THE FAUNA OF KRAKATAU, VERLATEN ISLAND AND SEBESY

by

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The terrible eruption of Krakatau, August 1883, has been an unexpected opportunity for biologists as perhaps will not occur for years. Although the consequences of the disaster were dreadful, no less than 30,000 people having perished, this experiment of Nature is of most interest for zoogeographical problems, especially how a barren island, wholly destitute of animal life, is reoccupied again.

The question about the total devastation of the fauna of the islands of the Krakatau-group in 1883 cannot be settled absolutely, but there is every evidence that no animal could have survived the eruption. From the 20th May till the 26th August the explosions followed each other with short interruptions, covering the islands with stones and ashes. By the last and most violent explosion the volcanoes Danau of 450 M. in height and Perbuwatan disappeared altogether, and the Peak of Rakata or Krakatau of 800 M. was split in its very midst and one half blown away. The three islands which remained after the eruption, Krakatau (Krakatoa), Verlaten Island (Forsaken I.) and Lang Island, were overshed by hot ashes, a layer of 30—60 M. thickness! No animal could have remained in his hiding place during the explosions and, buried by the ashes, it could not have escaped from destruction, the bottom layer of ashes remaining hot for days. The possibility that a single animal, concealed in a recess of the rocks, survived the disaster may be maintained, but such an animal would have perished after a short time as no food was available, the whole vegetation also being destroyed or burnt. All biologists who have visited the islands after the eruption are of the same opinion. But granted to sceptics that a single animal did survive and could maintain itself after the eruption, this is of little or no importance, for certainly 99 % of the animals living now on the islands are new invaders.

Now let us see what questions arise from the Krakatau-problem:—

1. First of all we may put the question:— In what sequence have animals reached the islands?
2. How far is the present condition of the fauna to be considered as normal? The answer would give us an indication of how long it will be before the islands again possess a fauna as rich as before the eruption.

3. From where did the present species arrive and how have they reached the islands?
4. Have local forms already originated on the islands?

1. The sequence in which animals have reached the islands.

Unfortunately zoologists have not interested thomselves enough in Krakatau. The fauna was not studied thoroughly for the first time until 25 years after the eruption, so it is quite impossible to answer the question which animals have reached the islands first?

SLUITER, who paid a short visit to Krakatau in November 1888 and July 1889, turned all his attention to the problem of the new growth of corals around the devastated island. He writes that time was not available to study the land fauna, which is most to be regretted. He was also on Krakatau before the disaster, namely in 1880, at which time narrow coral reefs were to be found at different localities, but during the eruption of 1883 all these were destroyed or covered by a layer of pumicestone and ashes as thick as 20 M. and more. In 1888 there was already a new reef growing in the bay of Zwarte Hoek (Black Hillock, see Map Fig. 1).

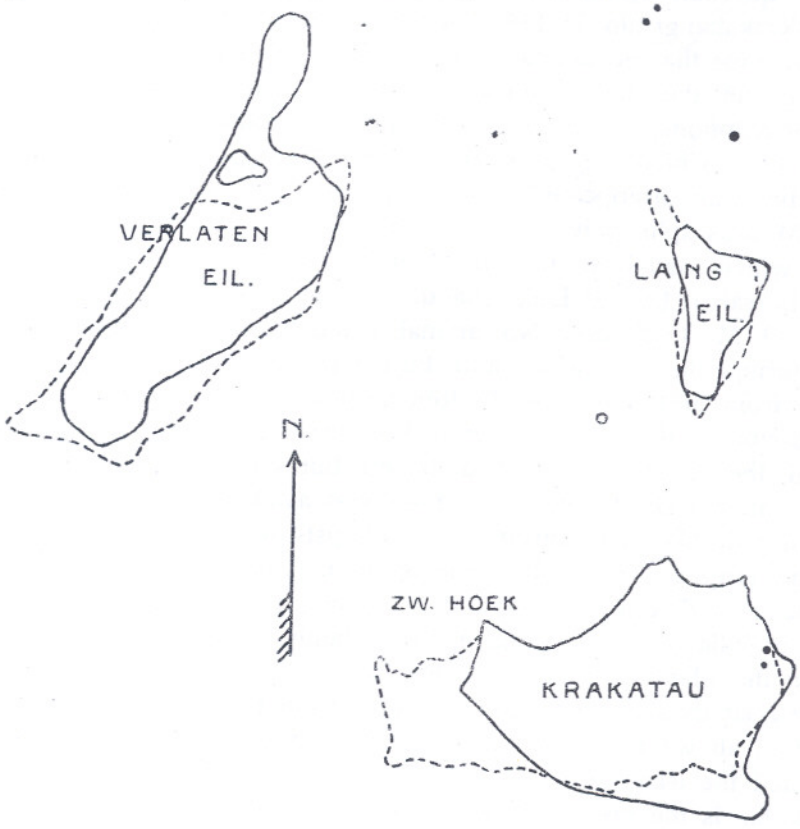

Fig. 1. Map of the Krakatau Islands, Scale 1: 125.000.
Dark lines indicate the present condition of the islands; the dotted lines the coastline shortly after the eruption (after VERBEEK).

Also at the west side of Zw. Hoek a fringing reef existed of 1 M. in breadth and 2 dM. in thickness, built up by *Madrepora nobilis* (DANA) and a few *Porites micronata* (DANA) and *Favia affinis* (M. EDW.).

In 1889 this reef, for the greater part, was destroyed again by blocks of basalt which fell from the steep rocks at this end of the island. In the bay big pumicestones were found grown over by corals (*Madrepora* and *Porites*); and *Seriatopora elegans* (M. EDW.) was observed forming "schon ganze Korallenwäldchen". Compact corals like *Fungia*, *Astrea* a.o. were not represented, but the other corals were growing over the whole bay, and SLUITER expected that it would be filled up by the coral reef simultaneously, and that later on a barrier reef would arise which would increase at the ocean side.

In April 1921 the author, together with Dr. H. BOSCHMA, had an opportunity to search after these coral formations at Zwarte Hoek, but none of the coral species mentioned by SLUITER could be retraced and in the bay no corals existed, apparently the oceanbreakers having destroyed all again. At the west side of Zwarte Hoek the former coralreef must have disappeared altogether because the coastline here has changed very much, (see Map Fig. 1). A big piece of land built up during the eruption of pumicestones and ashes has been washed away, the full ocean swelling breaking on the coast at this point of the island. But at the northern end of Krakatau, however, we found corals growing on the blocks of basalt at the foot of the steep rocks. *Porites*, *Madrepora* and the ramified *Pocillopora* of dark rose colour were observed at this place by Dr. BOSCHMA.

