley, 53 Principe, 63 Seychelles, 70 Three Kings Is, and 72 Tonga Is.

Let us now consider the situation in isolated islands. As a rather arbitrary measure I have taken those islands situated at least 1000 km away from the nearest conceivable source area. It is difficult to indicate a series of 'comparable' islands. As they are, moreover, widely scattered and in ecological conditions vary from 'very favourable' (Hawaii) to 'reasonable' (S. Helena) I have preferred to draw a broken line round the dots concerned: 3 Azores, 9 Bermudas, 18 Cook Is, 20 Desventuradas, 21 Easter I., 26 Galapagos Is, 29 Hawaiian Is, 41 Marquesas, 46 New Zealand, 52 Ponape, 54 Rapa I., and 60 S. Helena. Exceptionally unfavourable islands have been omitted (2 Ascension).

These dots crowd round the line connecting the 'poor continental regions'. In other words: the number of genera on isolated islands with reasonable to very favourable conditions for plant growth and the increase correlated with size is the same as in continental regions with poor conditions. Islands falling within this line are: 14 Christmas I., 43 Mayor I., 16 Cocos I., 34 Juan Fernandez, 37 Kermadecs, 47 Niue I., 48 Norfolk I., 56 Rodriguez I., and 65 Socorro, of which the first two are much less isolated than the rest.

The coral islands: 30 Heron I., 35 Kapingamarangi, 15 Clipperton, 17 Cocos Keeling, and 10 Bikini I. are about equally poor, the two least isolated (Heron and Kapingamarangi) are slightly richer than the other three, though they happen to be the smallest.

They are still slightly richer than those isolated 'high' islands where conditions for plant life are at a minimum: 67 S. Trinidad and 2 Ascension. Their floristic poverty is even more striking when compared with that of the tiny rocky islet Toppers Hoedje in the Sunda Strait, not included in this survey, which is only 0.05 sq.km in area and 65 m high, but has 38 genera now on record (Docters van Leeuwen, 1934).

Two more small islets close to a continental shore deserve attention: the sand banks 28 Hare I. (0.6 sq.km) and 64 Ship I. (6 sq.km) have 75 and 199 genera respectively. This contradicts De Candolle's statement that small islands, however close to a continent, are always poor.

Fig. 3 shows the number of genera on the ordinate as plotted against distance in km from source area on the abcissa. To obviate as much as possible the effect of size the regions have been divided into five size classes indicated by different symbols: I 1—10, II 10—100, III 100—500, IV 500—5000, V 5000—25000 sq.km. This classification is of course somewhat arbitrary and crude, but in view of the effect of so many other factors it would be senseless to attempt a finer classification. The one here adopted may serve to illustrate the general tendency. Some of the smallest and largest regions drop off. Truly continental regions have been regarded as if isolated 1 km.

In all five classes there is a decrease in the number of genera correlated with isolation; the decrease is slightly stronger in the larger regions. The trend is apparent when again connecting 'comparable' regions: (a) 74 White Pine Hollow, 70 Three Kings Is, 20 Desventuradas; (b) 71 Tjibodas, 19 Dagelet I., 9 Bermudas; (c) 11 Botel Tobago, 52 Ponape, 18 Cook Is; (d) 58 S. Catalina, 65 Socorro, 60 S. Helena, 21 Easter I.; (e) 23 Fernando Po, 62 S. Tomé, 73 W. Carolines, 41 Marquesas.

It can be observed that in regions of the same size class (series d and e) though running perfectly parallel there is considerable discrepancy in the number of genera, series e consisting of islands where the conditions for plant life are much less favourable than in islands of series d.

A number of dots lie in a rather aberrant position, for which we may try to find an explanation.

Of class II 36 Kapiti I., 43 Mayor I., and 57 Rottnest I. deviate in a negative and 75 Yakusima and 54 Rapa I. in a positive way. The poverty of Mayor and Kapiti can no doubt be attributed to a large measure to the poverty of the source area (New Zealand). Rottnest, though near a richer source area (W. Australia), is a flat, rather arid island and has suffered from overgrazing. Yakusima is a high, fertile island and, despite its latitude, enjoys a very favourable climate, so that its relatively high number of genera is not surprising. Rapa, in view of its strong isolation, its latitude, and the poverty of its putative source area (New Zealand), compares favourably in number of genera with such islands as Juan Fernandez, Kermadecs, Norfolk, and Lord Howe I., that are so much nearer their source areas. This would suggest that either its area has been much larger in the past, or that its isolation has been less, or both.

