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On some Anomalies in Zoological and Botanical Geography.

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THE subject of Geographical Distribution is now generally allowed to be one of the most interesting branches of Natural History, and owing to the accumulation of much trustworthy material within the last few years, we are at length enabled to generalise many of the most important facts, and to form a tolerably accurate idea of the import and bearing of the whole inquiry.

In the admirable chapters on this topic in the "Origin of Species," Mr Darwin has given us a theory as simple as it is comprehensive, and has besides gone into many of the details so fully as to render it needless to say another word here on those parts of the question which he has treated. As an explanation of the main facts, and of many of the special difficulties, of geographical distribution, those chapters are in every respect satisfactory; and I therefore propose now to consider only the anomalies and discrepancies which so frequently occur between the distribution of one class or order and another, and to discuss the possibility of arriving at a division of the earth into Regions, which shall represent accurately the main facts of distribution in every department of nature.

In doing this I shall consider in detail a few cases of special difficulty only, and endeavour to establish certain

principles, which, if accepted, will enable us to deal with such cases for the future, and avoid the confusion into which the whole question must necessarily fall, if (as has hitherto been the case) every naturalist proposes a distinct set of geographical regions for the group to which he pays most attention.

The entire subject naturally comes under the two heads of *terrestrial* and *marine* distribution, which may be treated of independently, but upon similar principles. I now confine myself entirely to the terrestrial division. The chief fault of the Zoological and Botanical regions that have been hitherto proposed is, that they have generally been too numerous, and have been more or less artificially bounded by lines of latitude and longitude. Those established by Meyen for plants, and by Woodward for shells, have this fault, and were, besides, never intended to apply to the whole organic world. Swainson's division (Geog. and Class. of Animals in *Lardner's Cab. Cyc.*), was much more natural, and was, I believe, the first that took into consideration all classes of animals, and can lay any claim to rank as a general system. But by carrying out even here his favourite quinary theory, and by following too closely the supposed typical races of man, he was led into many important errors,—such as including the northern and southern continents of America in one region, and placing Northern Asia with India rather than with Europe.

In June 1857, a paper was read before the Linnean Society by Dr Sclater, entitled, "On the general Geographical Distribution of the Members of the Class Aves," which marks an era in this branch of natural history. The subject was now for the first time treated in a philosophical manner by a naturalist well acquainted with the whole class with which he proposed to deal, and who, by looking chiefly to groups, —to genera and families rather than to species—and by taking account of broad contrasts rather than local peculiarities, has succeeded in marking out upon the globe those divisions, which not only represent accurately the great facts presented by the distribution of birds, but seem also well adapted to become the foundation for a general system of Ontological regions.

The following six Regions are those established by Dr Sclater:—

1*st*, The Neotropical, comprising South America, Mexico, and the West Indies; 2*d*, The Nearctic, including the rest of America; 3*d*, The Palæarctic, composed of Europe, Northern Asia to Japan, and Africa north of the Desert; 4*th*, The Ethiopian, which contains the rest of Africa and Madagascar; 5*th*, The Indian, containing Southern Asia and the western half of the Malay Archipelago; and 6*th*, The Australian, which comprises the eastern half of the Malay Islands, Australia, and most of the Pacific Islands. Each of these regions is characterised by a number of peculiar genera, and even families of birds, which, while found everywhere within the region, do not pass over its boundaries; and by other genera which, though found sparingly in several regions, have their metropolis in one. This scheme of Ornithological distribution has been founded on such an extensive basis of facts, and after having been five years before the world has met with such general acceptance, that it may fairly be taken as established, subject only to modifications of the dividing lines between those regions which gradually merge into each other.

It remains to be shown whether this is not only a true Ornithological, but also a true Zoological and Botanical division of the earth; and if not, to show how it is that what is true for one part of nature should not be equally true for all.

In a paper on the "Geographical Distribution of Reptiles" (*Proc. Zool. Soc.* 1858, p. 373), Dr Gunther has shown that for snakes and batrachians the same divisions will almost exactly apply; the only important discrepancy being that Japan, judging from its snakes, would belong to the Indian region, while its batrachians are decidedly related to those of the Palæarctic region.

