

ON THE ZOOGEOGRAPHY OF JAVA.

By

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In a paper read before the Third Netherlands-Indian Science Congress, held at Buitenzorg in 1924, the author expounded his views on the zoogeographical relations of the Java fauna to those of the surrounding countries.

These views were based upon lists of all vertebrates and the molluscs of Java, with their distribution, which lists, however, were not published with the paper that appeared in the Proceedings of the said congress (1925).

In the meantime I found a number of specialists willing to revise the various lists or to draw up entirely new ones, so I thought it desirable to publish these lists (see hereafter), which, I presume, will prove to be a great help to future workers. Although the data now at our disposal are far more complete and exact, the results arrived at in the following pages are not materially differing from those already put down in my previous paper, written in dutch.

The list of the mammals has been composed by the author himself.

Mr. BARTELS Jr., a student at the Bern university, made an entirely new list of the birds, based mainly upon the fine and almost complete collection of Java birds made by his father, Mr. M. BARTELS Sr. He could secure the valuable aid of Mr. STRESEMANN of the Berlin Museum and the result of their coöperation is published separately in the next paper of this volume. The distribution of the Java birds, as entered in the list appended to the present paper, has been compiled by the author with the assistance of Mr. SIEBERS, ornithologist of our Museum.

The lists of reptiles, batrachians and fresh-water fishes have been composed at the hand of the excellent monographs by DE ROOY, VAN KAMPEN, and WEBER and DE BEAUFORT. Mr. BRONGERSMA of the Amsterdam Zoological Laboratory has carefully revised the list of reptiles and I am grateful for the accuracy with which he has accomplished his task.

Prof. DE BEAUFORT himself has been kind enough to go over the list of fishes. This list of the fresh-water fishes is not entirely complete, the families of the *Mastacembelidae* and *Gobiidae* having been omitted. According to Prof. DE BEAUFORT there is still a great deal of confusion about the taxonomy of the members of these families. Moreover, the non-marine Gobiids

are all recent intruders from the sea and therefore of less value for the determination of zoogeographical relations.

Finally we are indebted to Miss VAN BENTHEM JUTTING of the Amsterdam Museum for a new list of the Java Molluscs, which has been composed with great accuracy. Not only have all species, described from Java since LESCHKE's list of the molluscs of Java and Celebes in 1914, been incorporated but a great many of the species represented in the Amsterdam and Leyden Museum, not yet been recorded from Java, have been inserted.

Before passing on to a discussion of the zoogeographical relations of the fauna of Java, we may first review in systematic order the different groups which served as a basis for our speculations.

JAVA MAMMALS.

The mammalian fauna of Java is far less rich than that of Sumatra or Borneo but still the island possesses 134 species of mammals, to which we may add 9 marine species — one belonging to the Sirenia and eight Cetaceans. Of the total number of land mammals nearly one half belongs to the bats, which amount to a total of 59 species; this rather large number is explained by the fact that these winged creatures are able to spread from island to island whereas the dividing waters are an effective barrier for most terrestrial species.

Recently a great number of subspecies have been described from the island Java as there is nowadays a strong tendency to split the old species and to name every form, how slightly different it may be from its near relatives. No wonder that nearly all these subspecies are confined to Java; for our discussion of the zoogeographical relations of the island they are of minor importance, we will therefore refer in the following lines mainly to the true species.

The greater bulk of the species has been described from West Java half the number only being recorded from Mid or East Java. Some of these West Java forms will doubtlessly become recorded from more eastern localities in course of time but yet there are a number of mammals which, apparently, are restricted to the western part of Java. We may mention here the silvery gibbon, the *Pithecus aygula*, the one-horned rhinoceros, the Javanese hare, and possibly *Pithecheirus melanurus* and *Hylomys suillus*.

Out of the total number of species 18 are supposed to be peculiar to Java (see enumeration on page 4), or a percentage of 13. Some of these may possibly be united with other species occurring in the surrounding islands when they have been subjected to a more minute study; this applies specially to the species of musk-shrews (*Crocidura*) and bats. None of the genera is confined to the island.

GEOGRAPHICAL RELATIONSHIP OF THE JAVA VERTEBRATES AND MOLLUSCS.

	Java total	Java endemic	Asia not Sumatra	Sumatra not Borneo	Sumatra and Borneo	Borneo not Sumatra	Celebes	Lesser Sunda Islands	West Java	Mid Java	East Java
Mammalia	134	18	19	20	67	11	18	35	116	68	66
subspecies	81	64	0	8	6	1	3	8	64	45	52
Chiroptera	59	8	10	11	24	6	9	21	53	24	22
subspecies	20	14	0	3	1	0	0	3	18	14	14
Resident birds	337	14	24	57	224	12	95	184	322	283	243
subspecies	310	100	2	45	87	7	40	129	270	245	204
Reptilia	150	16	9	20	91	9	53	38	103	57	64
Lacertilia	46	5	5	8	20	7	19	17	30	14	20
Chelonia	9	0	1	0	8	0	1	0	6	1	2
Ophidia	95	11	3	12	63	2	33	21	67	42	42
Amphibia	39	10	3	4	21	1	8	6	31	18	19
Fresh-water fishes	92	8	4	20	59	4	2	6	75	49	31
Mollusca	442	245	8	84	48	14	84	79	271	56	121
terrestrial	251	177	7	21	12	7	21	21	163	31	61
fresh-water	136	57	1	47	18	5	31	31	78	16	40
brackish-water.	55	11	0	16	18	2	32	27	30	9	20

GEOGRAPHICAL RELATIONSHIP OF JAVA MAMMALS.

JAVA (endemic)

<i>Sus verrucosus</i>	<i>Crocidura bartelsi</i>
<i>Mustela lutreolina</i>	<i>Rousettus shortridgei</i>
<i>Petaurista elegans</i>	<i>Cynopterus melanocephalus</i>
<i>Sciurus diardi</i>	<i>Rhinolophus geminus</i>
<i>Rattus lepturus</i>	<i>Murina balstoni</i>
<i>Rattus bartelsi</i>	<i>Kerivoula javana</i>
<i>Crocidura orientalis</i>	<i>Kerivoula bartelsi</i>
<i>Crocidura brevicauda</i>	<i>Miniopterus medius</i>
<i>Crocidura melanorhyncha</i>	<i>Miniopterus tibialis</i>

ASIA (not Sumatra)

<i>Bos banteng</i>	<i>Hipposideros larvatus</i>
<i>Felis pardus</i>	<i>Hipposideros speoris</i> (?)
<i>Felis viverrina</i>	<i>Coelops frithi</i>
<i>Viverricula malaccensis</i>	<i>Megaderma lyra</i> (?)
<i>Herpestes javanicus</i>	<i>Nycteris javanica</i>
<i>Helictis orientalis</i>	<i>Tylonycteris pachypus</i>
<i>Sciuropterus sagitta</i>	<i>Pipistrellus circumdatus</i>
<i>Rattus cremoriventer</i>	<i>Pachyotis temmincki</i>
<i>Crocidura fuliginosa</i>	<i>Pachyotis castaneus</i>
<i>Taphozous theobaldi</i>	

BORNEO (not Sumatra)

<i>Hylobates leuciscus</i>	<i>Hipposideros larvatus</i>
<i>Bos banteng</i>	<i>Hipposideros speoris</i> (?)
<i>Cervus hippelaphus</i>	<i>Tylonycteris pachypus</i>
<i>Crocidura fuliginosa</i>	<i>Pachyotis temmincki</i>
<i>Crocidura monticola</i>	<i>Murina suilla</i>
<i>Rhinolophus borneensis</i>	

CELEBES (non Chiroptera)

<i>Macacus irus</i>	<i>Rattus norvegicus</i>
<i>Cervus hippelaphus</i>	<i>Mus musculus</i>
<i>Paradoxurus hermaphroditus</i>	<i>Crocidura murina</i>
<i>Rattus concolor</i>	<i>Crocidura fuliginosa</i>
<i>Rattus rattus</i>	

LESSER SUNDA ISLANDS (not Sumatra or Borneo)

<i>Rhinolophus megaphyllus</i>	<i>Rhinolophus euryotis</i>
<i>Rhinolophus acuminatus</i>	<i>Nycteris javanica</i>

As may be expected, the greater part of the non-endemic species is identical to those of the two other Greater Sunda Islands, one half of them being found both in Borneo and Sumatra. With Sumatra only Java has 20 species in common, while 11 species inhabiting Java and Borneo do not occur in Sumatra. The closer relationship between Java and Sumatra is also demonstrated by the occurrence of eight identical subspecies in both islands whereas all the subspecies of Borneo and Java are different with one exception only, viz., the *Cervus hippelaphus*, but the latter species is certainly not indigenous to Borneo. Of the 11 species, listed as peculiar to Borneo and Java, more than half the number belong to the bats and it is probable that when collecting this often neglected group is done more efficiently the majority of these forms will be found to be represented also in Sumatra. Of the remaining land mammals the two *Crocidura* and *Cervus hippelaphus* are of less importance, as the systematic position of the first two species is still doubtful, and the Java deer has most likely been introduced into Borneo. The silvery gibbon (*Hylobates leuciscus*), formerly considered a separate species confined to Java, has lately been united with the species *mülleri* from Borneo and quite recently POCOCK proposes to put both in the Formenkreis of *H. lar*, which is also represented in Sumatra. Consequently this putting into one species of *H. mülleri* with the Java gibbon does not imply that there has been any closer connection between Java and Borneo than there is between Java and Sumatra.

Thus the only mammal peculiar to Borneo and Java and apparently absent from Sumatra is the banteng. Most probably this wild ox has also inhabited Sumatra in former days, but is now either extinct there or has become extremely rare.

One of the most interesting problems offered by the Java mammals and which has always attracted the attention of the students of its fauna, is the similarity of certain Java forms with those occurring on the Asiatic mainland while lacking in the interjacent countries. This remarkable discontinuity of the distribution is exhibited by 19 species, to which we may add perhaps the Javanese hare (*Lepus nigricollis*) which is said to occur in the southern part of Sumatra though not recorded from any other part of that island nor from the Malay Peninsula.

Out of this rather large assemblage of species ten belong to the bats, some of which may be found in Sumatra but have not yet been recorded from there up to the present. But a few certainly show this anomalous distribution whereas other species are closely allied forms of Asiatic types.

Of the remaining terrestrial forms there are only a few of which we can state with any amount of certainty that they are really absent from Sumatra. These are five in number: *Bos banteng*, already referred to above, *Felis pardus*, *Viverricula malaccensis*, *Herpestes javanicus* and *Helictis orientalis*, all common and well-known species of Java; if these

species actually did occur in Sumatra their discovery would have been unavoidable.

Of the remaining number *Felis viverrina*, the fishing cat, has only comparatively lately been recorded from Java, and living in the mangrove swamps, it may easily have escaped the attention of non-resident collectors. Also the finding of the other species in Sumatra may but a question of time.