Of class III 59 S. Croix occupies an aberrant position, no doubt caused by the fact that as a measure for isolation the distance to Venezuela has been taken, whereas Porto Rico has probably been the main source, the latter being only 60 km distant.

Of class IV it is 5 Bahrain that has a flora much 'too poor'. It is the only island in this class with a truly subdesert climate. Such islands as 40 Madura and 66 Socotra with an arid climate, the former moreover impoverished by man, still have a considerable number of genera.

Tonga has a flora 'too rich' in view of its isolation for which the distance to New Guinea has been taken. This relative richness can be explained by the proximity of Fiji.

Class V has its dots very much scattered. It will be agreed that 4 Bahamas and 22 Falkland Is are very poor in proportion to their size. But the former is a low lying island group with a poor soil, and no other island group in this class has such adverse climatic conditions as the Falklands.

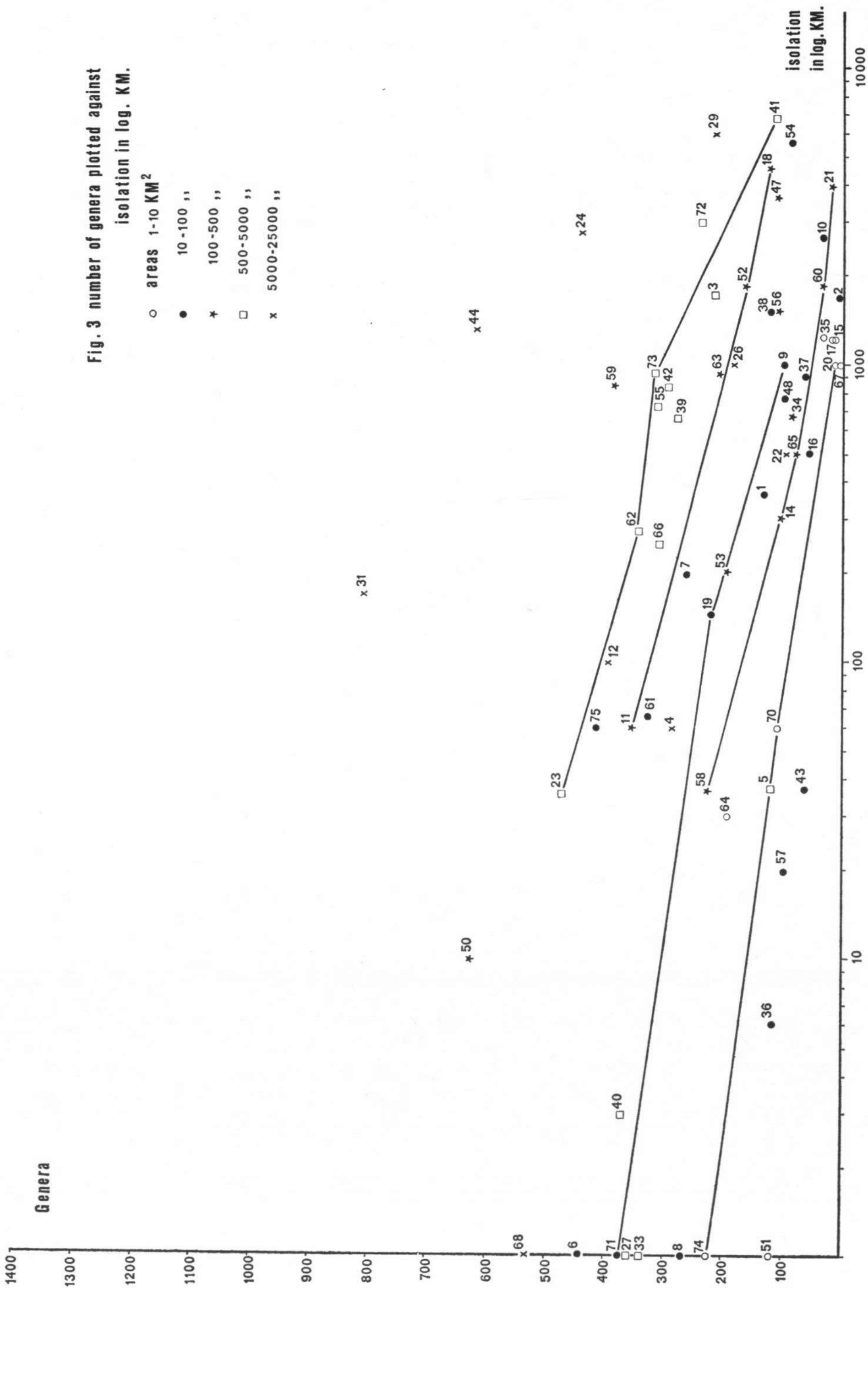

Fig. 3 number of genera plotted against isolation in log. KM.

On the other hand, 24 Fiji and 44 New Caledonia have a number of genera unexpectedly high in proportion to their isolation. As they are neither in height, nor in any other way exceptionally favourable for supporting a rich flora, I think this fact supports the claims that have been made for continental connections, or at least much greater proximity to continents in the past.

Summarizing the correlation between isolation and the number of genera we may say that there are in fact three categories of islands: (1) islands that are in close proximity to a land mass or that are on geological grounds regarded as continental but of which the number of genera is as low as in isolated islands; (2) islands of great present-day isolation but in number of genera 'behaving' like continental islands; (3) islands of which the number of genera is in agreement with their present-day isolation. The latter form the majority.