In Mammalia the same geographical divisions are very strongly marked, but here again one important discrepancy has been pointed out, namely, that the quadrupeds of North Africa are of Ethiopian, while the birds and reptiles are of European forms. (*Ibis*, vol. i. pp. 93, 157.

In the immense class of Insects, very little has been done

to work out the details of Geographical distribution. There is no doubt but that the six regions marked out by Dr Sclater are generally characterised by distinct forms of insects. There is one case, however, which has come under my own observation, in which the entomological would not correspond with the ornithological regions. The Moluccas and New Guinea in their birds and mammals are most decidedly Australian, while the insects show a general correspondence with the Indian type. It has also been pointed out that the insects of Chili and of south temperate South America have little affinity with Neotropical forms.

Land shells, I am informed by the Rev. H. B. Tristram, generally agree very well with the ornithological regions. The subdivisions or provinces are, however, often very strongly marked.

In Plants, I am informed by Dr Hooker, the regions will in many cases not at all correspond.

In order to arrive at the cause and meaning of these singular differences in the Geographical distribution of the various classes, we must inquire how Zoological and Botanical regions are formed, or why organic existences come to be grouped geographically at all.

It appears to me that this can be explained by a few simple principles—

1*st*, The tendency of all species to diffuse themselves over a wide area, some one or more in each group being actually found to have so spread, and to have become, as Mr Darwin terms them, dominant species.

2*d*, The existence of barriers checking, or absolutely forbidding that diffusion.

3*d*, The progressive change or replacement of species, by allied forms, which has been continually going on in the organic world.

4*th*, A corresponding change in the surface, which has led to the destruction of old and the formation of new barriers.

5*th*, Changes of climate and physical conditions, which will often favour the diffusion and increase of one group, and lead to the extinction or decrease of another.

By means of these principles we will endeavour to ex-

plain the discrepancies already mentioned. And, first, how is it that the snakes in Japan are Indian and the batrachians Palæarctic? Dr Gunther informs us, in the paper already alluded to, that snakes are a pre-eminently tropical group, decreasing rapidly in the temperate regions, and absolutely ceasing at 62° N. Lat. Bactrachians, on the other hand, are almost as fully developed in northern as in tropical regions. They can support intense cold, and are, moreover, more diffusible, geographically, than snakes. These facts furnish a clue to the peculiarities of the Japanese reptile fauna. For let us suppose that Japan once formed a part of northern Asia (with which it is even now almost connected by two chains of islands), it would then have received its birds, mammals, and batrachians from the Palæarctic region; but there could have been few or no snakes, owing to the much lower curve of the isothermal lines in Eastern Asia than Western Europe, giving to Mandtchouria a climate as rigorous as that of Sweden. Now, at a subsequent period, Japan must have been connected with Southern Asia through the line of the Loo-choo and Madjicosima islands, and would then acquire its population of Indian forms of snakes, which would easily establish themselves in an unoccupied region,—whereas the batrachians, as well as the birds and mammals of Southern Asia, would find a firmly established Palæarctic population ready to resist the invasion of intruders, and it is therefore not to be wondered at that but few, if any, Indian forms of these groups should have been able to maintain themselves. Again, the insects of Japan are decidedly Palæarctic in character, except in the case of a few tropical forms of diurnal lepidoptera, which would have been able to establish themselves, like the snakes, on account of the extreme poverty of that group in high latitudes. It would thus appear that the tropical character of the snakes is quite exceptional, depending upon the fact of the whole group being pre-eminently tropical, and can therefore not be held to throw any doubt on the position of Japan in the Palæarctic zoological region.

We have next to consider the supposed discrepancy in the mammals of Algeria compared with the birds, reptiles, insects, and plants—all of which are decidedly of Palæarctic

forms. It will, I think, be found that the facts have here been somewhat hastily assumed, and that the mammalia do not differ very much in this respect from other classes, and in no degree invalidate the position that North Africa belongs to the Palæarctic region. Leaving out domesticated animals, I have drawn up a list of the genera of Algerian mammals (from Captain Loche's Catalogue), and have divided the species, so as to show how far they correspond with those of the Palæarctic or other regions.

