

BIOLOGY-GEOLOGY

# "Wallace's Line"

## "A Classic of Science"

### Former Extent of the Pacific and Asiatic Continents Is Indicated by Distribution of Malasian Animal Life

#### PART TWO

ON THE ZOOLOGICAL GEOGRAPHY OF THE MALAY ARCHIPELAGO. By Alfred R. Wallace. Communicated by Charles Darwin. Read Nov. 3rd, 1859. Published in the *Journal of the Proceedings of the Linnean Society (Zoology)*, Vol. IV. London: Longman, Green, Longmans and Roberts, and Williams and Norgate. 1860. This is an exact reprint of the original publication.

THE GREAT Pacific continent, of which Australia and New Guinea are no doubt fragments, probably existed at a much earlier period, and extended as far westward as the Moluccas. The extension of Asia as far to the south and east as the Straits of Macassar and Lombok must have occurred subsequent to the submergence of both these great southern continents; and the breaking up and separation of the islands of Sumatra, Java, and Borneo has been the last great geological change these regions have undergone. That this has really taken place as here indicated, we think is proved by the following considerations. Not more than twenty (probably a smaller number) out of about one hundred land birds of Celebes at present known are found in Java or Borneo, and only one or two of twelve or fifteen Mammalia. Of the Mammalia and birds of Borneo, however, at least three-fourths, probably five-sixths, inhabit also Java, Sumatra, or the peninsula of Malacca. Now, looking at the direction of the Macassar Straits running nearly north and south, and remembering we are in the district of the monsoons, a steady south-east and north-west wind blowing alternately for about six months each, we shall at once see that Celebes is more favourably situated than any other island to receive stray passengers from Borneo, whether drifted across the sea or wafted

through the air. The distance too is less than between any of the other large islands; there are no violent currents to neutralize the action of the winds; and numerous islets in mid-channel offer stations which might rescue many of the wanderers, and admit, after repose, of fresh migrations. Between Java and Borneo the width of sea is much greater, the intermediate islands are fewer, and the direction of the monsoons along and not across the Java sea, accompanied by alternating currents in the same direction, must render accidental communication between the two islands exceedingly difficult; so that where the facilities for intercommunication are greatest, the number of species common to the two countries is least, and *vice versa*. But again, the mass of the species of Borneo, Java, &c., even when not *identical* are *congeneric*, which, as before explained, indicates *identity* at an earlier epoch; whereas the great mass of the fauna of Celebes is widely different from that of the western islands, consisting mostly of genera, and even of entire families, altogether foreign to them. This clearly points to a former total diversity of forms and species,—existing similarities being the result of intermixture, the extreme facilities for which we have pointed out. In the case of the great western islands a former more complete identity is indicated, the present differences having arisen from their isolation during a considerable period, allowing time for that partial extinction and introduction of species which is the regular course of nature. If the very small number of western species in Celebes is all that the most favourable conditions for transmission could bring about, the complete similarity of the faunas of the western islands could never (with far less favourable conditions) have been produced by the same means. And what other means can we conceive but the former connexion of those islands with

each other and with the continent of Asia?

In striking confirmation of this view we have physical evidence of a very interesting nature. These countries are in fact *still connected*, and that so completely that an elevation of only 300 feet would nearly double the extent of tropical Asia. Over the whole of the Java Sea, the Straits of Malacca, the Gulf of Siam, and the southern part of the China Sea, ships can anchor in less than fifty fathoms. A vast submarine plain unites together the apparently disjointed parts of the Indian zoological region, and abruptly terminates, exactly at its limits, in an unfathomable ocean. The deep sea of the Moluccas comes up to the very coasts of Northern Borneo, to the Strait of Lombok in the south, and to near the middle of the Strait of Macassar. May we not therefore from these facts very fairly conclude that, according to the system of alternate bands of elevation and depression that seems very generally to prevail, the last great rising movement of the volcanic range of Java and Sumatra was accompanied by the depression that now separates them from Borneo and from the continent?