The first category comprises: Bahamas, Bahrain, Christmas I., Falklands, Kapiti, Mayor, New Zealand, Rottnest, and S. Catalina. It has been stated above that adverse climate (Bahrain, Falklands), low elevation and poor soil (Bahamas), low elevation in addition to aridity and overgrazing (Rottnest), poverty of source area (Kapiti and Mayor) are the main factors responsible. Christmas I. may be underexplored but Batan I., which is perhaps even less thoroughly explored, has yielded more than twice the number of genera. Possibly the flora is not as old as the geological age of the island suggests. S. Catalina, despite its great geological age, probably owes its relative poverty, apart from its rather arid climate, to its Pleistocene partial submergence.

Most interesting in this category is New Zealand. Considering its size and ecological diversity it certainly can be classed as floristically poor, at least as regards number of genera. The turbulent geological history (Fleming, 1962) and especially the effect of Pleistocene glaciations (Burrows, 1965, Wardle, 1963) have combined in reducing the available space and in rendering the climate less favourable in the past. This may well be a good example of what happens to a (sub)continental region that becomes isolated as discussed on p. 000. It is unfortunate that no figures are available for a part of Patagonia of the same size as New Zealand.

Among the second category the following islands have been shown to have a flora 'too rich' in regard to their isolation: 24 Fiji, 38 Lord Howe, 44 New Caledonia, 54 Rapa, 59 S. Croix, 72 Tonga, 73 W. Carolines.

For New Caledonia this is not so surprising and also most of the other islands have on other grounds been claimed as continental, but Rapa I. is a curious case. Both the number of genera and the character of its flora (van Balgooy, 1960, p. 413) are hard to explain in view of its position. Better accessibility in the past from the west is suggested.

The islands belonging to the third category show a very clear correlation between their number of genera and isolation.

One of our initial questions was: can diversity of an island's flora give us a clue to its past history? We may conclude that it can give additional support to evidence from other fields.

This paper is only concerned with the number of *genera*. But the systematic affinity and distribution, the ecological requirements, the structure of the diaspores, and other details of the *species* must be thoroughly known before anything definite can be said about the history of the flora. This paper can be said to stop where things become interesting. But I think such elementary data as presented here are simply needed because