From an examination of this table, it will be seen that thirty-three of the Algerian mammals are absolutely identical with European or West Asian species, fourteen more are representative species of European genera, and ten belong to West Asian and Siberian (and therefore Palæarctic) genera, giving a total of fifty-seven species and about twenty-eight genera, as the measure of Palæarctic affinity. Now, to balance this, what have we to indicate an Ethiopian fauna? The most important, and what have probably been most relied on as giving an extra-European character to the country, are the four large felines,—the lion, the leopard, the serval, and the hunting-leopard,—but as these all range the whole of Africa, from the Cape to the Mediterranean, and may very probably have crossed the desert in the tracts of caravans, they cannot be held to have much weight on the present question. Then there is the solitary monkey; but as that actually inhabits Europe, we need hardly have included it among the representatives of Ethiopian groups, except to give all the facts that can be fairly claimed on that side. The antelope is a desert-haunting species, and therefore may be looked upon as a straggler on the northern side of the Sahara; and, besides these, we have representatives of two really African genera (Macroscelides and Zorilla), giving a total of only eight species as the measure of Ethiopian affinity. The remaining species, seven in number, are true desert-haunters, roaming over North Africa, Egypt, and Arabia, into the Indian deserts, and have scarcely any more right to be considered as belonging to one region than another, since they inhabit the district which forms the boundary and debateable land of the Ethiopian, Indian, and Palæarctic regions.

	Genera of Algerian Mammals.	Palæarctic Species.	Species of Palæarctic Genera.	Ethiopian Species and Genera.	Asiatic or Desert Species and Genera.
	Macacus innuus . . .	1	..	1	...
Carnivora.	Ursus	1	...	...	...
	Canis	1	3	...	...
	Fenecus	...	...	...	1
	Hyena	...	1	...	...
	Meles	1	...	...	...
	Mangusta	...	...	...	1
	Genetta	1	1	...	...
	Felis	1	...	4	1
	Putorius	3	...	...	...
	Zorilla	...	...	1	...
	Lutra	1	...	...	...
	Sus	1	...	...	...
Ruminantia.	Cervus	1	...	...	...
	Dama	1	...	...	...
	Antelope	...	...	1	...
	Gazella	...	...	...	2
	Musimon	...	1	...	...
	Vespertilionidæ . . .	8	...	...	...
Insectivora.	Sorex	2	...	...	...
	Pachyura	...	1	...	...
	Crocidura	1	...	...	...
	Crossopus	1	...	...	...
	Macroscelides . . .	...	...	1	...
	Erinaceus	...	1	...	...
Rodentia.	Hystrix	1	...	...	...
	Myoxus	...	1	...	...
	Dipus	1	2	...	...
	Alactaga (Siberian Genus) .	...	1	...	...
	Lepus	1	1	...	...
	Gerbillus (N. and W. Asian Genus)	...	7	...	...
	Ctenodactylus (Asiatic Group)	...	...	...	1
	Sciurus	...	1	...	...
	Mus	5	3	...	...
		33	24	8	6

It would seem, therefore, that the supposed discrepancy of the Mammalia, in determining the southern limit of the Palæarctic province, is altogether imaginary. The number of species absolutely identical is not so great as in the birds; but Europe is not the whole Palæarctic province, and if we take *genera* instead of *species*, we shall find the correspondence as complete as possible,—twenty-eight genera being truly Palæarctic, only three Ethiopian, while five are Asiatic, or desert-dwellers. In this case, therefore, the whole of the vertebrata combine with the insects, the land shells, and the plants, to place North Africa in the Palæarctic region.

The case of the insects in the Australian portion of the Malay Archipelago is one of much greater difficulty. Australia itself contains a remarkable assemblage of insects, among which its Lamellicornes, Buprestidæ, and Curculionidæ offer a number of striking forms and genera quite peculiar to it. In New Guinea and the Moluccas, on the other hand, Lamellicornes are comparatively scarce, and with the Buprestidæ and Curculionidæ are of Indian rather than Australian genera; while the great family of the Anthribidæ, which is almost entirely absent in Australia, is here everywhere abundant in genera, species and individuals, though less so than in the Western or Indian region.