After SLUITER no zoologist seems to have visited the islands until 1908. The botanist ERNST, who made a trip to Krakatau in April 1906, communicates a few observations on land animals, but his remarks are too vague to be of much importance. It was in May 1908 that for the first time a more thorough survey of the fauna of Krakatau was made. Mr. JACOBSON visited all three islands at that time and has given a complete list of the animals found by him. As far as the species have been worked out by specialists, they are listed in Appendix B. Unfortunately the greater part of the species collected by him are still unidentified. The work of JACOBSON will be discussed at length below, but we will first mention the other zoologists who have been on the islands after him.

Five years after JACOBSON, in October 1913, Dr. KONINGSBERGER paid a very short visit to Krakatau, but probably time was too short for collecting as no further details are known. On the occasion of the first "Ned. Indisch Natuurwetenschappelijk Congres", in 1919, a trip to Krakatau and Verlaten I. was to be made. Therefore in April of that year Dr. DOCTERS VAN LEEUWEN, Director of the Botanical Gardens at Buitenzorg, visited the islands, Along with him were Mr. BARTELS, the wellknown ornithologist, and Dr. SUNIER, Chief of the Laboratory for Marine Investigations at Batavia. Mr. BARTELS collected many birds new to the islands;

Dr. SUNIER paid special attention to the brackish-water lake on Verlaten I. He also brought together a small collection of land animals and discovered for the first time true earthworms on Krakatau.

The above mentioned Congress was held at Batavia in October 1919; but as the excursion to Krakatau and Verlaten I. lasted not more than one day, only a few hours could be spent on both islands and there was no time for much collecting. At this Congress a new and complete survey of the flora and fauna of the islands was planned;— Dr. DOCTERS VAN LEEUWEN would do the flora and the author the fauna.

My first trip of longer duration was made in December 1919 when I visited Krakatau from 10—14 Dec. and Verlaten I. from 15—17 Dec. For a few days Mr. GROENEWEGE, bacteriologist at the Department of Agriculture, accompanied me. In the samples of soil he brought with him to Buitenzorg he found several soil *Protozoa*.

In April 1920 Mr. VAN LEEUWEN and myself again visited both Krakatau and Verlaten I.; I was on Krakatau from 23—26 April; on Verlaten I. from 21—22 and the 27th April. In September 1920 Mr. SIEBERS, the ornithologist of the Buitenzorg-Museum, was my companion; we stayed at Krakatau from 22—25 September; at Verlaten I. from the 26th—28th. On the 26th April 1921 I was only one day on Verlaten I. and in the morning of that day I searched for corals on Krakatau together with Dr. BOSCHMA, as has been mentioned before.

In October 1921 I paid a short visit of one day, the 23rd, to Krakatau and of two days, 24th and 25th, to Verlaten I. The last trip I made to Krakatau was in January 1922, for only two days, the 19th and 25th. So altogether I was able to spend 16 days on Krakatau and 12 on Verlaten I. If we now compare what JACOBSON found in 1908 and I myself in 1920—1921, we will have to reckon with the fact that I could collect on the islands so much longer than JACOBSON.

JACOBSON's trip to Krakatau lasted but three days, and he could spend only a few hours on Verlaten Island and Lang I. Lang I. has not been visited by myself as I thought it better to confine myself to Krakatau and Verlaten I., Lang I. being practically in the same condition as Verlaten I. as to situation, altitude and vegetation.

The total amount of animals found on Krakatau in 1920—1921 is nearly three times that which has been found in 1908. JACOBSON recorded from Krakatau 196 species (see Appendix A); from Verlaten I. only 29. I found on Krakatau 573 species; on Verlaten I. 325. As already mentioned, this increase of species may be accounted for not only by the lapse of 13 years between the two investigations, but having occasion to visit the islands so often, I could collect many animals which were certainly already on the islands in 1908 and escaped JACOBSON's notice because his time was so limited. Besides, I used two methods of collecting, viz. trapping by light and sifting, which apparently JACOBSON could not practise during his

short visit. With the light trap several species of moths were caught; by the second method I got many beetles, the total of Coleoptera from Krakatau, which was 23 in 1908, being brought up to 115, of which number nearly half was collected by sifting.

Certainly a great part of the increase of species is due to these methods and the time for research being so much longer, but there are doubtless many species or even groups of animals found in 1920—1921 which probably invaded the islands after 1908.

JACOBSON stated positively that no mammals existed on the islands in 1908. He writes that even at night not a single bat was seen. Nowadays, strolling through the wood, every moment one disturbs bats and at night they are not rare, either on Krakatau or Verlaten I. Of this order, which apparently was not represented on the islands in 1908, two species were found on Krakatau and one on Verlaten I. Mr. BODEN KLOSS of the F.M.S. Museums, Kuala Lumpur, has kindly examined the species. One is a subspecies of *Cynopterus horsfieldi* GRAY and the other *Cynopterus sphinx tithaecheilus* TEMM. or *C. angulatus* MILLER; the latter species was found on both islands. The specimens caught were too young for a certain determination.

In April 1921, when we were at anchor at Sebesy, several nights we observed a great number of Flying-foxes, coming from Sebuku (Seboekoe) or the Sumatra coast. Some of these seemed to fly over Sebesy in the direction of Krakatau; it is not impossible that these large bats also visit this island to enjoy the fruits, especially of Ficus trees. In the daytime I have never seen a Flying-fox on Krakatau or Verlaten I. The above mentioned *Cynopterus*-species are also fruit-eating bats and it may be that these animals did not invade the islands before the fruit trees, and particularly Ficus trees were to a greater extent matured.

The many caves on the coast of Sebuku were said to contain bats in abundance. I have not visited these caves but could examine some of the caves and holes along the rocky coast of Krakatau N. E. and E.; but no bats or other cave-dwelling animals were found; also in the evening no bats were seen flying from out of the caves.

Another mammal, not yet present in 1908, was rather abundant on Krakatau in 1920—1921, namely house rats (*Rattus rattus diardi* JENT.). This rat has been found not only on the S. E. side of Krakatau, where most of the collecting has been done, but also at Zwarte Hoek. I was surprised to find this species as well at the opposite side of the island, because this animal was undoubtedly introduced by man.

This introduction probably took place in or shortly after 1917, when Mr. HANDL settled on the S. E. part of Krakatau to gather volcanic materials. In the vicinity of his house, built of wood and bamboo, now a mass of ruins (October 1921), many house rats were trapped; litters also were found (December 1919). Most likely the rats reached Krakatau hidden

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in building materials or victuals for this temporary establishment. Mr. HANDL himself told me that no rats were seen when he arrived on the island, but they appeared later on.