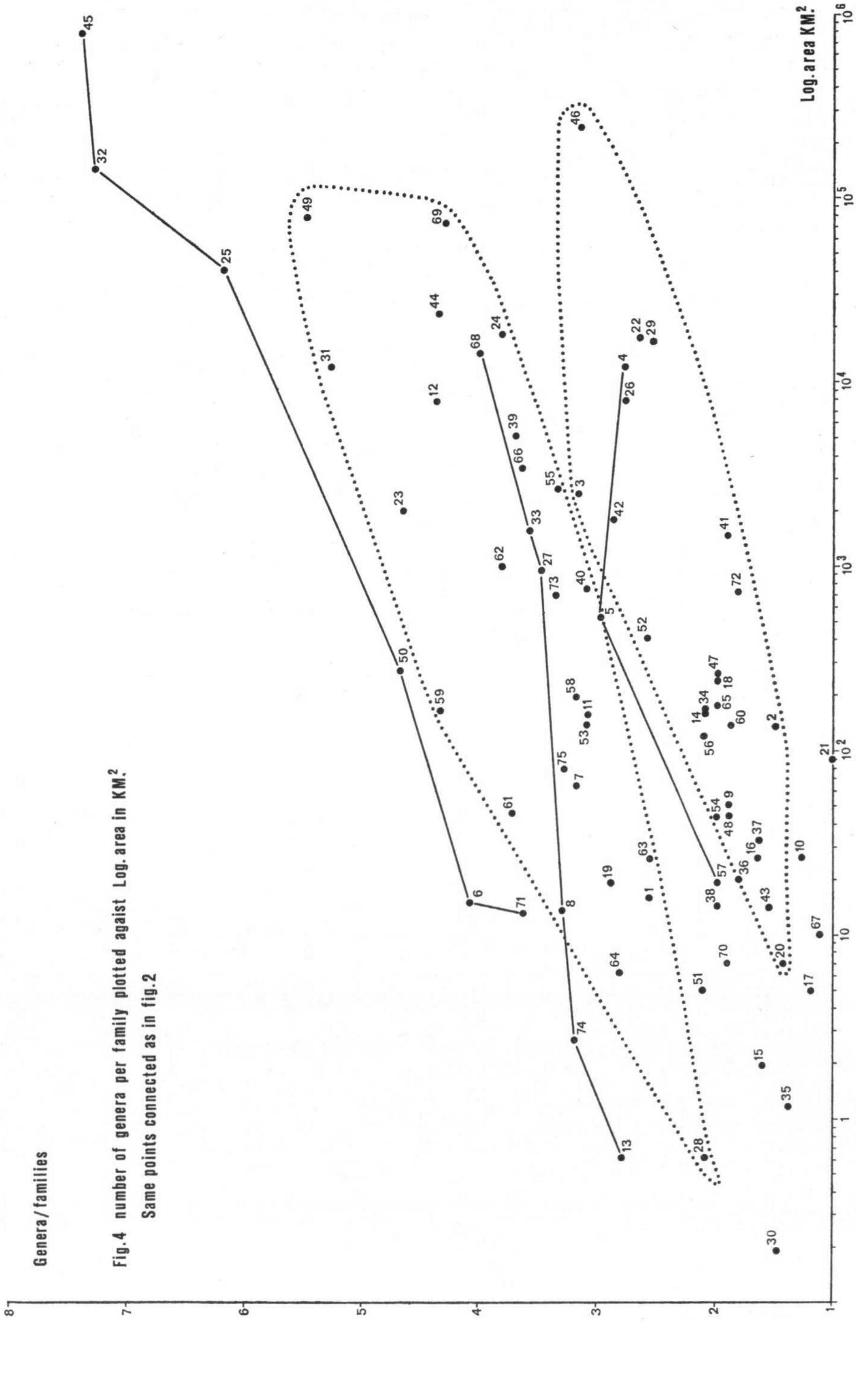

Fig. 4 number of genera per family plotted agaist Log. area in KM².
Same points connected as in fig. 2

they have not been brought together in any quantity since Hemsley. Starting with these data a number of steps in various directions may be undertaken.

Fosberg (1948) proceeded in the following way. He analyzed the present flora of Hawaii not only as to geographical affinity, but also to the number of assumed 'original immigrants' that are required to build up the whole present-day Hawaiian flora. In his opinion the present flora of Hawaii can be explained by only about 270 of such original immigrants. If it is at all possible to indicate these original immigrants with any certainty, I should like to see similar analyses be made of other islands, including those generally agreed to be continental. Is there a distinct decrease of 'original immigrants' moving away from continents or centres of development?

Another direction is that of an analysis of 'dispersal spectra'. Stapf's (1894) analysis of the Kinabalu flora is a classical example. Ridley (1930) devoted a chapter to island floras with special reference to dispersal methods, and more recently Carlquist (1966, 1967) made similar studies on the floras of some Pacific islands. Care should, however, be taken with regard to effectiveness of dispersal mechanisms on morphological grounds which relate only to mechanical transport possibilities. Van der Pijl (1968) had some critical words to say on the subject.