It is worthy of remark that the various islands of the Moluccas, though generally divided by a less extent of sea, have fewer species in common; but the separating seas are in almost every case of immense depth, indicating that the separation took place at a much earlier period. The same principle is well illustrated by the distribution of the genus *Paradisea*, two species of which (the common Birds of Paradise) are found only in New Guinea and the islands of Aru, Mysol, Waigou, and Jobie, all of which are connected with New Guinea by banks of soundings, while they do not extend to Ceram or the Ké Islands, which are no further from New Guinea, but are separated from it by deep sea. Again, the chain of small volcanic islands to the west of Gilolo, though divided by channels of only ten or fifteen miles wide, possess many distinct representative species of insects, and even, in some cases, of birds also. The Baboons of Batchian have not

passed to Gilolo, a much larger island, only separated from it by a channel ten miles wide, and in one part almost blocked up with small islands.

Now looking at these phenomena of distribution, and especially at those presented by the fauna of Celebes, it appears to me that a much exaggerated effect, in producing the present distribution of animals, has been imputed to the accidental transmission of individuals across intervening seas; for we have here as it were a test or standard by which we may measure the possible effect due to these causes, and we find that, under conditions perhaps the most favourable that exist on the globe, the percentage of species derived from this source is extremely small. When my researches in the Archipelago are completed, I hope to be able to determine with some accuracy this numerical proportion in several cases; but in the mean time we will consider 20 per cent. as the probable maximum for birds and mammals which in Celebes have been derived from Borneo or Java.

Let us now apply this standard to the case of Great Britain and the Continent, in which the width of dividing sea and the extent of opposing coasts are nearly the same, but in which the species are almost all identical,—or to Ireland, more than 90 per cent. of whose species are British—and we shall at once see that no theory of transmission across the present Straits is admissible, and shall be compelled to resort to the idea of a very recent separation (long since admitted), to account for these zoological phenomena.

It is, however, to the oceanic islands that we consider the application of this test of the most importance. Let any one try to realize the comparative facilities for the transmission of organized beings across the Strait of Macassar from Borneo to Celebes, and from South Europe or North Africa to the island of Madeira, at least four times the distance, and a mere point in the ocean, and he would probably consider that in a given period a hundred cases of transmission would be more likely to occur in the former case than one in the latter. Yet of the comparatively rich insect-fauna of Madeira, 40 per cent. are continental species; and of the flowering plants more than 60 per cent. The Canary Islands offer nearly similar results. Nothing but a former connexion with the Continent will explain such an amount of specific identity (the weight of which will be very much increased if

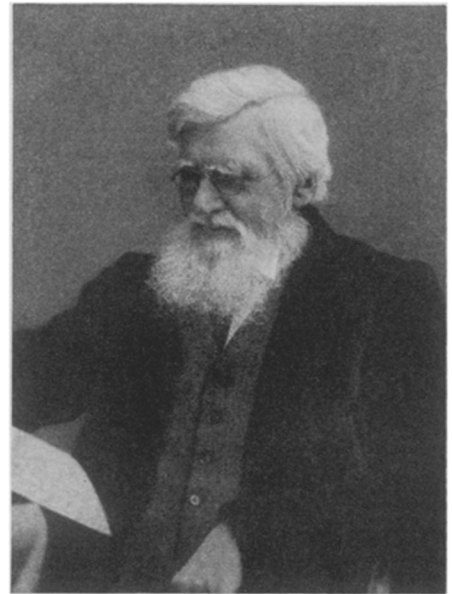
we take into account the representative species); and the direction of the Atlas range towards Teneriffe, and of the Sierra Nevada towards Madeira, are material indications of such a connexion.