The finding of house rats at Zwarte Hoek (September 1920) proves that the rats obviously spread over the island in less than three years. A separate introduction at this point seems rather doubtful, Zwarte Hoek being visited rarely, if ever, by anybody. Fishermen may touch here sometimes, but they never take so many things ashore during their short stay that rats could be introduced. That there are no rats on Verlaten Island N., a much better landing place than Zwarte Hoek, seems also to justify the opinion that the rats at Zwarte Hoek have come from the S. E. part of Krakatau.

Mr. GROENEWEGE, who visited Verlaten I. in December 1919, maintained that he has seen a small darkhaired carnivorous animal on this island stealing through the glagah (*Saccharum spontaneum*). I was unable to make out what this mammal could have been.

The number of birds from Krakatau in 1920—1921 is two and a half times that of 1908, but one must take into consideration that now two ornithologists, Mr. BARTELS in April 1919 and Mr. SIEBERS in September 1920, have paid special attention to the avifauna (see Appendix C).

Besides, the species mentioned from Krakatau by JACOBSON in 1908 are all resident forms except *Tringoides hypoleucus*. Of the 34 species of birds observed on Krakatau in 1920—1921 six are migrants, viz. *Astur* spec., *Hirundo gutturalis*, *Motacilla flava*, *Lanius superciliosus*, *Tringoides hypoleucus* and *Numenius phaeopus;* two, *Demiegretta sacra* and the Frigate bird, cannot be said to be true resident forms. Of the birds from Verlaten I, 38 species altogether, we must deduct even a greater number to get the true resident forms.

Migratory species noted on this island are *Hirundo gutturalis*, *Motacilla flava*, *Tringoides hypoleucus*, *Orthoramphus magnirostris* (?) and *Ochthodromus geoffroyi*. As non-resident forms we have to consider those straying birds such as *Micropus pacificus*, *Butorides javanica*, the 5 species of Terns and the Petrel. After deducting all these species from the total number we find 26 resident forms for Krakatau and 25 for Verlaten I., against 13 on Krakatau in 1908. In this respect the number of birds on Krakatau has only doubled.

Two of the birds recorded by JACOBSON, viz. *Alcedo beryllina* and *Pycnonotus aurigaster*, were not found again in 1920—1921. Some of the birds mentioned as new to Krakatau are now so common that they must have struck JACOBSON if they had been already present in 1908. I suppose, therefore, that *Eudynamis honorata*, *Calornis chalybea*, *Myristicivora bicolor*, *Amaurornis phoenicura*, and perhaps some others, are new invaders which have reached the islands after 1908. The wood getting thicker, the shrinking of the grassy plains and the maturing of fruit-bearing trees, may have attracted the birds.

I will further draw attention to the presence of *Dicaeum trigonostigma* on Krakatau and Verlaten I. Most *Dicaeum* are said to feed chiefly on spiders and on the fruit of Loranthaceae, but the absence of this family of parasitic plants on both islands seems to prove that this species of *Dicaeum* also can live without these plants.

The abundance of papaw trees on Verlaten I. North may be responsible for the great number of birds living there. In this connection I wish to mention that at my last visit on the 24th of October 1921 all the papaw trees on the northern part of Verlaten I. had been destroyed by a root disease. Not a single tree was left erect, all had fallen down bent just at the foot which was wholly rotten. One may suggest that as these fruit trees have died out on Verlaten I. many birds which feed on papaws will abandon the island.

For zoogeographical problems, however, birds are not so important as mammals, reptiles, etc. All the birds found on Krakatau or Verlaten I. can easily accomplish the distance which separates these islands from the other islands in the vicinity or from the Java and Sumatra coast.

Much more interesting are Reptiles, which can reach the islands only by sea. JACOBSON recorded from Krakatau only two species; he stated that no snakes were seen. I found four species on Krakatau and five on Verlaten I., of which only one was a snake, *Python reticulatus* SCHN. (see List D). Natives often assured us that they had met this snake on the islands and Mr. HANDL, already mentioned above, told us that his chickens were always devoured by Pythons, but it was not until January 1922 that we succeeded in catching two young specimens on Krakatau. Both were found in the shrubs near the beach and were about 1 M. in length, apparently young from one hatch. The stomach of one was empty that of the other contained the remnants of a rat.

The *Hemidactylus* mentioned by JACOBSON probably was *H. frenatus* D. et B. This house tjitjak, spread throughout the Indo-Australian Archipelago, is now common on both Krakatau and Verlaten I. Another tjitjak collected on both islands is *Lepidodactylus lugubris* D. et B. It is remarkable that this species has not been found yet in Java or Sumatra; the nearest localities from which it is recorded being Riou and Borneo.

Further on Verlaten I. only occurs a skink (*Lygosoma atrocostatum* LESS.). This species, now common on the northern part of Verlaten I., has certainly come to the island after 1908, otherwise JACOBSON would have observed it. The *Varanus*-species mentioned by JACOBSON, is most probably *Varanus salvator* LAUR., this species abounding now on both islands. The absence of crocodiles is certainly due to the absence of rivers and of proper food on the islands. Also Amphibians are still wanting. The chance of their arrival and settling on the islands is not great, Krakatau being absolutely without fresh water. On Verlaten I. only are there fresh-water pools besides the brackish-water lake.

As to the insects, only general remarks can be made, the great bulk of the material being still undetermined.

On Krakatau 441 species of insects altogether have been found; on Verlaten I. 238. These two islands have only 114 species in common, one fifth of the total for both islands. This proves, I think, that we either caught only a small part of the total number of species present or that the general conditions on the islands are rather divergent. Now the whole northern part of Verlaten I, where nearly all the collecting has been done, is new land clad with a vegetation somewhat different from that on Krakatau. Owing to this difference we surmise that the insect fauna on both islands is also disparate. But the first mentioned factor is also of importance. One will find, especially in the tropics, every time different species on the same spot, and many of those formely caught are not to be found again.

Although the total number of insects on Krakatau has been tripled since 1908, of *Hymenoptera* only 66 species were collected here in 1920—1921, and 28 on Verlaten I., against 8 on the latter island and 51 on the former in 1908.

Of *Hymenoptera parasitica* the double number has been obtained on Krakatau, but on Verlaten I. only 2 species were collected, JACOBSON mentioning 4 species. One would suggest that this small number of parasitic insects on Verlaten I. North is due to the recentness of this part of the island, the hosts arriving here first without their parasites. But on Sebesy, where the vegetation is far in advance of that of Krakatau, we collected also no more than 3 parasitic Hymenoptera. So the above suggestion cannot be correct. Also worth mentioning are three species of fig insects found on Karakatau and Verlaten I.; JACOBSON does not record these insects. Did not the fig trees produce at the time of his visit or could they do so only after the arrival of these small insects, which perhaps took place after 1908? Nowadays all fig trees on the islands abound with fruit and in nearly every ripe fig one will find the insect.