To account for this remarkable discrepancy, we must consider,—1*st*, That insects are much more immediately dependent on the character of the vegetation, and therefore on climate, than are vertebrated animals; and, 2*dly*, That water-barriers are much less effective in preventing their dispersion. A narrow strait is an effectual bar to the migration of mammals and of many reptiles and birds, while insects may be transported in the egg and larva state by floating timber, and from their small size and great powers of flight, may be easily carried by the winds from one island to another. Now, the characteristic insects of Australia seem specially adapted to a dry climate and a shrubby flower-bearing vegetation, and could hardly exist in the excessively moist atmosphere and amid the dense flowerless forests of the equatorial islands. If, therefore, we suppose Australia itself to be the most ancient portion of this

region (which its great richness in peculiar generic forms seems to indicate), we can easily understand how, when the islands of the Moluccas and New Guinea first rose above the waters and became clothed with dense forests nurtured by tropical heat and perpetual moisture, though the birds and mammals readily adapted themselves to the new conditions, the insects could not do so, but gave way before the immigrants from the islands to the west of them, which having been developed under similar climatal conditions, and thus become specially adapted to them, were enabled, by the enormous powers of multiplication and dispersion possessed by insects, at once to establish themselves in the newly-formed lands, and develop an insect population in many respects at variance with other classes of animals.

There are, however, several instances of groups of insects almost as strictly confined to one-half of the Archipelago as is so remarkably the case with the vertebrata; and when the extensive collections made by myself in most of the islands come to be accurately worked out, no doubt more such instances will be found. Among Coleoptera I may mention the *Tmesisterninæ*, a remarkable sub-family of Longicornes, as being strictly confined to the Australian region, over the whole of which it extends, and has its western limit in Celebes along with the Marsupials and the Trichoglossi. Again, Mr Baly, so well known for his acquaintance with the Phytophagous Coleoptera, finds that one of the principal sub-families of that tribe (Adoxinæ), which he has recently classified, though spread over Europe and the whole of Asia, is only found in the Archipelago in those islands which belong to the Indian region of zoology. This proves that there is an ancient insect-population in the Austro-Malayan Islands, which accords in its distribution with the other classes of animals, but which has been overwhelmed, and in some cases perhaps exterminated, by immigrants from the adjacent countries. The result is a mixture of races, in which the foreign element is in excess; but naturalists need not be bound by the same rule as politicians, and may be permitted to recognise the just claims of the more ancient inhabitants, and to raise up fallen nationalities. The aborigines, and not the invaders, must

be looked upon as the rightful owners of the soil, and should determine the position of their country in our system of Zoological geography.

My friend, Mr Bates, has kindly furnished me with some facts as to the entomology of Chili and south temperate America, which would show that the insects of this region have very little connection with those of tropical America.

Out of ten genera of butterflies found in Chili, not one is characteristic of tropical America. Four (Colias, Argynnis, Erebia, and Satyrus) are northern forms, only one of which occurs at all in tropical America, and that high up in the Andes ; three others are peculiar to Chili, but have decided north temperate or Arctic affinities ; and three more (Anthocharis, Lycæna, and Polyommatus) are cosmopolitan, but far more abundant in temperate than tropical regions. Judging, therefore, from butterflies only, we should decidedly have to place south temperate America in the Nearctic region, or form it into a region by itself.

Two important families of Coleoptera, the Geodephaga and the Lamellicornes, furnish different but equally remarkable results. There are 77 genera of these families found in Chili, of which 46 are peculiar to south temperate America, being $\frac{2}{3}$ths of the whole ; 17 are cosmopolitan, 2 are north temperate, 10 tropical American, and 1 is African.

But of the 46 peculiar genera, no less than 10 are closely allied to Australian forms, and 3 to South African,—so that the affinities of these groups of coleoptera are almost as strong to Australia as to tropical America ; next comes South Africa, and, lastly, the north temperate zone ; though as the two genera *Carabus* and *Geotrupes* are very extensive and important, and are totally absent from the tropics, but appear again in Chili, the real amount of affinity to northern regions may be taken as somewhat larger.

Here, then, as only 10 genera out of 77 are common to south temperate and tropical America, and as the remainder have wide-spread affinities—to the northern hemisphere, to Australia, and to South Africa—it would seem impossible, from a consideration of these families of Coleoptera alone, not to separate the south temperate zone of South America as a distinct primary region.