The Galapagos are no further from South America than Madeira is from Europe, and, being of greater extent, are far more liable to receive chance immigrants; yet they have hardly a species identical with any inhabiting the American continent. These islands therefore may well have originated in mid-ocean; or if they ever were connected with the mainland, it was at so distant a period that the natural extinction and renewal of species has left not one in common. The character of their fauna, however, is more what we should expect to arise from the chance introduction of a very few species at distant intervals; it is very poor; it contains but few genera, and those scattered among unconnected families; its genera often contain several closely allied species, indicating a single antitype.

The fauna and flora of Madeira and of the Canaries, on the other hand, have none of this chance character. They are comparatively rich in genera and species; most of the principal groups and families are more or less represented; and, in fact, these islands do not differ materially, as to the general character of their animal and vegetable productions, from any isolated mountain in Europe or North Africa of about equal extent.

On exactly the same principles, the very large number of species of plants, insects, and birds, in Europe and North America, either absolutely identical or represented by very closely allied species, most assuredly indicates that some means of land communication in temperate or sub-arctic latitudes existed at no very distant geological epoch; and though many naturalists are inclined to regard all such views as vague and unprofitable speculations, we are convinced that they will soon take their place among the legitimate deductions of science.

Geology can detect but a portion of the changes the surface of the earth has undergone. It can reveal the past history and mutations of what is now dry land; but the ocean tells nothing of her bygone history. Zoology and Botany here come to the aid of their sister science, and by means of the humble weeds and despised insects inhabiting its now distant shores, can discover some of those past changes which the ocean itself refuses to reveal. They can indicate, approximately at least, where and



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1823-1913

*contemporary, professional rival and personal friend of Charles Darwin, whose specialty was the results of environment on island life.*

at what period former continents must have existed, from what countries islands must have been separated, and at how distant an epoch the rupture took place. By the invaluable indications which Mr. Darwin has deduced from the structure of coral reefs, by the surveys of the ocean-bed now in progress, and by a more extensive and detailed knowledge of the geographical distribution of animals and plants, the naturalist may soon hope to obtain some idea of the continents which have now disappeared beneath the ocean, and of the general distribution of land and sea at former geological epochs.

Most writers on geographical distribution have completely overlooked its connexion with well-established geological facts, and have thereby created difficulties where none exist. The peculiar and apparently endemic faunae and florae of the oceanic islands (such as the Galapagos and St. Helena) have been dwelt upon as something anomalous and inexplicable. It has been imagined that the more simple condition of such islands would be to have their productions identical with those of the nearest land, and that their actual condition is an incomprehensible mystery. The very reverse of this is however the case. We really require no speculative hypothesis, no new theory, to explain these phenomena; they are the logical results of well-known laws of nature. The reg-

ular and unceasing extinction of species, and their replacement by allied forms, is now no hypothesis, but an established fact; and it necessarily produces such peculiar faunae and florae in all but recently formed or newly disrupted islands, subject of course to more or less modification according to the facilities for the transmission of fresh species from adjacent continents. Such phenomena therefore are far from uncommon. Madagascar, Mauritius, the Moluccas, New Zealand, New Caledonia, the Pacific Islands, Juan Fernandez, the West India Islands, and many others, all present such peculiarities in greater or less development. It is the instances of identity of species in distant countries that presents the real difficulty. What was supposed to be the more normal state of things is really exceptional and requires some hypothesis for its explanation. The phenomena of distribution in the Malay Archipelago, to which I have here called attention, teach us that, however narrow may be the strait separating an island from its continent, it is still an impassable barrier against the passage of any considerable number and variety of land animals; and that in all cases in which such islands possess a tolerably rich and varied fauna of species mostly identical, or closely allied with those of the adjacent country, we are forced to the conclusion that a geologically recent disruption has taken place. Great Britain, Ireland, Sicily, Sumatra, Java and Borneo, the Aru Islands, the Canaries and Madeira are cases to which the reasoning is fully applicable.