In 1908 ants were very abundant on Krakatau and a great nuisance. In 1920—1921 the number of species had increased only a little; but the number of individuals seems to be decreasing, except in the glagah fields where they are still annoying. The decrease of specimens is apparently due to the superseding of the grassy plains by the woods.

The number of *Coleoptera*, however, has greatly advanced; from 23 for Krakatau in 1908 it went up to 115 in 1920—1921; for Verlaten I. these numbers are resp. 2 and 68. One of the causes of this increase, as already mentioned, is the practice of sifting. A special study has been made of the soil and surface fauna, and a great many insects and other animals could be collected in this way. Nearly half the total number of beetles has been caught by sifting, as appears from the following list:—

Surface Coleoptera	Kr.	V. I.	K.+V.
Carabidae	9	4	11
Staphylinidae	16	7	18
Pselaphidae	4	4	5
Tenebrionidae	10	11	16
Other families	9	3	9
Total . . .	48	29	59

Of all these families only one Carabid was collected in 1908. Another medium-sized black Carabid is common on Krakatau and has been found also at an altitude of 800 M. by Dr. DOCTERS VAN LEEUWEN.

Of most interest is the presence of aquatic beetles on the islands, none of which were recorded in 1908. No less than 6 species occurred on Verlaten I., living there in the brackish-water lake (see Map Fig. 2 and Chapter V). This lake did not exist in 1908, consequently the beetles must have invaded the island after that time. It is remarkable that I found also two species of water beetles on Krakatau, where fresh or brackish water is absent. The beetles were caught in a water-tun at Mr. HANDL's house. In the same habitat were found aquatic bugs (Notonectids). In a small well dug at a short distance from the sea I collected several larvae of dragon-flies. Only one of the aquatic beetles from Krakatau occurred also on Verlaten I., but most probably both species have invaded first the lake on Verlaten I. and from there have come to Krakatau.

All these breeding places on Krakatau were hidden in the wood and not visible for insects reaching the island from the seaside. They existed a few years only and now have disappeared again. That the above mentioned aquatic insects could have found such a temporary breeding place difficult to detect, proves, I surmise, that many more insects than those which have been discovered reach the islands continually, but those which do not find the proper environmental conditions will perish or migrate again.

Of the other Coleoptera the following species may be discussed briefly: — Noteworthy are six species of *Coccinellidae* on Krakatau. Except a leaf-eating *Epilachna* the others are feeding upon Aphids or Coccids. That not one of the predaceous species was found in 1908, can be accounted for by the fact that Phytophthires were far less common at that time than nowadays.

Two enemies of the cocoanut palm have been collected, viz. *Xylotrupes gideon* L. and *Oryctes rhinoceros* L. Only the first species is recorded by JACOBSON, but ERNST, when he visited Krakatau in April 1906, published in his paper a photograph of a cocoanut palm apparently damaged by

Oryctes. Mr. LEEFMANS (Med. 41 Inst. v. Plantenziekten, Buitenzorg 1920) was the first to draw attention thereto.

That so many more *Lepidoptera* have been collected is especially due to using the light-trap. JACOBSON recorded only 10 species, though many Heterocera were noted by him but are not listed.

On this group of insects not much can be said before the material has been worked out. Till now only some Danaids have been identified by Mr. MOULTON (see List E); to some of these species we will revert in Chapter IV.

Noticeable is the occurrence on Krakatau of *Schoenobius bipunctifer* WLK., the well-known rice pest. It must breed here in wild grasses, although wild foodplants are unknown in Java or elsewhere. The only gall producer among the Lepidoptera found on Verlaten I. is a species which causes gall-formations on the leafs of Callophyllum inophyllum.

To the *Diptera* not so many species could be added as to the other groups of Insects. May be the great number of Diptera already collected by JACOBSON in 1908 is responsible for this. A complete list of the Diptera found by him and identified by DE MEYERE is given in Appendix B.

For the gall-producing species, as for the other galls found on Krakatau and Verlaten I., one should consult the papers of DOCTERS VAN LEEUWEN (see Literature).

Mosquitos, not abundant in 1908 according to JACOBSON's narrative, are now a very great nuisance, especially at Verlaten I. North, the brackish-water lake there being a suitable breeding place. This part of the island is infested by these annoying insects in such a way that more than once while lying at anchor in the northern bay of Verlaten I., we had to stand out to sea in order to sleep peacefully. At least three species of mosquitos have been caught, the larvae abounding in the lake on Verlaten I. and also in the well and water-tuns on Krakatau.

The increase of *Rhynchota*, however, has been very important again; five times the number found in 1908 being collected on Krakatau.

Worth being mentioned are the aquatic bugs; one species, a Notonectid, as stated above, was found on Krakatau. On Verlaten I. I was able to collect two species, a Naucorid and a *Corixa*.

Noticeable among the *Homoptera* are the singing Cicadas. One rather large species, *Dundubia rufivena* WLK., is very abundant on both islands. Every morning and evening we could hear their shrill sounds sustained without interruption for just a quarter of an hour. They began exactly at 5.30 a.m. every morning and ended at 5.45 a.m; every evening they lasted from 6.30 p.m. till 6.45 p.m. These times were noted in September; in January the sounds arose a quarter of an hour later.

This Cicada is not recorded by JACOBSON, but nowadays it is such a noticeable insect on the islands that it would not have escaped his attention if it was already present in 1908.

Also Aphids were not observed on Krakatau or Verlaten I. in that year; one species was found on Lang I. only. In 1920—1921 one species, *Aphis malvae* KOCH, was very common on both islands.

From Verlaten I. DOCTERS VAN LEEUWEN has recorded another species which produces shoot galls on Oplismenus compositus BEAUV.

JACOBSON found in 1908 only one Coccid on Krakatau, now five species were collected on this island and six on Verlaten I. The abundance of mealy bugs on beach plants was very striking. Among the gall-producing Phytophthires the Psyllids hold the majority. The Phytophthires identified by V. D. GOOT are listed in Appendix H.

A great number of *Thysanoptera*, not recorded at all by JACOBSON, has been collected by DOCTERS VAN LEEUWEN. Most species were found in flowers and, owing to their smallness, these insects may have been overlooked in 1908. The species are determined by Dr. KARNY (see List G.).