Moreover, an analysis of dispersal spectra only of the islands is a one-sided approach. I would suggest to attack the problem from the other end, by analysing the dispersal spectrum of, say, the New Guinea lowland rain forest flora and compare this with a similar analysis of that of the Solomons, Fiji, Samoa, etc. In this way we could find out the relative importance of dispersal agents. It could be imagined that the percentage of wind and water dispersed species increases with distance.

It has been argued, amongst others by Lam (1938), that a thorough analysis of a single group may throw more light on historical geographical matters than that of the whole flora. Florin's (1963) paper of the Conifers and Taxads and Corner's (1963) on *Ficus* are good examples of studies on a single taxonomic group. One may also study a group of plants bound to a limited set of ecological requirements. The study by van Steenis (1934) on the Malesian mountain flora is a classical example.

One should, however, correlate the evidence obtained by studying various groups and by different methods of investigation. It is interesting in this connection that the conclusions of botanists and zoologists are often contradictory. The inclusion of New Guinea in the Australian faunistic region is a well known example. This is based on the distribution of mammals and birds, but botanists advocate the inclusion of New Guinea in the Indomalesian region, which finds support from the side of entomologists and malacologists.

Zoologists consider New Caledonia a rather uninteresting island. The fauna is called rather rich, with many endemics, but disharmonic (Gressitt, 1961), and apparently there is nothing comparable to the tremendous wealth of forms in Phanerogams. Zoologists are satisfied that the Hawaiian Insect fauna has been built up from some 250 immigrants within a few million years (Zimmerman, 1948). The number of Phanerogam genera is certainly very low considering the size and ecological diversity of the islands. Also the numbers of genera on the Azores, Cocos I., Easter I., Galapagos, Marquesas, S. Helena, and Socorro are consistent with permanent isolation on numerical grounds, but it is impossible to say to what degree they have been isolated. All we can say is that apparently access to these islands has always been difficult.

In fig. 4 the number of genera per family for each region has been plotted against area. Comparison with fig. 2 shows the strong resemblance. It appears that in general both