It is certainly a curious fact, worth mentioning, that of the five species mentioned above the three smaller beasts of prey are all abundant in Java around human habitations, the rase (*Viverricula*) and the mongoose being, moreover, often kept in confinement. This may be an indication that in some cases at least we may not repudiate the suggestion of introduction by man. The same suggestion may be made with regard to the Javanese hare, its distribution in the island being restricted to a small area extending from Batavia to Buitenzorg.

Now if we come to the relations between Java and Celebes we will find that the total number of identical species amount to eighteen, nine of which are bats. If we exclude from the remaining nine forms the cosmopolitan species of rats and mice and the common and widely distributed musk-shrews, which might easily have been imported by traffic, there are only three mammals which require closer consideration.

The common macaque is an animal often seen on ships or Malay boats and everywhere kept as a pet, as well by natives as by Europeans. In this way it is transported to every part of the Archipelago and in many places specimens kept in confinement have undoubtedly been set free again. Thus the occurrence of this common monkey in Celebes need not be a matter of surprise. As the species, moreover, is only found in the extreme southern part of the island it is fairly certain that it has been introduced there and only comparatively recently.

The same may be said of the common musang or palm-civet (*Paradoxurus hermaphroditus*) which is also often found in captivity and probably has been transferred to various localities for the purpose of rat-catching.

The Java deer as well, should not be considered indigenous to Celebes, this valuable game having been imported into many islands, a supposition which is supported by historical data. The absence of deer bones in the Celebes caves, as pointed out by the SARASIN's, is likewise a point in favour of our opinion.

The relations of the Java mammals to those of the Lesser Sunda Island are also less striking there being 35 species in common, two-thirds of which are bats.

The majority of the terrestrial species are the same as those found in Celebes and their presence may be put down to importation. Others, such as the tiger, a few squirrels and *Tupaia javanica*, do not go further than Bali.

There are only four species occurring in Java and the Lesser Sunda Islands which are lacking in Sumatra or Borneo, all four being bats. Among these *Nycteris javanica* and *Rhinolophus acuminatus* are of Asiatic origin, while the remaining two are of Austro-Malayan types.

JAVA BIRDS.

In the list appended to this paper a total number of 445 species of birds from Java are mentioned but only 337 species should be considered to be true resident birds having been found actually breeding in Java or being very likely to breed there. Ninety seven forms — species and subspecies — are recorded as migrants from the northern hemisphere, this number amounting to a little more than one-fifth of the total number of birds. Out of these 97 forms, however, of three it is still doubtful whether they are really migratory, viz., *Plegadis falcinellus*, the *cucullata* form of *Pitta sordida* and *Dicrurus annectans*. Three migratory species are known to occur in Java in two subspecies: *Charadrius mongolus*, *Cyanoptila cyanomelana* and *Phylloscopus borealis*.

Nine species are listed of which a breeding and a migratory form have been recorded as occurring together; they are:-

- Butorides striatus javanicus* and *amurensis*
- Accipiter virgatus virgatus* and *gularis*
- Falco peregrinus ernesti* and *calidus*
- Pandion haliaëtus cristatus* and *haliaëtus*
- Ninox scutulata javanensis* and *malaccensis*
- Eurystomus orientalis orientalis* and *calonyx*
- Hierococcyx fugax fugax* and *nisicolor*
- Cuculus micropterus concretus* and *micropterus*
- Acrocephalus stentoreus siebersi* and *orientalis*

From the southern hemisphere, in casu Australia, four species only migrate to Java, *Stiltia isabella*, *Falco cenchroides*, *Halcyon sancta* and *Chalcites basalis*, being found here during the southern winter, i.e. in the dry or east monsoon in Java. That so few species only come to Java is due to the fact that the main route, followed by the southern migrants, is a direct northern one via the Lesser Sunda Islands, the Moluccas and the Philippines.

Of one species, *Fulica atra*, it is still doubtful whether it is a northern or southern migrant.

Not only have all the migratory species been excluded from our schedule on page 3, also a number of species — nineteen in all — have been left out as it is still uncertain whether they breed in Java or not, or even if they may be classed among the Java birds at all. Into the latter category we have to place such species as *Horizillas affinis*. To the former group belong all those straying or oceanic birds, such as a few members

GEOGRAPHICAL RELATIONSHIP OF JAVA BIRDS.

JAVA (endemic)

<i>Arborophila javanica</i>	<i>Prinia polychroa</i>
<i>Cyornis banyumas</i> (?)	<i>Crocias guttatus</i>
<i>Rhipidura phoenicura</i>	<i>Psaltia exilis</i>
<i>Garrulax rufifrons</i>	<i>Serinus estherae</i>
<i>Stachyris grammiceps</i>	<i>Aethopyga eximia</i>
<i>Mixornis javanica</i> (?)	<i>Aethopyga mystacalis</i> (?)
<i>Bradypterus montis</i>	<i>Zosterops maxi</i> (?)

ASIA (not Sumatra or Borneo)

<i>Pavo muticus</i>	<i>Timelia pileata</i>
<i>Turnix dussumieri</i>	<i>Tesia cyaniventris</i>
<i>Treron bicincta</i>	<i>Cisticola exilis</i>
<i>Spizaetus nipalensis</i> (?)	<i>Prinia inornata</i>
<i>Glaucidium cuculoides</i>	<i>Dicrurus macrocercus</i>
<i>Loriculus vernalis</i>	<i>Gracupica melanoptera</i>
<i>Halcyon smyrnensis</i>	<i>Aethiopsar grandis</i>
<i>Cyanops lineata</i>	<i>Ploceus manyar</i>

BORNEO (not Sumatra)

<i>Sterna fuscata</i> (?)	<i>Conurus alexandri</i>
<i>Himantopus himantopus</i> (?)	<i>Enicurus leschenaulti</i>
<i>Phalacrocorax javanicus</i>	<i>Saxicola caprata</i>
<i>Butastur liventer</i>	<i>Chlorura hyperythra</i>
<i>Falco moluccensis</i> (?)	<i>Mirafra javanica</i>
<i>Strix seloputo</i>	<i>Dicaeum trochileum</i>

LESSER SUNDA ISLANDS (not Sumatra or Borneo)

<i>Gallus varius</i>	<i>Coracina javensis</i>
<i>Ptilinopus melanocephalus</i>	<i>Cyanoderma melanothorax</i>
<i>Ducula rosacea</i>	<i>Cisticola exilis</i>
<i>Ducula lacernulata</i>	<i>Megalurus palustris</i>
<i>Nettion gibberifrons</i>	<i>Pachycephala pectoralis</i>
<i>Glaucidium cuculoides</i>	<i>Dicrurus macrocercus</i>
<i>Alcedo caeruleascens</i>	<i>Gracupica melanoptera</i>
<i>Halcyon smyrnensis</i>	<i>Aplonis minor</i>
<i>Cyanops lineata</i>	<i>Munia ferruginosa</i>
<i>Dryobates analis</i>	<i>Ploceus manyar</i>
<i>Chrysocolaptes strictus</i>	<i>Oreosterops javanica</i>

of the genus *Chaetura* and *Fregata*, *Phaëton*, *Sula* a.o., which possibly breed in lonely islands or in some places far away from Java.

We find that 14 species are peculiar to Java or 4 per cent only of the total number that breed in the island. Four of these species, provided with a question mark in the accompanying list, may perhaps be classed with species occurring elsewhere.

The number of resident birds recorded from West Java far exceeds the number of those from Central and East Java. There is nothing astonishing in this, as the majority of the species have first been described from the western part of the island. A great many of the western species may possibly also be found in more eastern localities; but we wish to point out that East Java, although its avifauna is better known than that of Mid Java, shows a lower figure than the latter part of the island, which may be taken as an indication that, as is also the case with other groups of animals, there is among the birds also a decline of the species in passing from west to east. The number of species which, with any certainty, may be assigned as being restricted to the western part of Java is, however, extremely small at present. Among these we may mention *Aethopyga siparaja* alone, while *Arborophila javanica* and *Garrulax rufifrons* are apparently absent in East Java.

We may now proceed to give an outline of the relations of the resident birds of Java with those of the surrounding countries.

With the birds it is as with the mammals, those Java species which inhabit the Asiatic mainland but not Sumatra arouse most interest; their number amounts to 24. Eight are also recorded from Borneo, so there remain 16 species of birds which Java and Asia have in common, which are lacking in Sumatra and Borneo. A certain number is sure to be discovered in Sumatra in the future, but such well-known members of the avifauna as the peacock, the Javanese love-bird, the black drongo, the crested and white mynah, and the striated weaver-bird are apparently not found in Sumatra.

Next we have 281 species which occur both in Java and Sumatra, i.e. 83%, whereas there are 57 species and 45 subspecies which are found in both islands but not in Borneo. Both Borneo and Java are inhabited by 236 species or 70% of the total number of resident birds. Although these figures show that the relation between Borneo and Java is less close than that between Java and Sumatra, this fact is even more clearly demonstrated by the presence of 12 species only and 7 subspecies which Java and Borneo have in common and are absent in Sumatra. Out of this small number no less than eight species are also found in Asia as already mentioned above. There is every chance that the majority of the latter will be found in course of time in Sumatra too, so that then possibly only five species will remain which seem actually lacking in Sumatra. These are:- *Falco moluccensis*, *Conurus alexandri*,

Enicurus leschenaulti, *Mirafra javanica* and *Dicaeum trochileum*, all rather common birds in Java except the first-mentioned species, but as to the latter it is still doubtful whether this bird is really an inhabitant of Borneo. Moreover, *Falco moluccensis* is a denizen of the eastern part of the Archipelago and has certainly not reached Java from the west. With regard to the remainder a direct importation of these bird into Borneo from Java is not probable, as, with the exception of the common Java paraket (*Conurus*), they are seldom if ever kept as cage-birds. *Conurus alexandri* and *Dicaeum trochileum* occur, moreover, also in the Karimon-djawa and Bawean islands in the Java Sea.

Of the subspecies found in Java and Borneo and not in Sumatra there is one of which special mention should be made, viz., *Copsychus saularis amoenus*. The latter species shows a remarkable parallelism in the distribution as the East Java form *amoenus* is confined to the eastern part of Borneo and the West Java form *musicus* to West Borneo.

The list of the Java birds further exhibits the fact that 95 species or 28% of the Java resident birds are identical with Celebes ones. This is a rather large number and the proportion far exceeds that of the mammals, batrachians and fishes, of which, being earth- and waterbound, the power of dispersing is more restricted. None of the species is confined to Java and Celebes only, there being one member which is found in Java, Celebes and again on the Asiatic mainland, viz., the crested mynah (*Aethiopsar grandis*); all others occur either in Sumatra or Borneo, or in the Lesser Sunda Islands. We may also bring forward as an evidence of the more isolated position of Celebes with regard to Java the fact that not one of the six Java species of barbets (*Capitonidae*) and only one woodpecker (*Mülleripicus pulverulentus*) out of the sixteen that are recorded from Java, inhabit Celebes. Moreover, the Javanese members of the families of the *Pycnonotidae*, the *Timeliidae* and *Turdidae* (the genera *Aegithina* until and inclusive *Saxicola* of our list) have no representatives in Celebes except a very few. These are the doubtful *Horizillas affinis*; *Turdus javanicus*, which like other denizens of the highest mountains has spread far beyond the western part of the Archipelago; and *Saxicola caprata* itself being a bird with a very large area of distribution, it is found from Asia to New Guinea and more abundant in the eastern than in the western portion of the East Indies.