JACOBSON writes it struck him that so few *Orthoptera* were to be seen, as well with regard to species as to individuals. This cannot be maintained for the present time, the total number of Orthoptera from Krakatau having been doubled and on Verlaten I. 22 species have been caught against one in 1908.

Interesting to note is the abundance of this group of insects on Verlaten I. North. Here about the same number has been found as on Krakatau, whereas from other groups only half the number of species is recorded.

Nearly all families are represented, only Phasmids are still absent. Especially *Locustidae (Phasgonuridae)* have increased greatly, one species being mentioned for both islands in 1908, and 8 in 1920—1921. A preliminary list of the Orthoptera identified by Dr. KARNY is to be found in Appendix F.

Odonata are very common not only at the lake on Verlaten I. North but also on Krakatau where, except at the small breeding places near the house on the S. E. end, brackish or fresh water is absent. Six species have been collected on Verlaten I., four on Krakatau. Dragonflies have great powers of flight and can easily accomplish long distances.

We have often observed a great number of these insects swarming around coral islands in the bay of Batavia or Java Sea, although these islands are very dry and not a single breeding place could be detected.

The three *Neuroptera* collected on Krakatau consist of a *Myrmeleon*, of which ant-lion the larvae were found abundantly around Mr. HANDL's house; further one Psocid and one Chrysopid. Another species of the last family was caught on Verlaten I.

Isoptera are also abundant on both islands, especially one species building large nests adhering to the stems of trees. Once in a nest of this termite on Verlaten I. two species of termitophilous *Staphylinidae* were found by the author. Altogether three species of termites have been collected.

The *Aptera* are represented by two species, one of which belongs to the *Thysanura*, probably the same species as recorded by JACOBSON.

Remarkably enough, of *Myriapoda* I have found even less species than JACOBSON 13 years ago. This is the more surprising as I paid so much attention to the surface fauna. The phosphorescent species noticed on the summit of Krakatau by the topographic surveyors in 1908 was probably a species of *Geophilus* occurring everywhere in houses. Perhaps this species was introduced with the luggage of the explorers. But even if we deduct this species from JACOBSON's number, there is still a decline in 1920—1921.

Further, JACOBSON stated that the large Scolopendras were even annoying at the time of his visit. Nowadays this species, although not rare, is far from abundant, as also the large *Spirostreptus*-species. Whether the decrease of Myriapods is due to the wood getting thicker or to the appearance of their enemies on the islands, must be left undecided.

The number of *Arachnida*, however, went up considerably. Of this Class of animals four times the total of 1908 has been brought together on Krakatau.

The number of Spiders on this island has tripled; also many mites have been collected, none of which are recorded by JACOBSON, except an Ixodid living on *Varanus*. This species, just as other external or internal parasites, I have excluded from List. A, in so far as these species cannot have reached the islands independent from their hosts. The majority of the mites consists, however, of gall-producing species, only five free-living species having been found. The Scorpionid mentioned by JACOBSON could not be found again.

Of *Crustacea* only the truly terrestrial forms are of importance; all those crabs and Pagurids haunting the beach, the larvae of which live in the sea, we can here leave out of consideration. The same number of Oniscoids (3 species) as in 1908 are met with on Krakatau; on Verlaten I. only one species was found, but very abundantly. In addition a terrestrial Amphipod (*Orchestia*) occurs on this island, a species also common on Java.

The land *Mollusca* on Krakatau have increased from 2 in 1908 to 5 in 1920—1921, and on Verlaten I. from 0 to 3. Three of the species from Krakatau are very small ones and belong to the surface fauna, living in mould and decaying leaves. The two others are the *Bulimulus* already recorded by JACOBSON, and a *Scarabus*. *Bulimulus* has been noticed on Krakatau by DOCTERS VAN LEEUWEN also at an altitude of 500 and 800 M. *Scarabus* is now so common on both islands that JACOBSON would not have overlooked the species if it had been present in 1908. This mollusc is living under dead leaves in small ravines near the coast and can stand excessive drought. I collected a few of these Scarabus in September 1920, keeping them in a tin box without any moistening for 35 days! All this time they remained motionless but they revived at once after making them wet. However, I could not find again the *Pupina* mentioned by JACOBSON.

True earthworms were not yet found in 1908; the *Pheretima* noticed by JACOBSON was a species living always in decaying wood. Now earthworms are fairly common on Krakatau, but they are still absent on Verlaten I.

Another Annelid collected on Krakatau is probably an Enchytraeid. The four remaining species of worms are Nematodes (*Plectus*, *Mononchus*, *Dorylaimus*) and a Rotifer detected by Dr. MENZEL in samples of moss from Krakatau. In the same samples he found also Tardigrades (*Macrobiotus*) and Protozoa (*Rhizopoda* and *Ciliata*).

II. Is the fauna of Krakatau and Verlaten I. still abnormal? Comparison with the island Sebesy.

If there were any records of the fauna of Krakatau before the eruption of 1883, then the answer to the question how far the present fauna of this island is to be considered as normal, would be easily given.

But nothing seems to be known of the animals occurring on the island before 1883. So we had to look to another island for comparison, an island similarly situated as Krakatau and with about the same area and altitude but the fauna of which could be considered as normal.

For this reason Sebesy was chosen, an island immediately north of Krakatau and of about the same size and altitude. During the eruption of 1883 Sebesy was said to be only partly devastated and at our first visit the island looked indeed rather normal, at least the northern part of it which is the best place to go ashore. According to our presumption, the vegetation here was wholly restored although VERBEEK in his well-known work on Krakatau (1885) gives a coloured drawing of the island from the N. E. side, soon after the eruption, from which it can be seen that the whole island was covered with grey ashes, above which only a few burnt trees arise. But the layer of ashes was far less thick than on Krakatau and certainly less hot. By the enormous flood waves, which succeeded the eruption, everything in the plain of the island was swept away and all the inhabitants, about 2,000 people, were drowned.

The present flora of Sebesy, however, is quite different from that on Krakatau and seems to be in a far more advanced stage of restoration. Dr. DOCTERS VAN LEEUWEN, who also visited Sebesy, is of opinion that the vegetation of the island was only partly destroyed and was restored soon, only galls having disappeared altogether. So we supposed the fauna also would be far more normal than on Krakatau, but the result of our research proves that the fauna of Sebesy was also destroyed wholly, or nearly so, at the eruption of 1883.

I visited Sebesy in the following months: — In September 1920, only one day, the 29th, was spent on the island for a provisional survey. Next year a longer trip was made, from 22 till 25 and from 27 till 29 April, Mr. SIEBERS of the Museum accompaning me.