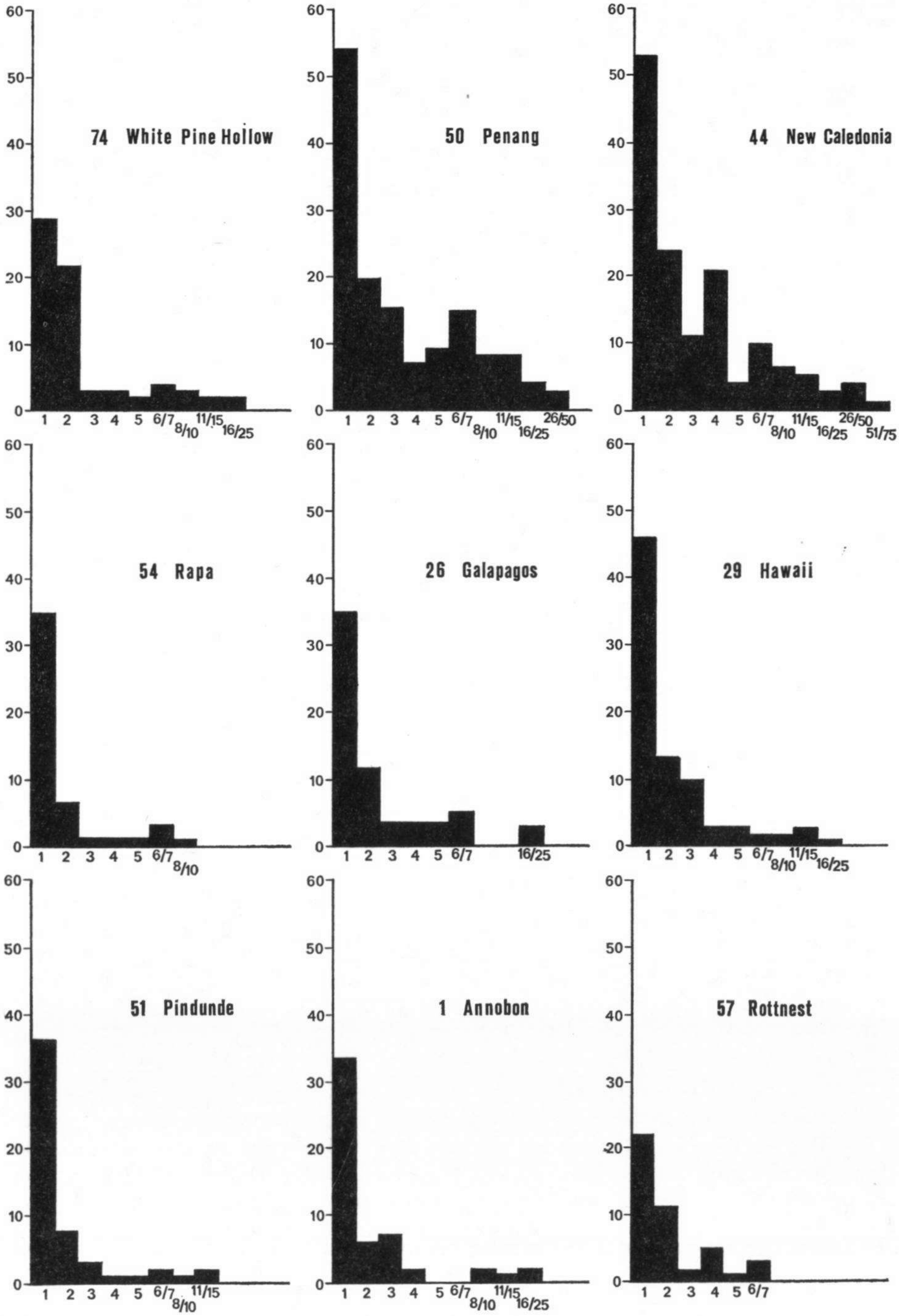

Fig. 5 family size of some areas, height of the columns indicate the number of families in each of the size classes the total number of genera and the number of genera per family increases with size and decreases with isolation.

Fig. 5 shows for a few regions the number of genera plotted against the number of families. The first column represents the number of families with one genus, the second that with two genera, the larger families were taken together e.g. in column 7 families with 8—10 genera, in column 9 those with 16—25 genera, etc. In this way 'hollow curves' in the sense of Willis (1922) are obtained. It appears that the curves are more hollow in isolated islands (Hawaii, Galapagos) than in continental regions (White Pine Hollow, Penang). In other words continental regions have more families with more than one genus, whereas in isolated islands most families are represented by one genus only. In this respect New Caledonia again shows a 'continental' type of family/genera ratio. An alpine valley on a tropical mountain (Pindunde), which in fact can be regarded as an island, and an island like Annobon that is not quite so isolated as Rapa I. or the Galapagos, have a family/genus ratio of an 'insular' type. The preponderance of families with one genus is correlated with insularity. This appears from the situation e.g. in Rottnest I., as an example of a continental island with a poor flora.

CONCLUSIONS

The correlation between isolation and diversity as expressed in the number of genera is obscured by a multitude of factors, one of the most important of which is size.

When ruling out as much as possible the influence of other factors by comparing only islands that are more or less similar, the figures presented in this survey show clearly the striking difference in the number of genera in continental areas and islands and those of isolated islands, the latter being much poorer. This appears by comparing for instance the floras of isolated Easter I., S. Helena, Marquesas, and Hawaii with those of sub-continental Botel Tobago, Penang, Fernando Po, and Jamaica.

In cases of divergence from this general rule it is possible to suggest the causes responsible. Some islands now widely isolated, by the diversity of their floras, suggest continental connections or at least better accessibility in the past. Such islands are for instance New Caledonia, Lord Howe, Fiji, West Carolines, Tonga and, rather unexpectedly, Rapa.

Other islands which by some have on various grounds been claimed as continental, however, have a flora suggesting permanent isolation. Such islands are for instance S. Helena, Christmas I., Galapagos, Socorro. New Zealand and Falklands are considered as special cases of islands with a poor present-day flora. Due to their high latitude it is believed that climatic and geological changes, especially in New Zealand, have had a more detrimental effect on the flora than on most of the other islands that are mostly situated in the tropics.

Poverty is often considered almost as good as proof for permanent isolation. From the foregoing it is clear that numerical data as presented here should only be regarded as supplementary evidence, and should never be used for jumping at conclusions concerning the genesis of an island's flora.

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