In his introductory Essay on the Flora of New Zealand Dr. Hooker has most convincingly applied this principle to showing the former connexion of New Zealand and other southern islands with the southern extremity of America; and I will take this opportunity of calling the attention of zoologists to the very satisfactory manner in which this view clears away many difficulties in the distribution of animals. The most obvious of these is the occurrence of Marsupials in America only, beyond the Australian region. They evidently entered by the same route as the plants of New Zealand and Tasmania which occur in South temperate America, but having greater powers of dispersion, a greater plasticity of organization, have extended themselves over the whole continent though with so few modifications of form and structure as to point to a unity of origin at a comparatively recent pe-

riod. It is among insects, however, that the resemblances approach in number and degree to those exhibited by plants. Among Butterflies the beautiful *Heliconidae* are strictly confined to South America, with the exception of a single genus (*Hamadryas*) found in the Australian region from New Zealand to New Guinea. In Coleoptera many families and genera are characteristic of the two countries; such are *Pseudomorphidae* among the Geodephaga, *Lamprimidae* and *Syndesidae* among the Lucani, *Anoplognathidae* among the Lamellicornes, *Stigmoderidae* among the Buprestes, *Natalis* among the Cleridae, besides a great number of representative genera. This peculiar distribution has hitherto only excited astonishment, and has confounded all ideas of unity in the distribution of organic beings; but we now see that they are in exact accordance with the phenomena presented by the flora of the same regions, as developed in the greatest detail by the researches of Dr. Hooker.

It is somewhat singular, however, that not one *identical species* of insect should yet have been discovered, while no less than 89 species of flowering plants are found both in New Zealand and South America. The relations of the animals and of the plants of these countries must necessarily depend on the same physical changes which the Southern hemisphere has undergone; and we are therefore led to conclude that insects are much less persistent in their specific forms than flowering plants, while among Mammalia and land birds (in which no genus even is common to the countries in question) species must die and be replaced much more rapidly than in either. And this is exactly in accordance with the fact (well established by geology) that at a time when the shells of the European seas were almost all identical with species now living, the

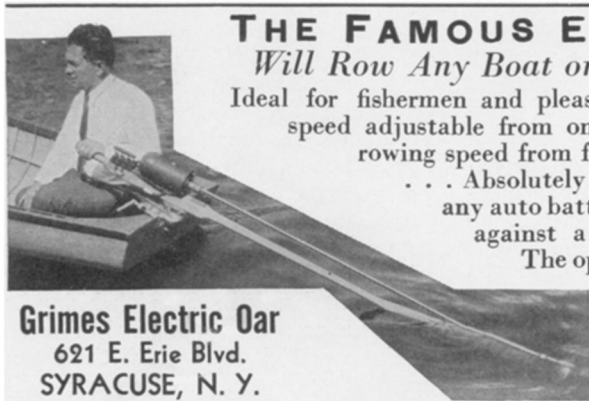
European Mammalia were almost all different. The duration of life of species would seem to be in an inverse proportion to their complexity of organization and vital activity.

In the brief sketch I have now given of this interesting subject, such obvious and striking facts alone have been adduced as a traveller's note-book can supply. The argument must therefore lose much of its weight from the absence of detail and accumulated examples. There is, however, such a very general accordance in the phenomena of distribution as separately deduced from the various classes or kingdoms of the organic world, that whenever one class of animals or plants exhibits in a clearly marked manner certain relations between two countries, the other classes will certainly show similar ones, though it may be in a greater or a less degree. Birds and insects will teach us the same truths; and even animals and plants, though existing under such different conditions, and multiplied and dispersed by such a generally distinct process, will never give conflicting testimony, however much they may differ as regards the amount of relationship between distant regions indicated by them, and consequently notwithstanding the greater or less weight either may have in the determining of questions of this nature.

This is my apology for offering to the Linnean Society the present imperfect outline in anticipation of the more detailed proofs and illustrations which I hope to bring forward on a future occasion.

*Science News Letter, July 22, 1933*

Hungarian women in Baranya county used to wear hoods of some eight different colors, representing their ages, and it was considered disgraceful for a woman to wear a color not correct for her age group.



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