In October 1921 I was from 26 till 28 on the island, and my last visit took place on the 25th and 26th January 1922. Altogether I had 13 days in which to collect on Sebesy as against 16 on Krakatau.

Nearly all the collecting has been done on the northern part of the island. The 25th April 1921 we ascended the summit of the island and reached an altitude of 700 M. On the 27th April we tried to put ashore at the southern coast of Sebesy, but the full ocean swelling breaking on the shore here with great power made it too dangerous to stay any longer, and after a very short visit we had to go aboard the ship again. At this point of the island I could collect only a few insects and some earthworms. At this part of the island there were still to be seen here and there layers of ashes from the Krakatau eruption.

On Sebesy a total of 638 species were collected against 573 on Krakatau, a difference of small importance.

Of mammals only one more species than on Krakatau was found, if we exclude at least the cattle and goats which have grown wild on the island. These ruminants were introduced on purpose and we are indebted to the "Gezaghebber" (an offical of the Civil Service) of Kalianda, Lampongs, for the following narrative about their origin.

He writes as follows: — "Sebesy remained uninhabited until 1890; in that year Hadji Djamaludin and a great number of coolies went to the island to clear the land. Having laid it out he introduced about 20 years ago (about 1900) fifteen head of cattle on Sebesy and later on 20 goats and five horses. All these animals were housed in stables but about 10 years ago (about 1910) some of them managed to escape. They have become wild and spread over the whole island and nowadays they are fairly abundant. When the above mentioned Hadji came to Sebesy in 1890, there was only a scanty vegetation, but many trees were planted by him."

The plantations on Sebesy are chiefly of cocoanuts fringing in a rather large border the north coast of the island. Further there are some fruit trees, and regularly "ladangs" (temporary rice-fields in cleared wood) are laid out. However, a permanent population does not exist on the island, the people coming and going continually from and to the Sumatra coast. Only those who gather the cocoanuts remain for longer periods on the island.

As fresh meat was always welcome, every time we were at Sebesy one or two of the wild cattle were shot. Only once, April 1921, a goat, a white-haired female, was shot by Mr. SIEBERS at an altitude of 700 M. These beasts do not seem to descend into the plain, remaining always high up in the mountains.

The number of cattle which had grown wild was estimated at a thousand head. The bulls are of isabel colour with a dark longitudinal stripe along the back; the cows are brown; also swarthy bulls occur.

A couple of horses which were running loose were seen sometimes in the neighbourhood of the small bay at the north side of the island. The people told us it was impossible to catch these animals again as they had grown quite wild.

Apart from these animals introduced purposely by man, four species of mammals have been found on Sebesy. Two species of rats occur on the island, viz. the house rat (*Rattus rattus diardi* JENT.), and the country rat (*R. rattus brevicaudatus* H. et DE R.).

House rats were trapped in and near the native dwellings; country rats were caught in the wood, but quite near harvested rice fields, at an altitude of about 100 M. Undoubtedly both species have reached the island by human agency, there being much traffic beween Sebesy and the Sumatra coast by rather large sailing vessels.

At least two species of bats were observed, a small one, a *Cynopterus*, and a large *Pteropus*. Many of these Flying-foxes came also in the evening to the island from the Sumatra mainland. Once, on the 29th September 1920, great swarms of smaller bats were noticed at twilight flying to Sebesy and coming from Sebuku.

In view of the extensive cocoanut plantations on the island and the constant communication with the Sumatra coast, I was surprised at the absence on the island of the common "badjing" *(Sciurus notatus* BODD.). Cocoanuts damaged by this squirrel have not been seen and the natives also have never noticed it, fortunately enough for their plantations.

As to birds, on Sebesy they are undoubtedly more plentiful than on Krakatau. Altogether 42 species have been observed; for an exact comparison we have to deduct, however, the migrants and non-resident forms. No less than 8 migratory birds have been noticed, viz. *Chalcococcyx basalis, Motacilla flava, Motacilla melanope, Phylloscopus borealis*, and the four *Limicolae;* also 3 straying species: — *Demiegretta sacra, Sterna melanauchen* and a Frigate bird.

As true resident forms there remain 31 species against 26 on Krakatau. Moreover Sebesy has been visited only once by an ornithologist and Krakatau twice.

That birds are so much more numerous on Sebesy can be accounted for by the far more advanced stage of the vegetation and the presence of fresh water. A bird which certainly followed the rice cultivation on the island is *Munia nisoria*.

Also the number of Reptiles is higher. Three species of snakes occur, namely *Python reticulatus* SCHN., *Chrysopelia ornata* SHAW and *Coluber melanurus* SCHLEG. Of the last species a nest was found with 14 eggs just hatched.

Of *Lacertilia* 4 species were caught: — *Lepidodactylus lugubris* D. et B. already recorded from Krakatau and Verlaten I.; a house gecko, *Gecko monarchus* D. et B; *Lygosoma bowringi* GTHR. and *Varanus salvator* LAUR., being here as common as on the islands of the Krakatau group. The widespread *Hemidactylus frenatus* D. et B., the commonest tjitjak of the Archipelago was not observed on Sebesy.

Though freshwater rivulets and pools are quite plentiful on Sebesy no Amphibians or freshwater fishes could be detected except a very small species of the latter, but probably this was an estuarine form.

The number of insects, however, found on Sebesy is not much higher than on Krakatau, 474 versus 441. There is a remarkable correspondence in the number of species belonging to the various orders of insects occurring on both islands, although the species themselves are quite different. Only Lepidoptera and Orthoptera are far more abundant on Sebesy.

Of *Hymenoptera* even less species were found on Sebesy than on Krakatau. Noteworthy is the small number of *Hymenoptera parasitica*, only 3 species; it is not clear what is the cause thereof.

Two species of fig insects have been collected. Species of ants are only a trifle more numerous than on Krakatau, but some species, viz. the gramang-ant (*Plagiolepis longipes* JERD.) were extremely abundant.

Also the number of *Coleoptera* is less on Sebesy. Worth being mentioned are the Cicindelids, of which 5 species have been collected on this island against none on Krakatau. Common were *Cicindela aurulenta* F., distributed throughout the western part of the Archipelago, also *C. longipes* F., which species occurs on the beach and runs along the water line. The presence of these beetles on the island we may surmise to be due to the larvae, burrowed in the ground, having escaped destruction at the eruption.

Aquatic beetles, however, so well represented on Verlaten I., were wholly absent, notwithstanding that more freshwater here is available.

Interesting to note is the absence of *Oryctes rhinoceros*, occurring already so many years on Krakatau. Also the well-known damage caused by this beetle to the leaves of the cocoanut has never been noticed. But another cocoanut pest, the Palm Weevil (*Rhynchophorus ferrugineus* var. *schach*), occurs on the island.