Finally we find that a large number of Java species have penetrated into the Lesser Sunda Islands, no less than 184 of the resident birds or 55 per cent. being present there. This high proportion is mainly due to the species which Java and Bali have in common, in the other Lesser Sunda Islands the Javanese species are much more poorly represented. Twenty-two only out of the number of identical species have not been recorded so far either from Sumatra or Borneo, but seven are known from Asia. So there remain fifteen species only which are found in Java and in these islands eastwards lying with the exclusion of Asia and the western

part of the Archipelago. Among these only a small number, such as *Pachycephala pectoralis*, *Aplonis minor* and the pigeons *Ptilinopus melanocephalus*, *Ducula rosacea* and *lacernulata*, are likely to have reached Java from the east.

JAVA REPTILES.

Java can boast of a total number of 150 Reptiles, comprising 46 Lacertilia, 9 Chelonia and 95 Ophidia. We may further add 3 species of crocodiles, 4 marine turtles and 16 species of sea snakes; these marine species are not discussed here.

Of the non-marine species a large number has been recorded from West Java only, 103 against about half that number from Mid or East Java. As has been already demonstrated with regard to other groups of animals, there may be a certain decline of the abundance of species going from west to east, but here also we have to make due allowance to the fact that Mid and East Java have been far less thoroughly explored.

Peculiar to Java are 16 species, enumerated in the accompanying list; of the genera two only are endemic, *Tetralepis* and *Dipsadoides*, both represented by a single species, seldom met with; besides, of *Dipsadoides decipiens* only one single specimen is known. Moreover, it is doubtful whether Java is indeed the true locality of the latter species. The rather high percentage of endemic forms, about onetenth, is, however, no indication of a long isolation of the island as the great majority of these endemic species is of rare occurrence and many may be found on some of the other islands in course of time. The only species found in greater abundance, confined to Java, *Gonyocephalus kuhli*, is restricted to the higher mountain regions.

We find further that no less than 120 out of the remaining 134 non-endemic species inhabit also Sumatra or Borneo; Java and Sumatra have 111 species in common or 74% of the total number of reptiles, Borneo and Java 100 species or 66%.

The higher percentage demonstrating a closer relation with Sumatra is mainly due to the larger number of snakes which occur both in Java and Sumatra; of the latter group 75 inhabit Sumatra and Java, as against 65 Borneo and Java.

The species which indicate a direct relation to Asia, being absent in Sumatra and Borneo and reappearing on the Asiatic mainland, amount only to five, one of which, *Python molurus*, is found also in Celebes. Of the other species, *Varanus nebulosus* and the two members of the genus *Dryophis* are rather rare and their occurrence in Sumatra is not at all impossible. The fresh-water tortoise *Damonia subtrijuga*, being recorded only from a few places in West Java, may have been introduced into Java.

A few species Java has in common with the Asiatic mainland which also inhabit Borneo but not Sumatra. These four species, *Mimetozone*

GEOGRAPHICAL RELATIONSHIP OF JAVA REPTILES.

JAVA (endemic)

<i>Draco cryptotis</i>	<i>Tetralepis fruhstorferi</i>
<i>Harpesaurus tricinctus</i>	<i>Oligodon propinquus</i>
<i>Gonyocephalus kuhli</i>	<i>Ablabes libertatis</i>
<i>Dendragama fruhstorferi</i>	<i>Calamaria goeringi</i>
<i>Lygosoma leucostictum</i> (?)	<i>Calamaria occipitalis</i>
<i>Typhlops kapaladua</i> (?)	<i>Calamaria sondaica</i>
<i>Typhlops bisubocularis</i>	<i>Calamaria bungaroides</i> (?)
<i>Pseudoxenodon inornatus</i>	<i>Dipsadoides decipiens</i> (?)

ASIA (not Sumatra or Borneo)

<i>Varanus nebulosus</i>	<i>Dryophis xanthozona</i>
<i>Damonia subtrijuga</i>	<i>Dryophis mycterizans</i>
<i>Python molurus</i>	

BORNEO (not Sumatra)

<i>Mimetozone craspedotus</i>	<i>Lygosoma atrocostatum</i>
<i>Draco lineatus</i>	<i>Lygosoma bowringi</i>
<i>Mabuia rugifera</i>	<i>Brachyorrhus albus</i>
<i>Lygosoma smaragdinum</i>	<i>Calamaria melanota</i>
<i>Lygosoma cyanurum</i>	

CELEBES (not Sumatra, Borneo or Less. Sunda Islands)

<i>Gymnodactylus fumosus</i>	<i>Python molurus</i>
<i>Typhlops ater</i>	<i>Tropidonotus chrysargoides</i>

LESSER SUNDA ISLANDS (not Sumatra or Borneo)

<i>Gecko vittatus</i>	<i>Ablepharus boutonii</i>
<i>Calotes jubatus</i>	<i>Typhlops polygrammicus</i>

craspedotus, *Mabuia rugifera*, *Lygosoma atrocostatum* and *L. bowringi*, may all one day be found in Sumatra; *L. atrocostatum* is recorded from both the Rhio Archipelago and Simalur, and *L. bowringi* was found by the author on Sebesi in the Sunda Straits.

There remain five other species which occur in Borneo and Java and are not represented in Sumatra. One of these, *Calamaria melanota*, is a species seldom met with, but the others, *Draco lineatus*, *Lygosoma smaragdinum*, *L. cyanurum* and *Brachyorrhus albus*, are species found widely

distributed in the eastern part of the Archipelago, the range often extending beyond New Guinea. The centre of dispersal of these species must apparently to be looked for in the Austro-Malayan or Papuan regions, the western boundaries of the distribution being Borneo and Java.

Of the rather large number of species, 53 or 35% of the total number of reptiles, which inhabit both Java and Celebes, nearly all are found also in Sumatra or Borneo, whereas only three are restricted to the two former islands. Among the latter species we find *Gymnodactylus fumosus*, but it seems doubtful whether the typical *fumosus* of Celebes really occurs in Java. The two snakes, *Typhlops ater* and *Tropidonotus chrysargoides*, are again rather uncommon species and their area of distribution is probably larger than is known at present. Only one single species of tortoise, *Cyclemys amboinensis*, Java has in common with Celebes, but this semi-aquatic species is of general occurrence all over the western part of the Malay Archipelago.

Let us now see what the relationship with the Lesser Sunda Islands is. These islands share with Java 38 species or 25%, a much lower figure than that shown by Celebes.

There are certainly many incentives for a more thorough examination of these islands and the knowledge of their reptile fauna is far from complete. So we may expect that in future the proportion of identical species will show a much higher figure. If we take into consideration only those species which occur in Java and the Lesser Sunda Islands, but are lacking in Sumatra or Borneo, we will find this number to be very small, only four species coming under this category. Among these we find *Gecko vittatus*, the presence of which in Java is doubtful, and *Calotes jubatus*, which is not wholly absent from the western part of the Archipelago, outside Java, as the species inhabits Singkep (Rhio Archipelago). The two remaining species, *Ablepharus boutoni* and *Typhlops polygrammicus* seem more at home in Papuan and Australian regions; the first mentioned species has a remarkable area of distribution as it is also found in tropical America and Africa, but obviously not in the Oriental region.

We may further call attention to the fact that the number of lizards in common with Java is proportionally much higher than the number of snakes. Of the latter there are 21 out of the 95 species found in Java, this makes up 22%, as against 37% of the Lacertilia (17 out of 46). This seems in accordance with the rule that in remote islands snakes are less numerous than lizards. The case of Krakatau is another confirmation of this rule, as after the eruption a far greater number of lizards than of snakes have reached the islands. The above mentioned feature may be taken as an indication that the reptiles of Java have come by chance only to the Lesser Sunda Islands without any permanent land bridges, but it may also be that snakes have not been collected in these islands to the same extent as lizards.

JAVA AMPHIBIANS.

The batrachian fauna of Java is represented by two species of Gymnophiona and 37 of the Anura. No less than 31 of the total number have been found in West Java, not even two-third of this number being described from Central or East Java. A rather large proportion, 10 out of 39 or 26%, is endemic (see list), the only peculiar genus being *Nyctixalus*, very nearly related to *Philautus*, which is represented also in Borneo and Sumatra. To the latter two islands the Amphibia of Java show the strongest similarity, as no less than 21 of the 29 non-endemic species occur in all three islands. A closer relation to Sumatra is demonstrated by the presence of only four species occurring in the latter island which are not represented in Borneo, whereas Borneo has only one species, *Rana whiteheadi*, in common with Java which is absent from Sumatra. *R. whiteheadi*, however, is a doubtful species and has possibly to be united with the far more abundant and widely distributed *Rana jerboa*.

With the Asiatic mainland Java has only three species in common which are not found in Borneo or Sumatra. One of them, *Rana doriae*, has only recently been recorded from Java and its finding in the other Greater Sunda Island may be a question of time only. The occurrence of the next species, *Rana hascheana*, in Java is still dubious; the third species only, *Oxyglossus lima*, is rather common in Java and apparently absent or rare in Sumatra and Borneo.

When we consider the connections with Celebes we find eight species which occur both in the latter island and Java, all common species widely distributed over the western part of the Archipelago, all being found also in Sumatra and Borneo. None of the species is restricted to Celebes and Java.

Six species have reached the Lesser Sunda Islands; they are on the whole the same common species which also inhabit Celebes. None of the eastern forms have come to Java by means of the Lesser Sunda Islands, the whole western portion of the Indo-Australian Archipelago, Celebes and the greater part of the Lesser Sunda Islands included, having a purely oriental batrachian fauna.

JAVA FISHES.

It has been mentioned in the introduction to this paper that the families of the *Mastacembelidae* and *Gobiidae* are not included in the list of Java fresh-water fishes in Appendix V. The systematic position of many members of these two families is still very doubtful; the Gobiids are, moreover, of less importance as far as zoogeographical speculations are concerned as they have invaded the fresh-water in comparatively recent time only. By omitting these families we find that Java possesses 143 species of fresh-water fishes; from this total number we have to deduct those species which live also in brackish water or are semi-marine, such as the eels,

GEOGRAPHICAL RELATIONSHIP OF JAVA AMPHIBIA.

JAVA (endemic)

<i>Bufo cruentatus</i>	<i>Philautus jacobsoni</i>
<i>Bufo chlorogaster</i>	<i>Philautus pallidiceps</i>
<i>Microhyla palmipes</i>	<i>Philautus vittiger</i>
<i>Rhacophorus javanus</i>	<i>Nyctixalus margaritifer</i>
<i>Philautus flavosignatus</i>	<i>Nyctixalus robinsoni</i>

ASIA (not Sumatra)

<i>Rana doriae</i>	<i>Oxyglossus lima</i>
<i>Rana hascheana</i> (?)	