Other orders of insects and other families of Coleoptera may very probably give somewhat different results. From Boheman's work on the Cassididæ, I find that the genera of tropical America send representatives into Chili, and even into Patagonia, and that none of the south temperate forms have a direct affinity with those of Australia. But this family is almost exclusively tropical, very few and obscure species inhabiting the colder regions of the earth, while there are no generic forms peculiar to the Australian region.

In many of the preceding facts we have a most interesting correspondence with those furnished by the distribution of plants. Dr Hooker has shown the large amount of resemblance between the flora of southern South America and Australia, especially Tasmania and New Zealand,—one-eighth of the whole New Zealand flora being identical with South American species. Again, the occurrence of northern genera of coleoptera in Chili, and the whole of the butterflies having northern affinities, agrees with the number of northern genera and species of plants in Patagonia and Fuegia, and is an additional proof of the intensity and long continuance of the glacial epoch which sufficed to allow so many generic forms to pass the equator from north to south.

We have here another illustration how much easier of diffusion, and how much more dependent on local conditions are insects than the higher animals. A great part of the southern portion of America is of more recent date than the central tropical mass, and must have had at one time a closer communication than at present with the antarctic lands and Australia, the insects and plants of which, finding a congenial climate, established themselves in the new country, being only feebly opposed by the few northern forms which had already, or soon after, migrated there. And the fact that Tasmania and New Zealand are the poorest countries in the world in butterflies, will enable us to understand how it is that all those found in Chili are northern forms, while the coleoptera of the same countries (Tasmania and New Zealand) being tolerably abundant and varied, and having a shorter journey to perform than the north temperate immigrants, were enabled to get the upper hand in colonizing the new country.

The marsupial Opossums are the most remarkable case of vertebrata in America having Australian affinities. It is very doubtful whether these could have been introduced in the same manner as the plants and insects already alluded to, because the latter have to a considerable extent an antarctic character, and do not appear in such numbers as to indicate an actual continuity of land, which would have been almost indispensable for the passage of mammalia, and would at the same time have undoubtedly admitted Australian forms of land birds, which do not exist in South America. It seems more reasonable, therefore, to suppose that these marsupials have inhabited America since the Eocene period, when the same genus existed in Europe, and the marsupial order had probably a universal distribution.

With this one exception, the birds, the mammalia, and the reptiles* of south temperate America have little or no affinity either with north temperate or Australian forms, but are modifications of the true denizens of the Neotropical regions. They appear to have been enabled rapidly to seize hold of the country, and to adapt themselves to its modified climate and physical features—a remarkable instance of which is mentioned by Mr Darwin in the woodpecker of the Pampas, which never climbs a tree. The tropical insects, on the other hand, having become gradually specialized during long periods for a life amid continual verdure and unvarying summer, were totally unfitted for the new conditions presented to them, and only in a very few cases were able to struggle against forms already adapted to a more barren country and a more rigorous climate.

. This difference in the adaptive capacity of groups, combined with an unequal power of diffusion, will cause the various kinds of barriers to be sometimes more and sometimes less effective. For example, when a mountain range has attained only a moderate elevation, it will already completely bar the passage of many insects, while mammalia, birds, and reptiles, more capable of sustaining different conditions, will readily pass over it. On the otherhand, an arm of the sea, or even a wide river, will completely

* Except the batrachians, which show some affinities between Australia and South America, a case analogous to that of Japan.

isolate most mammals and many reptiles, while insects have still various means of passing it.

Another consideration which must help to determine the amount of specific peculiarity in a given region, is the average rate at which specific forms have changed. Palæontologists have determined that mammalia have changed much more rapidly than mollusca, from the phenomena of the comparatively recent extinction of so many species of mammals, whose remains are found along with existing species of shells. From the evidence of the distribution of existing species, birds would appear to have changed at least as quickly as mammals, and insects, in some cases, perhaps more so; owing, no doubt, to their very small diffusibility, and the readiness with which they are affected by local conditions.