Also surface Coleoptera are less abundant, as appears from the following table: —

Surface Coleoptera	Krakatau	Sebesy
Carabidae	9	8
Staphylinidae	16	3
Pselaphidae.	4	1
Tenebrionidae.	10	8
Other families.	9	10
Total . . .	48	30

The difference in the total is caused mainly by the smaller number of *Staphylinidae*.

The number of *Lepidoptera* from Sebesy, however, is much higher than from Krakatau. At our first visit we were already impressed by the greater abundance of Rhopalocera. Heterocera also are far more numerous.

Of *Diptera* the totals on both islands are nearly the same, but the species are quite different. The presence of Tabanids on Sebesy has certainly to be accounted for by the cattle occurring on the island.

In the wood mosquitos are common but they are not such a nuisance as at the lake on Verlaten I. North. Further noteworthy is the greater number of gall-flies on Sebesy.

Also *Rhynchota* occur on both islands in about the same number. Although three species of aquatic bugs could be collected on the islands of the Krakatau group, remarkably enough none were to be found on Sebesy. Here *Dundubia* was a far less noticeable insect than on Krakatau.

Of the nine gall-producing species of *Phytophthires* seven belong to the *Psyllidae*.

The number of *Thysanoptera* also is not much higher on Sebesy than on Krakatau, but here again quite other species are found (see List G). Whereas gall producers in this group of insects do not occur on Krakatau or Verlaten I. they are well represented on Sebesy.

Compared with Krakatau the order of *Orthoptera* is far more abundant on Sebesy than any other group of insects. The total is nearly twice that of Krakatau. Of Phasmids, wholly absent on Krakatau and Verlaten I., one species has been collected.

The remaining orders of insects are represented on Sebesy and Krakatau in about the same degree, only no *Neuroptera* were collected on the first-mentioned island.

Much more abundant, however, than on Krakatau are the *Myriapoda* on Sebesy. On my first visit to this island, September 1920, the abundance of Myriapods in the wood was very striking. The ground was really covered by different species; on one square Meter I could count 42 individuals and six species (see further on). Two families of Myriapods, viz. the *Glomerulidae* and *Scutigeridae*, not found on Krakatau, were both represented by one species.

The number of *Arachnida* on Sebesy is only a little higher than on Krakatau. Free-living mites however were less abundant.

The terrestrial *Crustacea* consist of 4 species:— two Oniscoids, and two species belonging to the moss-fauna, viz. *Epactophanes richardi muscicola* (RICHTERS) and an Ostracod, which were identified by Dr. MENZEL. The *Orchestia* from Verlaten I. was not to be found on Sebesy.

Interesting to note is the greater number of *Mollusca* on this island, twice as many as on Krakatau. The species recorded from the latter island have also been collected on Sebesy. Besides there are two species of slugs, a *Pupina*, and two other snails not known on Krakatau.

Further, two species of fresh-water Molluscs have been found and a brackish-water species, which was also noticed in the lake on Verlaten I.

The number of *Vermes* observed on both islands is again the same, consisting on each island of species belonging to the same groups. Earthworms are more abundant on Sebesy than on Krakatau.

To obtain an answer as to the question whether the fauna of the Krakatau islands was still abnormal, I also used another method.

JACOBSON has already stated in his paper that on Krakatau a limited number of species occur, but that of most species there are plenty of individuals. The species which had newly invaded the island could increase abnormally, their parasites and enemies having not yet reached the island.

I searched for a method to put this thesis into figures and tried it by examining how many animals, species and individuals, occur on one square Meter. Only animals living under dead leaves and in the vegetable mould immediately beneath them were counted. This surface layer of the soil was chosen because in a tropical wood it is the only environment with uniform conditions throughout a large area.

The method was practised as follows: —

On a certain spot where the soil was covered by a uniform layer of vegetable debris, one square Meter was laid out. At this place the leaves and mould were heaped up, the mould only so far as it could be easily gathered together without loosening the soil.

The decaying vegetable material was further sifted through a 5 mm. — mesh wire sieve into a bag. The coarser material not going through the sieve was searched on the spot to collect the larger animals. What went through was taken along for a stricter examination, which took place the same day whenever possible. The sifted material was spread out in a thin layer on a white cloth and the animals were picked up by forceps, the smallest ones by a fine hair brush.

The method as practised by me does not give exact figures, only a part of all the animals occurring on the examined place being caught and many of the smaller ones being overlooked.

Besides, soft species are often damaged by the sifting; these mutilated animals covered with dust and sand are hard to detect, especially so if they do not move or are already dead. In this manner chiefly soft larvae, Aptera and woodlice are damaged; the number of these animals given in the lists is therefore proportionately always too low.

But notwithstanding these drawbacks, the method used is, I believe, the best to give in a short time comparatively reliable figures. For our purpose we do not require the exact numbers but only relative ones.

Occasionally time was not available to count all the individuals of certain species, in which case only the species are listed, not the number of specimens. Of ants always the species only are recorded.

The soil and surface fauna from different localities has been studied in this manner for a long period and I hope to publish later the results of this research in full.

In the table on the following pages are listed the species and individuals found on 1 M² of different localities on Krakatau, Verlaten I. and Sebesy.

The localities are distinguished by the vegetation. First of all there is the littoral zone, composed of beach plants. Behind this formation is usually a fringe of Casuarina-forest, consisting chiefly of Casuarina-trees mixed with a few other plants. The third zone is formed by the jungle proper composed of numerous species of trees so characteristic of a tropical wood.

In the littoral zone one finds as a rule the decaying leaves immediately on the barren sand; in the Casuarina-forest the soil is covered by a rather thick and firm layer of needles, whereas in the virgin forest the surface layer consists of dead leaves and mould which varies in thickness. The layer of leaves and mould in the tropics is, contrary to what one would expect, remarkably thin, as appears from the figures in the table. Certainly this is due to the fact that tropical trees shed their leaves as a rule the whole year round and decay being so much quicker here.

The altitude of the locality given as 0 M. in the list means at sea level or at least beneath 50 M.

If we look at the list on the following pages the results prove to be of great divergence, so it is hard to deduce an exact average from the figures especially as to the number of specimens.

On Krakatau I found for the littoral zone 14 species on 1 M²; on Sebesy an average of 14.5. The mean figure for the Casuarina-forest on Krakatau is 14, on Verlaten I. 7.8, on Sebesy 18.2. For virgin forest beneath 50 M. the figures are: — on Krakatau 20.4, on Verlaten I. 17, and on Sebesy 20.5 species on 1 M².