BORNEO (not Sumatra)

Rana whiteheadi

CELEBES

<i>Bufo biporcatus</i>	<i>Rana microdisca</i>
<i>Kaloula baleata</i>	<i>Rana chalconota</i>
<i>Rana cancrivora</i>	<i>Rana erythraea</i>
<i>Rana kuhli</i>	<i>Rhacophorus leucomystax</i>

LESSER SUNDA ISLANDS

<i>Bufo biporcatus</i>	<i>Rana cancrivora</i>
<i>Kaloula baleata</i>	<i>Rana microdisca</i>
<i>Rana limnocharis</i>	<i>Rhacophorus leucomystax</i>

which migrate to the ocean for spawning. These species may easily spread from island to island along the coasts. Furthermore two species of gold-fishes, *Cyprinus carpio* and *Carassius auratus*, now cultivated everywhere in Java, have certainly been imported from China. The remaining 92 species are living in fresh-water only but as truly genuine fresh-water fishes we have to consider the species of *Notopterus*, the cat-fishes (*Siluroidea*) and the carp-like fishes (*Cyprinoidea*). Their number in Java amounts to 81. The members of the other groups have all near relatives living in the sea and we may safely assume that only recently they have penetrated into fresh-water.

Out of the total number of 92 fresh-water-species 75 are described from West Java, as against 49 from Mid Java and 31 from East Java. As East Java has certainly been better explored than Mid Java we may conclude from the lower number found in the eastern part of the island that there is truly a decrease and possibly a strong one, of the species going eastwards. This view is also confirmed by the number of brackish-water

GEOGRAPHICAL RELATIONSHIP OF JAVA FRESH-WATER FISHES.

JAVA (endemic)

<i>Acrochordonichthys ischnosoma</i>	<i>Puntius microps</i>
<i>Homaloptera pavonina</i>	<i>Puntius platysoma</i>
<i>Cyclocheilichthys deventeri</i>	<i>Labeo erythropterus</i>
<i>Puntius aphyia</i>	<i>Tylognathus lehat</i>

ASIA (not Sumatra)

<i>Pangasius macronema</i> (?)	<i>Puntius orphoides</i>
<i>Puntius brevis</i>	<i>Puntius bramoides</i>

BORNEO (not Sumatra)

<i>Pangasius macronema</i> (?)	<i>Puntius bramoides</i>
<i>Puntius orphoides</i>	<i>Tylognathus hispidus</i>

CELEBES

<i>Monopterus albus</i>	<i>Ophiocephalus striatus</i>
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LESSER SUNDA ISLANDS

<i>Rasbora argyrotaenia</i>	<i>Monopterus albus</i>
<i>Rasbora lateristriata</i>	<i>Ophiocephalus striatus</i>
<i>Puntius binotatus</i>	<i>Trichopodus trichopterus</i>

or semi-marine species which have been recorded from the three parts of Java, the respective numbers being 37, 20 and 21. Here the difference between Mid and East Java has disappeared. The advance in numbers shown by West Java is no doubt due to the better knowledge we have always had of this part of the island.

Striking is the comparative scarceness of endemic species, eight in number, all of rare occurrence, some described from a single specimen only. This rareness makes it doubtful whether these fishes are really confined to Java. None of the genera is peculiar to the island, all the endemic species having near relatives in Sumatra or Borneo. We may here call attention to the fact that in our previous paper of 1924 we put the number of endemic species at eleven, in the meantime three of them have already been recorded from other localities.

Of the 84 non-endemic fresh-water fishes 79 or 94% occur also in Sumatra, as against 63 or 75% in Borneo. If we take into consideration the genuine fresh-water fish families only we get the respective proportions of 94 and 74.

Twenty of the Java species inhabit Sumatra but do not occur in Borneo, whereas there are only four species which Java and Borneo have in common but are absent from Sumatra. Three of the latter are known also from Siam.

The occurrence of *Pangasius macronema* in Java is, moreover, uncertain. The only species which seems to be confined exclusively to Java and Borneo is *Tylognathus hispidus*. The closer relationship to Sumatra is the more remarkable as Borneo has a larger number of truly fresh-water fishes than Sumatra; in both islands about twice as many species are found as in Java.

This close relationship to Sumatra is shown even more plainly when we compare the fish species from the South Sumatra or South Borneo rivers with those of Java. Out of the total number of 79 species which inhabit both Java and Sumatra 70 or 89% is known from South Sumatra, whereas South Borneo has only 33 species out of the total number of 63 or 52% in common with Java. Of the four species which are recorded from Java and Borneo, and not from Sumatra, *Puntius bramoides* is the only species known from the Barito basin in South Borneo, if we exclude at least the doubtful *Pangasius macronema*. The first-named species, however, is not confined to the Barito river but, as already mentioned, is known also from Siam and is, moreover, an inhabitant of the East Borneo Mahakam river and its affluents.

Recently DE BEAUFORT, in his excellent essay on the Zoogeography of the Indo-Australian Archipelago, has given us some further valuable information on the relationship of the fish fauna of the Java and Borneo rivers; we borrow from him the following remarkable facts.

In the Barito river (S. Borneo) and the Mahakam river (E. Borneo) 17 identical species of Cyprinoid fishes have their habitat; ten of these are also to be found in Java. Besides, the Barito is inhabited by 14 species being absent from the Mahakam, all of which are unknown from Java. But out of the 39 species which the Mahakam possesses above the number found also in the Barito, 12 are indigenous in Java. The conclusion these considerations lead to, viz., the closer relationship of the fish fauna of the Java rivers with the East Borneo Mahakam, rather than with the South Borneo Barito river, is certainly an unexpected one.

A similar feature, although less striking, is exhibited by the Siluroid fishes. The Mahakam and Barito have 11 species in common out of which number seven are also recorded from Java. Furthermore there are 13 species living in the Mahakam and lacking from the Barito; of these five are also known from Java. But out of the 15 species which inhabit the Barito and not the Mahakam not more than five species are also found in Java.

In one of the following chapters we will refer again to this remarkable relationship of the Java fish fauna to that of the East Borneo rivers.

Now let us see what the other relations of this part of the fauna are. There is only one species, which the Asiatic mainland and Java have in common, to the exclusion of Sumatra and Borneo, viz., *Puntius brevis*. This species is fairly abundant in Java and outside this island only recorded from Siam.

If we take into account only the truly genuine fresh-water fishes found in the Greater Sunda Islands, we find that Celebes is wholly destitute of

them. Of the remaining species two only occur both in Celebes and Java; one of these, *Monopterus albus*, is able to live for a rather long time outside the water and buries itself in the mud when the water is running dry. Moreover, the species is much used as food, like the other species, *Ophiocephalus striatus*, the well-known "ikan gabus". Both species may have been introduced into Celebes; this has actually been the case with *Ophiocephalus* into the Hawaiian Islands.

The relationship with the Lesser Sunda Islands is very faint too; six species are found further eastwards than Java, three of which only are truly fresh-water inhabitants. Of these *Rasbora argyrotaenia* does not get beyond the Lombok Straits; *Puntius binotatus* has reached Lombok, whereas *Rasbora lateristriata* has even gone as far as Sumbawa. Of the three remaining species found in the Lesser Sunda Islands *Ophiocephalus striatus* is found farthest eastwards as it is recorded from Flores.

JAVA MOLLUSCS.

Thanks to the valuable contribution by Miss VAN BENTHEM JUTTING we are now far better informed about the mollusc fauna of Java and its distribution than in 1924, and the more or less incomplete statements given in my previous paper can now be amplified.

We know nowadays 370 species of land and fresh-water molluscs from Java — 348 Gastropoda and 22 Lamellibranchiata or bivalves. In our schedule on page 3 in the total number are also included the 72 varieties which have been described. The total number of all molluscs is composed of 251 terrestrial forms (212 species and 39 varieties), 136 fresh-water forms (104 species and 32 varieties), and 55 brackish-water forms among which is only one variety. In the following lines when speaking of "species" we mean the true species and these varieties taken together.

In this group of animals, too, the largest number has been recorded from West Java (271), from Central Java only one-fifth of this number is known, whereas in East Java more than twice as many species as in Central Java have been found. About the same proportions hold good for all three groups: terrestrial, fresh-water and brackish-water species. As in most groups of animals, I think the larger numbers known from East Java are mainly due to the more thorough investigation of this part of the island as compared with Central Java.

When analysing the mollusc fauna of Java we may be surprised by the very large number of endemic species; as may be expected, this number is largest for the terrestrial species (177 out of 251 or 71%), smaller for the fresh-water (57 out of 136 or 42%) and smallest for the brackish-water species (11 out of 55 or 20%). This strikingly high proportion of peculiar species may be attributed partly to the fact that the molluscs are much older inhabitants of Java, from the point of view of geological age, than

the majority of the recent vertebrates, partly to the fact that malacologists apparently have a rather different conception of a "species" than students of vertebrate animals, as they base their species mainly on the outer appearance of the shell and not on anatomical characteristics.

With regard to the relations to Sumatra we see that this island and Java have 132 species in common, this being 30% of the total number of molluscs known from Java, but 67% of the non-endemic species; this rather high percentage is mainly caused by the large proportion of identical fresh and brackish-water species, amounting respectively to 82 and 77 per cent., the figure for the land shells being only 45%.

The relationship with Borneo is marked again by a much lower figure, being less than half that found for Sumatra, viz., 62 species recorded both from Borneo and Java, this is 14% of the total number or 31% if the non-endemic species only are considered. Here the figure for the brackish-water forms is highest, 45%, the percentages for terrestrial and fresh-water molluscs differing but little, being respectively 26 and 29. The figures are perhaps a little too low as the records for Borneo in our list are perhaps less complete, as there is no recent list of the Borneo molluscs, such as we have for Sumatra (see this Journal Vol. X). Anyhow the closer relation to Sumatra is the more striking as the mollusc fauna of Sumatra is far less rich than that of Borneo, there being about two and a half times more species known from the latter island.

How distant the relations with Borneo are becomes even more obvious if we consider the number of identical species which occur in Sumatra and are lacking from Borneo. Whereas all the three Greater Sunda Islands have 48 species in common, there are no less than 84 Java species which are recorded from Sumatra, which are not found in Borneo, as against 14 Java species known from Borneo, which are lacking from Sumatra. These 14 species are composed of seven terrestrial, five fresh-water and two brackish-water forms (see list on page 21). Of the seven land shells two species, *Ennea bicolor* and *Amphidromus interruptus*, are also known from the Asiatic mainland; these and the greater part of the remaining species, too, we may expect to be found in Sumatra someday, as none of the genera under consideration is restricted to Borneo. One species belongs to the genus *Leptopoma* which is chiefly represented in the eastern part of the Archipelago. As regards the fresh-water species — a small number anyhow — it is also not at all unlikely that a good many of them will be discovered in Sumatra in course of time.

We have already made reference to species which occur in Java and on the Asiatic mainland, and are not represented in Sumatra.

Altogether the number of molluscs which Java has in common with Asia, and not with Sumatra, amounts to eight; among these there is only one fresh-water species, *Ampullaria polita*, and none of the brackish-water forms.