Taking the various facts and arguments now brought forward into consideration, it appears evident that no regions (be they few or many in number) can be marked out, which will accurately represent the phenomena of the geographical distribution of all animals and plants. The distribution of the several Classes, Orders, and even Families, will differ, because they differ in their diffusibility, their variability, and their mode of acting and reacting on each other, and on the external world. At the same time, though the details of the distribution of the different groups may differ, there will always be more or less general agreement in this respect, because the great physical features of the earth—those which have longest maintained themselves unchanged—wide oceans, lofty mountains, extensive deserts—will have forbidden the intermingling or migration of all groups alike, during long periods of time. The great primary divisions of the earth for purposes of natural history should, therefore, correspond with the great permanent features of the earth's surface—those that have undergone least change in recent geological periods. Later and less important changes will have led to discrepancies in the actual distribution of the different groups; but these very discrepancies will enable us to interpret those changes, of which they are the direct effects, and very often the only evidence.

From this examination of the anomalies that occur in

the distribution of different groups, and of the probable causes of such anomalies, it appears that the six regions of Dr Sclater do approximately represent the best primary divisions of the earth for natural history purposes. They agree well with the present distribution of mammalia, birds, reptiles, land shells, and very generally of insects also. The cases in which they do not seem correct are those of isolated groups in restricted localities. The greatest discrepancies occur in groups which have at once great capacities for diffusion, and little adaptability to change of conditions; and, in the case of plants, have probably been much increased by what may be called the adventitious aid of the glacial period and of floating ice.

Of botanical distribution I have said little, from want of knowledge of that branch of the subject, and I can find no detailed information bearing directly upon the questions here discussed, but what I have already mentioned. It is much to be desired that some competent botanist would point out how far these regions agree with, and how far they contradict, the main facts of the distribution of plants. It seems evident that the various modes of glacial action have produced much more effect on the migrations of plants than on those of animals, and also that plants have, on the whole, more varied and more effectual means of dispersal. Still, if the views here advocated are true, the flora of each region should exhibit a characteristic substratum of indigenous forms, though often much modified, and sometimes nearly overwhelmed by successive streams of foreign invasion.

My object in calling attention to the subject by this very partial review of it, is to induce those naturalists, who are working at particular groups, to give more special attention to geographical distribution than has hitherto been done. By carefully working out the distribution of allied genera and closely connected groups of species, they could give the amount of agreement or discrepancy with other groups whose geography is best known, and furnish us with such information on the habits of the species, as might help to explain the anomalies which were found to occur. We should thus soon accumulate a sufficiency of detailed facts to enable us to determine whether these are the best pri-

mary divisions of the earth into terrestrial Zoological and Botanical regions, or whether such general divisions are altogether impracticable. Some such simple classification of regions is wanted to enable us readily to exhibit broad results, and to show at a glance the external relations of local faunas and floras. And if we go more into detail, and adopt a larger number of primary divisions, we shall not only lose many of these advantages, but shall probably find insuperable difficulties in harmonising the conflicting distribution of the different groups of organised beings.

On the Slaking of Quicklime. By JOHN DAVY, M.D., F.R.S., Lond. and Edin.*

IN some experiments which I have made on the slaking of quicklime, as its conversion into a hydrate is commonly called, I have noticed certain results new to me, and as I cannot find them noticed in any chemical work I have referred to, I propose to give a brief account of them on the possibility that they may be new to others.

It is well known that as soon as water is added to and absorbed by well-burnt lime fresh from the kiln, an immediate union takes place, the mass becoming broken up and falling into powder, with the production of much heat and steam.† But if the lime has been kept exposed to the air for two or three days, during which time it absorbs a small quantity of water,‡ without at all disintegrating, the same rapid union is not witnessed on the addition of water sufficient to form a hydrate; on the contrary, some minutes will elapse before the combination takes place, and I find there is a similar retardation of action from other causes as shown by the results of the following experiments:—

1. To a piece of lime taken from a mass, such as that

* Read at the Meeting of the British Association for the Advancement of Science held at Newcastle. (1863.)

† Gunpowder and sulphur have been ignited by it. See Annales de Chem. et de Phys. xxiii. p. 217. About six pounds were slaked.

‡ A little carbonic acid is absorbed at the same time, but this latter is not essential, inasmuch as the lime exhibits the same peculiarity if kept in damp air, excluding carbonic acid.