Of the terrestrial species two are also known from Borneo and I suppose the others may be found in future either in Borneo or Sumatra, the area of distribution of most of them extending even beyond the Malayasian part of the Archipelago.

Let us now see in how far the Java and Celebes mollusc fauna are identical. We know now 84 species which Java and Celebes have in common, this is 19% of the total number or 43% of the non-endemic species, being a higher percentage than that found for the Borneo relationship. But if we take only the land shells, we shall see that the percentage is about the same as that mentioned for Borneo, viz. 28%, the high total percentage being due to the much higher figures regarding the identical fresh-water and brackish-water species, these amounting respectively to 39 and 73 per cent.

Exclusively restricted to Celebes and Java are twelve species only, four being brackish-water, two fresh-water and six terrestrial species. One of the fresh-water species is a variety of the well-known and widely distributed *Limnaea javanica*; one of the identical land shells is likewise a variety of the common *Amphidromus interruptus*. There is only one genus which seems to be confined to Celebes and Java, *Philomycus*, whereas the other genera to which the terrestrial species belong are all represented also in the western part of the Archipelago; *Kaliella* of which no less than twelve species inhabit Java seems to be the only genus not found in Sumatra.

There is a remarkable similarity between the numbers of mollusc species which Java and Celebes have in common and those which are also found in the Lesser Sunda Islands. For the land shells and the fresh-water species the numbers of identical species are actually the same, there being only a slight difference in the proportion of brackish-water species, 61% of the non-endemic Java species against 73% in Celebes. A more detailed investigation into the mollusc fauna of the Lesser Sunda Islands will, I have no doubt, reveal the fact that the present figures are too low and that the relationship between Java and the chain of islands lying east of it will prove to be closer than that between Java and Celebes.

The species found in Java and the Lesser Sunda Islands, but not in Sumatra or Borneo, amount to 16, among which are nine terrestrial and four fresh-water species. Five land shells and one *Melania* have not been recorded from outside the two regions under consideration, the other species have also been found either in Celebes or the Moluccas. It is not at all necessary to conclude from this that the latter species have all spread from eastern centra to the western islands as all the genera to which they belong are represented in Sumatra too, *Leptopoma* and *Helicina* only being more or less peculiarly eastern genera.

We have also to call attention to a few species which occur in Java and are found again in the Moluccas or New Guinea (see list). There is no evidence whatever for supposing that this discontinuous distribution must

GEOGRAPHICAL RELATIONSHIP OF JAVA MÖLLUSCA

† brackish-water species; * fresh-water species.

ASIA (not Sumatra)

<i>Ennea bicolor</i>	<i>Opeas javanicum</i>
<i>Amphidromus interruptus</i>	<i>Meisenheimeria alte</i>
<i>Plectotropis rotatoria</i>	<i>Alyceus jadori</i>
<i>Prosopeas turricula</i>	* <i>Ampullaria polita</i>

BORNEO (not Sumatra)

<i>Ennea bicolor</i>	* <i>Melania rivularis</i>
<i>Dyakia regalis</i>	* <i>Melania mülleri</i>
<i>Trochomorpha planorbis javanica</i>	* <i>Melania coffea</i>
<i>Amphidromus interruptus</i>	* <i>Melania semicostata</i>
<i>Leptopoma whiteheadi</i>	* <i>Vivipara costata</i>
<i>Cyclotus biciliatus</i>	† <i>Neritina flavovirens</i>
<i>Alyceus hochstetteri</i>	† <i>Neritina inconspicua</i>

CELEBES (not Sumatra, Borneo or Lesser Sunda Islands)

<i>Helicarion adolfi</i>	* <i>Limnaea javanica ventrosa</i>
<i>Philomycus striatus</i>	* <i>Melania testudinaria</i>
<i>Sitala javana</i>	† <i>Stenothyra moussoni</i>
<i>Kaliella platyconus</i>	† <i>Stenothyra ventricosa</i>
<i>Amphidromus interruptus sultanus</i>	† <i>Neritina labiosa</i>
<i>Japonia ciliocincta</i>	† <i>Neritina subocellata</i>

LESSER SUNDA ISLANDS (not Sumatra or Borneo)

<i>Kaliella angigyra</i>	<i>Helicina oxytropis</i>
<i>Kaliella indifferens</i>	* <i>Melania anthracina</i>
<i>Trochomorpha tricolor</i>	* <i>Melania semiornata</i>
<i>Trichochloritis transversalis</i>	* <i>Vivipara gratiosa</i>
<i>Amphidromus furcillatus</i>	* <i>Septaria suborb. furcato-radiata</i>
<i>Succinea javanica</i>	† <i>Cassidula sulculosa</i>
<i>Leptopoma moussoni</i>	† <i>Melampus granifer</i>
<i>Diplommatina auriculata</i>	† <i>Neritina faba</i>

MOLUCCAS - N. GUINEA (not other islands)

<i>Hemiplecta densa herklotsiana</i>	* <i>Melania coarctata</i>
<i>Macrochlomys amboinensis</i>	* <i>Melania terebriformis</i>
<i>Sitala bandongensis</i>	* <i>Melania inhonesta</i>
<i>Trochomorpha lardea</i>	† <i>Melampus luteum</i>
<i>Opeus clavulinum</i>	

be accounted for by any direct connection between Java and these remote parts of the Archipelago. All these species belong to genera which are found also in Sumatra or Borneo and their discovery in the interjacent islands may be a question of time only.

Now that we have dealt with the zoogeographical relations of the different groups of animals we may discuss more in detail the problems these relations have raised.

DIRECT RELATION TO ASIA.

One of the most interesting features of the Java fauna and one that has puzzled many a worker is the presence in Java of a certain number of animals which do not occur in Sumatra or Borneo or even in the Malay Peninsula, but reappear in some remote part of the Asiatic continent.

Before entering on an explanation of this certainly extraordinary fact we may point out here again the different groups, mentioned above as instances of this curious phenomenon. Excluding those species which in future may yet be discovered in Sumatra, there are only very few mammals, among which a rather proportionately large number of bats, which are either identical with, or exhibit a closer similarity to Asiatic forms, than to those of the geographically nearer countries. Of the birds it is seven per cent. of the total number of resident species which shows such an anomalous distribution; with the reptiles this proportion is already lowered to a little more than three per cent., whereas among the batrachians and the fresh-water fishes there is only one species in each group which, with any certainty, may be said to show a direct relationship to Asia. With regard to the molluscs it is also an almost negligible fraction, viz., eight out of a total number of 370 species, which can be taken as evidence of a special relation of the Java fauna to that of Asia proper.

Now, as to the attempts that have been made to explain these facts, WALLACE in his "Geographical Distribution of Animals" made the suggestion — according to the conception, strongly advocated by him in those days, that such an anomalous distribution could be explained only by former land connections — that Java and Siam in an earlier period must have been brought into close connection, while Sumatra and Borneo by some means must have got out of the way. Nowadays the theory of continental drift has many supporters, and according to them such a curious shifting of large islands might be regarded as not quite impossible, but WALLACE himself has apparently found his earlier hypothesis too fantastic.

Later in his book "Island Life" he has given another explanation:— during the glacial epoch Himalayan species may have been driven southward and reached Java, but before they could return, when the cold has passed away from their former home, they became imprisoned owing to the island having become separated from Asia and the other Sunda Islands.

Other scientists have also thought of a former land bridge between Java and the Asiatic continent by the way of the smaller islands lying off the west coast of Sumatra and the Malay Peninsula as a probable solution of the problem.

Now, it would not be wise to lay too much stress on this closer relation to the Asiatic continent, as it is shown only by small percentages of the groups under consideration here. Any direct land connection or general change of climate would certainly have affected a larger proportion of the fauna. Furthermore the fact must be emphasized that this remarkable resemblance to the fauna of distant regions is mainly shown by bats and birds, in a far less degree by the reptiles and is almost negligible in the amphibia, fresh water fishes and molluscs. We need not suppose any direct connection between Java and Asia, for this remarkable similarity of remote species does not hold good for those animals which are most in need of land connections for their dispersal.

And as to the birds and bats even the present geographical conditions of land and sea would not prevent them to spread all over the chain of islands stretching from the Asiatic continent to Java.

For the same reasons we have to reject the hypothesis given by WALLACE in his "Island Life" as even nowadays hardly any species of bat or bird can be considered a prisoner in Java; the many birds and the bats already present now on Krakatau prove that the Sunda Straits between Java and Sumatra are no effective barrier for animals with any power of flight. Moreover, all the mammals and birds which have been mentioned before in this connection are found abundantly in the lowlands, not to mention the general opinion of geologists today that the Malay Archipelago has not been affected by the cold of the glacial epoch. Once arrived in Java or Sumatra there could have been no reason whatever for the animals to "return" to their original home.

The cousins SARASIN in their "Materialen zur Naturgeschichte der Insel Celebes" have suggested still another solution of the problem. They are of opinion that a number of animals, which were superseded by other species in Sumatra or Borneo, could have held their own in Java after this island became separated from the Asiatic continent.

Now, here the question arises whether these similar species, common to Java and the Asiatic mainland, were not superseded in the latter region, the home of the new invaders. But I agree with these authors that the present problem has to be considered less as a geographical one than as a biological one. It has to be put in this way: why did a number of species become extinct in Sumatra, a few also in Borneo and the Malay Peninsula, which could remain alive in Java and on the Asiatic continent. That some species found in Java have become extinct or are very rare in Sumatra is indisputable; for instance the Java rhinoceros, formerly supposed to be lacking from Sumatra, has recently been found to occur also in

south Sumatra, but it is a rare animal there, confined to certain localities. We cannot maintain that it has been superseded in Sumatra by the two-horned rhinoceros, as the two species inhabit together Burma and the northern part of the Malay Peninsula. Also man cannot be made responsible for its rareness in Sumatra, as the same species could subsist much better in the more densely populated Java.

On the other hand other species, which occur in Java and Asia and not in the intervening countries cannot be considered relics proper, like the rhinoceros and perhaps the peacock. We are unable to give for the moment any reasonable explanation why, for such birds as the black drongo, the two species of mynah or the weaver-bird, Java and India should be more suitable dwelling-places than Sumatra or Borneo.

RELATIONS TO SUMATRA AND BORNEO.

When discussing the relationship of the Java fauna with that of Sumatra and Borneo we have to call to mind the great preponderance of the species common to Java and Sumatra over those which inhabit Java and Borneo. The closer relation to Sumatra is even more evident from the number of species which occur both in Sumatra and Java, and which are not found in Borneo. On the other hand the number of species which Java and Borneo have in common and are absent from Sumatra is exceedingly small. If we omit from the figures given in the schedule on page 3 those species which probably will be found in Sumatra in course of time and a few others which possibly have been introduced into Borneo, there are very few species left which inhabit Java and Borneo and are missing in Sumatra. Only one mammal, the banteng, belongs to this category, as the silvery gibbon of Java and the same species from Borneo are rather distinct and have a very near relative in Sumatra. Among the birds the proportion of species more or less restricted to Java and Borneo is likewise very low and the majority is also found on the Asiatic continent. With regards to the reptiles here again a great many of the species recorded from Java and Borneo and not from Sumatra may be discovered in future in the latter island, while other members of this group have their main centre of dispersal in the eastern part of the Archipelago.

The doubtful *Rana whiteheadi*, the only species of the batrachians lacking from Sumatra and common to Java and Borneo, cannot be put forward as an evidence of a direct connection between the last-mentioned islands.

In the pages above we have already referred to the fact that there is also hardly any species of fresh-water fish that is confined to the South Borneo and Java rivers, and, as was pointed out by DE BEAUFORT, the similarity of the fish fauna of Java to the East Borneo Mahakam river is even greater than to the South Borneo Barito river. According to him the fish fauna of the Mahakam has to be considered an older one and

from the nearer relation of the Java fish fauna to that of the said Borneo river we may infer that Java has received less recent forms.

The Molluscs exhibit the same striking characteristics, a very low percentage of Java species found in Borneo which are not represented in Sumatra; many of these are sure to be found later on in the latter island, while there may be also a single species from eastern origin.

The facts expounded above taken all together teach us irrefutably that Java has obtained its fauna exclusively from Sumatra and that there is no reason whatever for postulating any direct connection between Borneo and Java, at least at comparatively recent times. The exceptions to this rule nearly all concern animals also present on the Asiatic mainland or near relatives of which occur there and which undoubtedly invaded the Archipelago from the west. If they inhabit Java and Borneo nowadays and not the intervening countries, such as Sumatra or the Malay Peninsula, we may put down this discontinuous distribution to the same cause as referred to above with regard to the problem of a direct relation of Java to the Asiatic continent. The very few instances of animals which Java and Borneo have in common, to the exclusion of Sumatra, can be interpreted in the same manner as those of species occurring in Java and on the Asiatic continent, and not in the other Greater Sunda Islands.

If we arrive at the conclusion that Java and Borneo were separated from each other long ago, it follows that the Java Sea did exist at the time the recent fauna was spreading all over the western part of the Archipelago. The very close relationship of the Java fauna to the Sumatra one, however, cannot be explained without supposing a land connection between the two at the same period when Sumatra and Borneo were united. The belief in the latter union is forced upon us by the very near zoogeographical relations of the last-named two islands.

The view advanced here has also been advocated by the SARASINS and this too because Java and Borneo have no species in common which do not occur in Sumatra. Our supposition is also in accordance with the opinion by VAN ES who, on geological grounds, assumed the Java Sea to be a very old basin (see map).

Our supposition is, on the contrary, incompatible with the views of MOLENGRAAFF, who in his well-known paper of 1919 demonstrated that in pleistocene age the Java Sea did not exist and that at that time the vast plain extending between Java and Borneo was intersected by a large river taking its course north of the Karimon-djawa and Bawean islands and flowing into the southern part of the Macassar Straits. Of this hypothetical stream the South Borneo rivers were affluents.

As proof against such an extensive continental union of Borneo and Java at that period may be taken the absence of any faunistical similarity in a direct sense between the two islands. If this supposed connection ever did exist, a closer relation of the Java fauna to that of South Borneo

would be noticeable, especially with regard to fresh-water inhabitants. As already pointed out above, there is hardly any fact to support the existence of such a relation.

We also wish to call attention to the investigations of CORNELIS, who, upon instigation of MOLENGRAAFF, has tried to trace the submerged rivers required to support his hypothesis. Now, he could not find any indications of the existence of such a large river basin in the Java Sea, which, according to the above mentioned author, once flowed there, while the very short extensions into the sea of some South Borneo rivers found by him are situated within the strip of land along the Borneo coast that became dry in the pleistocene period, according to VAN ES's views. On the other hand indications of the large hypothetical rivers and their affluents supposed to have flowed through the pleistocene plain between Borneo and Sumatra and uniting at that time some of the East Sumatra rivers with the West Borneo ones (see map) have actually been discovered.

In distinction with the relations of the Java fresh-water fauna to that of Borneo the very close relationship between it and that of South Sumatra is undeniable.

As was stated in the foregoing pages the proportion of fresh-water fishes identical to Java and South Sumatra amounts to no less than 89 per cent. of the total number of the non-endemic species found in Java.

According to the map drawn by VAN ES the connection of Java with South Sumatra during pleistocene times was a very narrow one, the Sunda Straits penetrating far into the land uniting the two countries. But we need not admit that the present sounding lines have always been the same in remote ages, so it is quite possible that the Sunda Straits have become deeper only after the Indian Ocean and the Java Sea were linked together or that the land connection between Java and Sumatra disappeared afterwards by subsidence.

The poverty of Java's fauna generally, when compared with that of Sumatra and Borneo, as also the greater abundance of species to be found in West Java, could readily be accounted for by the narrow strip of land connecting the two islands in the past. We have, however, to draw attention to the fact that formerly Java could boast of a much richer fauna; this is clearly demonstrated by palaeontological findings, but this older fauna became mostly extinct in the pleistocene age, in the period that the recent species were penetrating into the island. The far reaching volcanic action in Java at the end of the tertiary period may partly be held responsible for the disappearance of many of the older species, but we must not forget that in Sumatra and Borneo where there was no such action, at least not in the same measure as in Java, the greater part of the pleistocene animals died out also. The more recent fauna seems to have been affected to a far less degree by these volcanic phenomena; at least as far as we know at present the pig-tailed monkey (*Macacus nemestrinus*) is the only recent vertebrate animal that



———— coast-line of the pleistocene Sunda Land, according to MOLENGRAAFF;
 - - - - - coast-line of the Java Sea in pleistocene time, according to VAN ES;
 hypothetical rivers.

became extinct in Java, all other pleistocene vertebrates known from the island, except a few fishes, having died out everywhere else too.

Anyhow we have to reckon with two elements of the Java fauna, an older one and a more recent one. The views set forth above refer only to the question how Java has obtained its recent inhabitants.

Without going further into the controversies of geologists as to whether the Java Sea was existent or not in the post-pliocene and early pleistocene period, we may emphasize only that the zoogeographical relations of the fauna of Java are strongly in favour of any theory by which the Java Sea is supposed to be an open sea at the time the recent fauna invaded the island.

If the above supposition relating to the Java Sea is correct then the Karimon-djawa and Bawean islands situated in that sea must have remained isolated during the period the recent fauna came into Java and ought to be destitute of more modern species, except those which could reach these islands on the wing or have been imported by man. These islands may also harbour some elements of an older fauna, elements superseded in Java or elsewhere by recent species. So far as our present knowledge goes, there occur no genuine fresh-water fishes in these islands and this absence would certainly be in support of our theory. We hope to deal with the fauna of these islands in a future paper, as a thorough survey of it has been planned and partly already achieved by the author.

RELATION TO CELEBES.

We will now shortly summarize the features showing the relations between the fauna of Java and that of Celebes. We have already noted that there are no mammals common to Java and Celebes that may be mentioned in proof of a direct connection between the two islands. All the Celebes mammals known also from Java could have been introduced by human agency or could have reached the island without any land bridge, such as the bats.

The same can be said of the birds, the intervening chain of islands between Java and Celebes could easily have been used as stepping-stones before entering the latter island. We must also keep in mind that in pleistocene times the coast of East Borneo came to within a much shorter distance of the west coast of Celebes, so that at that time at least the Macassar Straits were a far less effective barrier for animals with power of flight than nowadays. The presence of the red jungle fowl (*Gallus gallus*) in Celebes which is not considered a strong flyer and does not occur in Borneo, may almost certainly be set down to importation. Other species of birds not found in Borneo are mostly of eastern origin and may have reached Celebes and Java along other routes. Another noteworthy fact is that such families of birds, which find their western boundaries of distribution in Java and Borneo, such as the *Capitonidae*, the *Pycnonotidae*, and nearly all woodpeckers, have not invaded Celebes.

The same holds good of the genuine fresh-water fishes, there is not a single species that has been capable of penetrating into the island.

As to the Molluscs we may mention here once more the suggestive feature that the proportion of identical fresh-water species which Java and Celebes have in common is much higher than that of the terrestrial ones. This must be attributed chiefly to the fact that the greater part of the fresh-water molluscs are able to live also in brackish water, and we may therefore not bring forward these species in support of a former land connection. It is a remarkable fact too that the fresh-water bivalves belonging to the family *Unionidae* which have spread over all the island of the western part of the Archipelago are lacking from Celebes.

Now, the cousins SARASIN have emphatically advocated the theory of an independent land connection between Java and Celebes, mainly on account of the great similarity of the Java mollusc fauna and that of the latter island. The first thing, that calls for special attention, is the fact that our present knowledge of the Java molluscs teaches us that the proportion of species confined to Java and Celebes has materially changed. Whereas the SARASINS based their views on 24 species of land and fresh-water molluscs common to the two islands and on 9 species confined to them, or a proportion of 37.5 %, we now know 52 such species in common and 8 species restricted, or a percentage of 15.4.

Furthermore we observed in the preceding pages that the percentages of terrestrial species common to Java and Borneo and respectively Java and Celebes are about the same. And as we arrived at the conclusion that a former direct land connection between Java and Borneo is highly improbable, this percentage of identical molluscs can hardly be taken in this case as evidence in support of a land bridge between Java and Celebes. If we premise such a land bridge, it seems unaccountable to us why not one fresh-water fish or one of the more recent mammals, nor the Unionids among molluscs, neither a number of bird families, were able to cross it.

Also the geologists VAN ES and MOLENGRAAFF, whose starting-points are widely divergent, do not surmise a land connection between Java and Celebes in post-pliocene and early pleistocene time.

In our opinion there is a more probable explanation for this relatively high percentage of identical species of molluscs occurring in Java and Celebes. The molluscs are in comparison with most vertebrates a very ancient group of animals, many genera date back from the Mesozoic period and quite a number of recent species are to be traced from the Miocene age, such as members of the genus *Melania* in Java. For tracing the derivation of the more recent fauna these ancient genera and species are mostly too unreliable guides. Most probably they arrived already in Celebes before the time the intrusion of the recent fauna of Asia into the Greater Sunda Islands took place. How in these more remote times the conditions of land and

sea have been cannot be deduced from the present distribution of the species and our knowledge of the fossil fauna of Celebes and the Greater Sunda Islands, Java being excepted, is too scanty to allow us to express a conclusive opinion.

There may yet be another reason for the similarity of the terrestrial species of molluscs inhabiting Java and Celebes, viz., the corresponding calcareous soil in both islands, especially so in East Java and South Celebes, to which VON MARTENS has already directed the attention. But we must not forget in this connection that Java and Borneo have about the same number of land molluscs in common, whereas there is little similarity as to soil conditions in these two islands.

RELATION TO THE LESSER SUNDA ISLANDS.

In the preceding pages we have seen how comparatively small the number of species is which have invaded the Lesser Sunda Islands from Java, if we exclude those which could have reached these islands either through the air or by sea, like the bats, the majority of the birds and the reptiles, or by the intermediary of man. There is, however, a sharp line of demarcation as far as distribution is concerned between Bali and the remaining islands of this group. Among the terrestrial mammals the tiger, the squirrels and *Tupaia*, and among the birds a great many of the species placed in the list as occurring in Java and these eastern islands do not cross the Lombok Straits. Out of the six species of woodpeckers common to Java and these islands no less than five, like all the members belonging to the families of the *Capitonidae* and *Bucerotidae*, do not go further than Bali. On the other hand, none of the batrachians from western origin stop at Bali, a few going even as far as Timor, and out of the six fresh-water fishes found in Java and the Lesser Sunda Islands two only make a stand before the Lombok Straits. This seems somewhat in contradiction with the fact that the latter straits are such an effective barrier for so many mammals and birds and we ought to be careful in supposing too readily the existence of former land bridges between these islands. Even a former land connection between Java and Bali seems hardly a necessary hypothesis, as in some parts the Bali Straits are so narrow that Java and Bali are only two kilometres (one nautical mile) apart, whereas the Lombok Straits, at the narrowest section, between Noesa Besar and southwest Lombok, are at least 21 kilometres wide, Noesa Besar itself being again 12 km distant from Bali.

Moreover, the heavy traffic of small native boats sailing between these islands may not be eliminated as an important factor in the dispersal. That only western species should have come to these islands and hardly any eastern species in the opposite direction may be imputed to the fact that only the more recent forms from western origin are able to extend

their range, whereas the members of the older and weaker fauna inhabiting the eastern part of the Archipelago, once introduced into western regions have no chance to hold out against the more vigorous modern species.

The case of Krakatau further teaches us how easily an island gets populated with birds, reptiles and even some mammals, without the intermediary of any land bridges or man. The somewhat irregular distribution of many species over the Lesser Sunda Islands may probably be put down to their more or less fortuitous arrival if their dispersal took place by sea.

Moreover, the change of climatic conditions which occurs in these islands going from west to east may have prevented the establishment of more than one species coming from the western islands.

I think, in reviewing the zoogeographical relations of the Lesser Sunda Islands, all these factors — dispersal through the air or by sea, introduction by man, either on purpose or unintentionally, and the transitional conditions of climate and other physical features — must be considered of far greater importance for the present state of the fauna, than all hypothetical landbridges, which might at some earlier period have linked all these islands together.

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Appendix I.

A LIST OF THE MAMMALS KNOWN FROM JAVA.

By

K. W. DAMMERMAN

(Buitenzorg).

(an undulating line means that the species is likely to occur but that exact localities are not recorded).

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks ¹⁾
Primates									
<i>Hylobates leuciscus</i> Geoffr.			—			—			
<i>H.l. leuciscus</i> Geoffr.			—						
<i>Macaca irus</i> F. Cuv.			—						
<i>M.i. mordax</i> Thos. & Wr.			—	—	—				
<i>Pithecus pyrrhus</i> Horsf.			—						
<i>P.p. sondaicus</i> Roh. & Kloss.			—						
<i>P.p. pyrrhus</i> Horsf.					—				
<i>Pithecus aygula</i> L.		—	—				—		
<i>P.a. aygula</i> L.		—	—						
<i>Nycticebus coucang</i> Bodd.		—	—						
<i>N.c. javanicus</i> E. Geoffr.			—						
<i>Tarsius tarsius</i> Erxl.		—	~~~~~	~~~~~					
<i>T.t. subsp.</i>									
Ungulata									
<i>Bos banteng</i> Raffl.	—	?	—						
<i>B.b. banteng</i> Raffl.			—						
<i>Bos bubalis</i> L.			—						introduced
<i>Cervus hippelaphus</i> Cuv.		?	—						
<i>C.h. hippelaphus</i> Cuv.			—						
<i>Muntiacus muntjak</i> Zimm.			—					?	
<i>M.m. muntjak</i> Zimm.			—						
<i>Tragulus kanchil</i> Raffl.			—						
<i>T.k. pelandoc</i> H. Smith.			—						

¹⁾ If the species is not known from one of the surrounding regions or if the distribution is discontinuous the nearest locality to Java only is given.

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
<i>Canis familiaris tenggerana</i> Kohlb. ...									domesticated
<i>Mydaus javanensis</i> Desm.									
<i>M.j. javanensis</i> Desm.									
<i>Helictis orientalis</i> Horsf.									India
<i>Mustela flavigula</i> Bodd.									
<i>M.f. henrici</i> West.									
<i>Mustela lutreolina</i> Rob. & Kloss.									
<i>Mustela nudipes</i> F. Cuv.									
<i>Lutra cinerea</i> Illig.									
<i>Lutra sumatrana</i> Gray.									
Rodentia									
<i>Lepus nigricollis</i> F. Cuv.		?							India
<i>Hystrix brachyura</i> L.							?		
<i>H.b. javanica</i> F. Cuv.									
<i>Petaurista petaurista</i> Pall.									
<i>P.p. petaurista</i> Pall.									
<i>P.p. nigricaudatus</i> Rob. & Kloss.									
<i>Petaurista elegans</i> Temm.									
<i>Iomys horsfieldi</i> Waterh.									
<i>I.h. horsfieldi</i> Waterh.									
<i>Sciuropterus sagitta</i> L.									
<i>S.s. sagitta</i> L.									
<i>Sciuropterus genibarbis</i> Horsf.									
<i>S.g. genibarbis</i> Horsf.									
<i>Ratufa bicolor</i> Sparrm.									
<i>R.b. bicolor</i> Sparrm.									
<i>R.b. albiceps</i> Desm.									
<i>Sciurus notatus</i> Bodd.									
<i>S.n. notatus</i> Bodd.									
<i>S.n. balstoni</i> Rob. & Kloss.									
<i>S.n. tamansari</i> Kloss									
<i>S.n. madurae</i> Thos.									Madura
<i>Sciurus nigrovittatus</i> Horsf.									
<i>S.n. nigrovittatus</i> Horsf.									
<i>S.n. besuki</i> Kloss.									
<i>Sciurus diardi</i> Jent.									N. Kam- bangan

Appendix II.

A LIST OF THE BIRDS OCCURRING IN JAVA.

(The names are according to the list of Java birds by M. BARTELS JR. and E. STRESEMANN, see next paper.)

o means species which have been found breeding or are likely to breed in Java;

N. means migratory species from the Northern hemisphere;

S. idem from the Southern hemisphere.

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
Podicipediformes									
Podiceps ruficollis Lath.									
o P.r. philippensis (Bonn.)									
Procellariiformes									
Oceanodroma monorhis (Swinh.)									
N. O.m. monorhis (Swinh.)									
Gruiformes									
o Hypotaenidia striata (L.)									
o Rallina fasciata (Raffl.)									
N. Rallina superciliaris Eyton (?)									
Porzana pusilla (Pall.)									
N. P.p. pusilla (Pall.)									
Poliolimnas cinereus (Vieill.)									
o P.c. cinereus (Vieill.)									
Limnobaenus fuscus (L.)									
o L. fuscus fuscus (L.)									
N. Limnobaenus paykulli (Ljungh)									
Amaurornis phoenicura (Forst.)									
o A.p. javanica (Horsf.)									
Gallinula chloropus (L.)									
o G.c. orientalis (Horsf.)									
N. Gallirex cinerea (Gm.)									
Porphyrio melanotus Temm.									
o P.m. indicus Horsf.									
Fulica atra (L.)									
F.a. subsp.									

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
Corvus enca (Horsf.)									
o C.e. enca (Horsf.)									
Corvus coronoides Vig. & Horsf. ...									
o C.e. macrorhynchos Wagl.									
Kitta chinensis Bodd.									
o K.e. thalissina Temm.									
o Crypsirhina varians (Lath.)									
Platylophus galericulatus (Cuv.) ...									
o P.g. galericulatus (Cuv.)									
(N?) Dicrurus annectans (Hodgs.)									
Dicrurus macrocerus Vieill.									
o D.m. javanus Kloss.									
Dicrurus leucophaeus (Vieill.)									Asia
o D.l. leucophaeus (Vieill.)									
Dicrurus hottentottus (L.)									
o D.h. termeuleni (Finsch)									Java Sea
o D.h. jentinki (Vord.)									
Bhringa remifer (Temme.)									
o B.r. remifer (Temme.)									
Dissemurus paradiseus L.									
o D.p. formosus Cab.									
Oriolus chinensis L.									
o O.c. maculatus Vieill.									
Oriolus xanthonotus Horsf.									
o O.x. xanthonotus Horsf.									
Oriolus cruentus (Wagl.)									
o O.c. cruentus (Wagl.)									
Artamus leucorhynchus (L.)									
o A.l. amydrus Oberh.									
Gracupica melanoptera (Daud.)									Asia
o G.m. melanoptera (Daud.)									
o G.m. tricolor (Horsf.)									
Aethiopsar grandis (Moore)									Asia
o A.g. javanicus (Cab.)									
Sturnopastor contra (L.)									Asia
o S.c. jalla (Horsf.)									
N. Sturnia sturnina* (Pall.)						?			

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
o Z.a. buxtoni Nich.									
Zosterops parvula Hombr. & Jacq...									
o Z.p. gallio Sharpe									
o Zosterops flava (Horsf.)									
o Zosterops maxi Finsch									Java sea
Zosterops palpebrosa (Temm.)									
o Z.p. sindorensis Siebers									
o Z.p. neglecta Seeb.									
Oreosterops javanica (Horsf.)									
o O.j. frontalis (Reich.)									
o O.j. javanica (Horsf.)									
o O.j. elongata Stres.									

Appendix III.

A LIST OF THE REPTILES FROM JAVA.

After "N. DE ROOY, Indo-Australian Reptiles, I & II 1915 - '17"

Revised

by

L. D. BRONGERSMA

(Amsterdam)

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
Lacertilia.									
Gymnodactylus marmoratus (Kuhl)					?				
Gymnodactylus fumosus F. Müll.									
Hemidactylus frenatus D.B.									
Hemidactylus garnoti D.B.									
Hemidactylus platyrus (Sehn.)									
Mimetozone craspedotus (Mocq.)									
Gehyra mutilata (Wieg.)									
Hemiphyllodactylus typus Blkr.									
Lepidodactylus ceylonensis Blgr.									
Gecko vittatus Houtt. (?)									Timor
Gecko monarchus (D.B.)									
Gecko verticillatus Laur.									
Gecko stentor (Cant.)									
Ptychozoon homalocephalum (Crev.) ...									
Draco volans L.									
Draco lineatus Daud.									Moluccas
Draco fimbriatus Kuhl.									
Draco cryptotis Despax									
Draco haematopogon Gray									
Cophotis sumatrana Hubr.									
Harpesaurus tricinctus (A. Dum.)									
Gonyocephalus kuhli (Schleg.)									
Gonyocephalus chamaeleontinus (Laur.)									
Dendragama fruhstorferi Boettger									
Calotes cristatellus (Kuhl)									
Calotes jubatus (D.B.)									Singkep

Appendix IV.

A LIST OF THE AMPHIBIA FROM JAVA.

After "V. KAMPEN, Indo-Australian Amphibia, 1923."

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
Gymnophiona									
<i>Ichthyophis glutinosus</i> (L.)									
<i>Ichthyophis monochrous</i> (Balkr.)									
Anura									
<i>Megalophrys montana</i> K. et v.H.									
" <i>hasselti</i> (S. Müll.)									
<i>Nectophryne borbonica</i> (Boie)									
<i>Bufo cruentatus</i> Tschudi									
" <i>melanostictus</i> Schneid.									
" <i>asper</i> Gravn.									
" <i>parvus</i> Blgr.									
" <i>biporcatus</i> Gravh.									Tenasserim?
" <i>chlorogaster</i> Daud.									
<i>Kaloula baleata</i> (S. Müll.)									
<i>Microhyla achatina</i> Boie									
" <i>annectens</i> Blgr.									
" <i>palmipes</i> Blgr.									Madura
<i>Rana limnocharis</i> Boie									
" <i>cancrivora</i> Gravh.									
" <i>macrodon</i> Kuhl									
" <i>doriae</i> Boul.									
" <i>kuhli</i> Schl.									
" <i>microdisca</i> Bttgr.									
" <i>hascheana</i> (Stol.) (?)									
" <i>jerboa</i> (Gthr.)									
" <i>whiteheadi</i> Blgr.									
" <i>hosii</i> Blgr.									
" <i>chalconota</i> (Schl.)									
" <i>erythraea</i> (Schl.)									
" <i>nicobariensis</i> (Stol.)									

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
<i>Oxyglossus lima</i> (Kuhl)	—				—				
<i>Rhacophorus leucomystax</i> (Kuhl)	—	—	—	—	—	—	—	—	
„ <i>javanus</i> Bttgr.			—						
„ <i>reinwardti</i> (Boie)		—	—	—	—	—			
<i>Philautus flavosignatus</i> (Bttgr.)			—						
„ <i>jacobsoni</i> (v. Kamp.)				—					
„ <i>pallidipes</i> (Barb.)			—						
„ <i>vittiger</i> (Blgr.)			—						
„ <i>aurifasciatus</i> (Schleg.)		—	—	—	—				
<i>Nyctixalus margaritifer</i> Blgr.				—					
„ <i>robinsoni</i> Annand.			—						

Appendix V.

A LIST OF THE FRESH-WATER FISHES OCCURRING IN JAVA.

After "WEBER and DE BEAUFORT, Indo-Australian Fishes I - IV, 1911 - 1922."

Revised

by

Prof. L. F. DE BEAUFORT
(Amsterdam).

† means brackish-water or semi-marine species.

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
Malacopterygii									
† Megalops cyprinoides (Brouss.)									
Notopterus notopterus (Pall.)									
" chitala (H.B.)									
† Setipinna melanochir (Blkr.)									
† Stolephorus tri (Blkr.)									
† Pellona xanthoptera Blkr.									
Siluroidea									
† Clarias melanoderma Blkr.									
† " nieuhofi C.V.									
† " batrachus (L.)									
† " teysmanni Blkr.									
Wallago attu (Bl. Schn.)									
Silurodes hypophthalmus (Blkr)									
Callichrous bimaculatus (Bl.)									
Hemisilurus scleronema Blkr.									
Cryptopterus bicirrhis (C.V.)									
" mononema (Blkr.)									
" micronema (Blkr.)									
" hexapterus (Blkr.)									
† Plotosus canius Ham. Buch.									
† " anguillaris (Bl.)									
Lais hexanema (Blkr.)									
† Pangasius pangasius (Ham. Buch.) ...									
" polyuranodon Blkr.									

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
† Mugil seheli Forsk.									
† „ heterochilus Blkr.									
Labyrinthici									
Ophiocephalus striatus Bl.									
† „ gachua H.B.									
„ lucius (K.v.H.)									
„ micropeltis (K.v.H.) ...									
† Anabas testudineus (Bl.)									
Polyacanthus hasselti C.V.									
Helostoma temmincki C.V.									
Osphronemus goramy Lac.									
Ctenops vittatus (C.V.)									
Betta picta (C.V.)									
Trichopodus trichopterus (Pall.)									
† Aplocheilus javanicus Blkr.									
† Panchax panchax (H.B.)									

Appendix VI.

A LIST OF THE LAND AND FRESH-WATER MOLLUSCA FROM JAVA.

By

TERA VAN BENTHEM JUTTING
(Zoological Museum, Amsterdam).

† means brackish-water genera

* means fresh-water genera

an undulating line means that the species is known from Java but that exact localities are not recorded.

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks ¹⁾
Gastropoda.									
<i>Ennea bicolor</i> Hutton	—		—	—	—	—	—	—	Molluccas
<i>Helicarion adolfi</i> Boettg.			—	—	—		—		
„ <i>albellus</i> v. Marts.			—	—	—		—		
„ <i>fruhstorferi</i> v. Moell.			—	—	—		—		
„ <i>lineolatus</i> v. Marts.			—	—	—		—		
„ <i>perfragilis</i> v. Moell.			—	—	—		—		
<i>Vitrinopsis collingei</i> Schepman			—	—	—		—		
„ <i>dohrni</i> Boettg.			—	—	—		—		
<i>Atopos ouwensi</i> Collinge			—	—	—		—		
<i>Parmarion luteus</i> v. Marts.			—	—	—		—		
„ <i>maculosus</i> Wiegmann			—	—	—		—		
„ <i>planus</i> v. Marts.			—	—	—		—		
„ <i>pupillaris</i> Humbert			—	—	—		—		
„ „ <i>var. punctata</i> v. Marts. ..			—	—	—		—		
„ „ <i>marmorata</i> v. Marts			—	—	—		—		
„ „ <i>vittata</i> v. Marts. ...			—	—	—		—		
„ <i>reticulatus</i> v. Hasselt		—	—	—	—		—		
„ <i>taeniatus</i> v. Hasselt		—	—	—	—		—		
„ <i>weberi</i> Simroth		—	—	—	—		—		
<i>Microparmarion austeni</i> Simroth			—	—	—		—		
„ <i>boettgeri</i> Simroth			—	—	—		—		
„ <i>fruhstorferi</i> Simroth ...			—	—	—		—		
„ <i>jacobsoni</i> Schepman...			—	—	—		—		
„ <i>javanica</i> Collinge			—	—	—		—		
<i>Collingea strubelli</i> Simroth			—	—	—		—		Sebesy
<i>Philomyces striatus</i> v. Hasselt			—	—	—		—		

¹⁾ Under "remarks" the nearest locality to Java is given if the species is not known from one of the regions listed or if the distribution is discontinuous.

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
<i>Hemiplecta acelidota</i> v. Moell.			—						
„ „ var. <i>robusta</i> v. Moell.			—						
„ <i>acutecarinata</i> v. Moell. ...			—						
„ <i>arguta</i> Pfr.		—	—						
„ <i>bataviana</i> v.d. Busch			—						
„ <i>centralis</i> Mouss.			—						
„ <i>densa</i> Ads. & Reeve	—	—	—			—			
„ „ var. <i>herklotsiana</i> Dohrn			—						N. Guinea
„ „ „ <i>moussoniana</i> v. Marts.			—						
„ <i>duplocincta</i> v. Moell.			—						
„ <i>humphreysiana</i> Lea	—		—						Natoena
„ „ var. <i>turbinata</i> v. Marts.			—						Anambas
„ „ „ <i>complanata</i> v. Marts			—						Nias
„ „ „ <i>gemina</i> v. Marts. ...			—						
„ <i>induta</i> Pfr.			—						
„ <i>javana</i> v. Marts.			—						
„ <i>marginata</i> v. Moell.			—						
„ <i>moussoni</i> Pfr.			—						
„ <i>patens</i> v. Marts.			—						
„ <i>rareguttata</i> Mouss.			—						
„ <i>umbilicaris</i> Guill.	—		—						
„ „ var. <i>sundana</i> v. Marts.			—						
„ „ „ <i>virescens</i> v. Marts.			—						
<i>Dyakia clypeus</i> Mouss.			—						
„ „ var. <i>zollingeriana</i> v. Marts.			—						
„ „ „ <i>jagoriana</i> v. Marts. ...			—						
„ <i>regalis</i> Bens.			—				—		Biliton
„ <i>rumphii</i> v.d. Busch	—	—	—						
„ <i>ryssolemma</i> Alb.			—						
<i>Xesta dwipana</i> Gude			—						
<i>Chiroktisma conus</i> Phil.			—						N. Baron
„ „ var. <i>lirata</i> Bttg.			—						
„ <i>multicarinata</i> Bttg.			—						
<i>Inozonites imitator</i> v. Moell.			—						
<i>Microcystina infans</i> Pfr.	—		—						
<i>Macrochlamys amboinensis</i> v. Marts. ...			—						Moluccas

	Mal. Pen.	Sumatra	W. Java	M. Java	E. Java	Borneo	Celebes	Less. Sd. I.	Remarks
<i>Pyramidula javana</i> v. Moell.									
<i>Trichochloritis crassula</i> Phil.		—	—	—	—				
„ <i>fruhstorferi</i> v. Moell.									
„ <i>helicinoides</i> Mouss.			—						
„ <i>tetragyra</i> v. Moell.									
„ <i>transversalis</i> Mouss.								—	
„ <i>malangensis</i> Bullen.					—				
<i>Amphidromus alticola</i> Fulton.									
„ <i>filizonatus</i> v. Marts.					—				
„ <i>furcillatus</i> Mouss.								—	
„ <i>heerianus</i> Pfr.			—						
„ „ <i>var. robustus</i> Fult.				—					
„ <i>interruptus</i> Müll.	—								
„ „ <i>var. emaciatus</i> v. Marts.					—				
„ „ „ <i>sultanus</i> Lam.				—			—		
„ <i>javanicus</i> Sow.			—						
„ <i>palaceus</i> Mouss.		—	—	—					
„ „ <i>var. purus</i> Mouss.			—						
„ „ „ <i>appressus</i> v. Marts.			—						
„ „ „ <i>tener</i> v. Marts.					—				
„ <i>perversus</i> L.	—		—						
„ „ <i>var. aurea</i> v. Marts. ...			—						
„ <i>porcellanus</i> Mouss.		—	—						
„ <i>winteri</i> Pfr.			—	—					
„ „ <i>var. inauris</i> Fult.					—				
<i>Pseudopartula galericulum</i> Mouss.			—		—				
„ „ <i>var. gedeanana</i> Pils.					—				
„ „ „ <i>fasciata</i> Anc.			—						
„ „ „ <i>impunctata</i> Anc.			—						
<i>Ganesella bantamensis</i> Smith.			—						
<i>Eulota similis</i> Fér.	—						—		
„ „ <i>var. subdepressa</i> v. Marts.			—						
„ „ „ <i>solidula</i> Mouss.			—						
„ „ „ <i>subsimilaris</i> v. Marts.			—						
„ <i>transversalis</i> Mouss.					—				
<i>Plectotropis ciliocincta</i> v. Moell.			—						