With regard to the number of individuals on 1 M², the figures vary too much to give an average, but such high numbers as observed on Verlaten I. North are evidently never noticed on Krakatau or Sebesy.

The conclusions to be drawn from this study of the surface fauna are the following: — Between the surface fauna of Krakatau and Sebesy there is only a slight difference, but on Verlaten I. North species are far less abundant whereas individuals are more plentiful. Verlaten I. North being more recent land has a newer fauna than Krakatau and Sebesy.

From Appendix A it appears that on Verlaten I. the total number of animals is about half that of Krakatau or Sebesy. The same relation exists in regard to the flora; DOCTERS VAN LEEUWEN collected 145 species of Phanerogams on Krakatau in 1919, and only 62 on Verlaten I.

The above mentioned research proves also that the fauna of Krakatau and Sebesy are both to be considered as still abnormal. Generally we may say the fauna of Sebesy is somewhat richer than that of Krakatau and seems to be in a more advanced stage of restoration. However, the total number of animals

Nos.	1		2		3		4		5		6		7
Locality and kind of vegetation	Krakatau Littoral zone		Krakatau Casuarine forest		Krakatau Casuarine forest		Krakatau Casuarine forest		Krakatau Virgin forest		Krakatau Virgin forest		Krakatau
Altitude	0 M.		0 M.		0 M.		0 M.		0 M.		0 M.		0 M
Month	April		April		Sept.		Dec.		April		April		Sep
Layer of leaves and mould (in cM.)	6 cM.		4 cM.		4 cM.		4 cM.		4 cM.		6 cM.		7 c
Number and species on 1 M².	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.
Hymenoptera	—	1	(1)	3	—	—	—	—	—	3	—	3	—
Formicidae	—	1	—	2	—	—	—	—	—	3	—	3	—
Coleoptera	2	2	16	7	3	3	2	2	27	7	40	11	18
Carabidae	1	1	1	1	1	1	1	1	14	1	4	1	2
Staphylinidae	1	1	2	2	—	—	1	1	1	1	3	3	4
Pselaphidae	—	—	2	1	1	1	—	—	3	1	6	4	—
Tenebrionidae	—	—	8	2	1	1	—	—	7	2	26	2	7
Curculionidae	—	—	—	—	—	—	—	—	—	—	—	—	—
Diptera (larvae)	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhynchota	4	2	2	2	7	2	1	1	4	3	9	4	6
Heteroptera	4	2	2	2	7	2	1	1	4	3	9	4	6
Lepidoptera (larvae)	1	1	3	1	—	—	—	—	2	1	—	—	—
Orthoptera	31	2	2	1	2	1	25	2	4	2	17	1	6
Blattidae	31	2	2	1	2	1	25	2	4	2	17	1	6
Forficulidae	—	—	—	—	—	—	—	—	—	—	—	—	—
Isoptera	—	—	—	—	—	1	—	—	—	—	—	—	—
Aptera	3	1	—	—	4	1	—	—	—	—	—	—	—
Crustacea	2	1	14	1	—	—	1	1	48	2	—	—	8
Oniscoida	2	1	14	1	—	—	1	1	48	2	—	—	8
Amphipoda	—	—	—	—	—	—	—	—	—	—	—	—	—
Myriapoda	2	1	2	1	7	1	1	1	10	2	7	3	
Chilopoda	2	1	2	1	—	—	1	1	1	1	1	1	
Diplopoda	—	—	—	—	7	1	—	—	9	1	6	2	
Arachnoidea	3	2	6	3	4	2	—	—	15	5	13	4	
Araneae	3	2	3	2	4	2	—	—	4	2	9	2	
Acarina	—	—	3	1	—	—	—	—	11	3	4	2	
Mollusca	—	—	7	3	—	—	—	—	8	2	—	—	
Vermes	5	1	2	1	—	—	2	1	—	—	14	1	
Total	53	14	55	23	27	11	32	8	118	27	100	27	

	9		10		11		12		13		14		15		16		17		18		19	
Virgin forest	Krakatau Virgin forest		Krak. Zw. H. Virgin forest		Krak. Zw. H. Virgin forest		Verlaten I. Casuarine forest		Verlaten I. Casuarine forest		Verlaten I. Casuarine forest		Verlaten I. Casuarine forest		Verlaten I. Virgin forest		Verlaten I. Virgin forest		Verlaten I. Virgin forest		Verlaten I. Virgin forest	
M.	0 M. Dec. 2 cM.		0 M. April 4 cM.		0 M. Sept. 5 cM.		0 M. April 4 cM.		0 M. Sept. 6 cM.		0 M. Oct. 5 cM.		0 M. Dec. 4½ cM.		0 M. April 5 cM.		0 M. Sept. 7 cM.		0 M. Oct. 7 cM.		0 M. Dec. 4 cM.	
s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.
3	—	1	—	2	—	3	—	—	—	—	—	2	—	—	—	1	—	—	—	4	—	2
3	—	1	—	2	—	3	—	—	—	—	—	2	—	—	—	1	—	—	—	4	—	2
4	56	7	10	6	15	5	1	1	2	1	—	—	6	4	31	9	17	6	11	9	32	4
1	—	—	6	3	—	—	—	—	—	—	—	—	2	1	1	1	1	1	1	1	—	—
1	1	1	3	2	1	1	1	1	—	—	—	—	3	2	6	2	3	2	1	1	1	1
1	5	2	—	—	—	—	—	—	2	1	—	—	—	—	6	2	—	—	1	1	—	—
—	36	2	—	—	13	3	—	—	—	—	—	—	1	1	14	2	13	3	2	2	31	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—
2	11	2	3	2	1	1	2	1	2	1	—	—	2	1	3	1	2	2	6	2	1	1
2	11	2	3	2	1	1	2	1	2	1	—	—	2	1	3	1	2	2	6	2	1	1
—	—	—	3	1	4	1	2	1	2	1	—	—	—	—	3	1	—	—	2	1	—	—
2	5	1	—	—	2	1	2	2	—	—	4	1	1	1	9	3	2	1	1	1	6	1
2	5	1	—	—	2	1	2	2	—	—	—	—	—	—	5	2	2	1	1	1	6	1
—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
1	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	103	1	258	1	9	2	17	1	131	1	178	1	148	1	3	1
—	—	—	—	—	—	—	103	1	258	1	7	1	17	1	131	1	178	1	148	1	3	1
—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—
—	4	2	—	—	—	—	3	1	—	—	—	—	3	1	—	—	—	—	—	—	—	—
—	1	1	—	—	—	—	3	1	—	—	—	—	3	1	—	—	—	—	—	—	—	—
—	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	12	4	2	1	6	3	2	1	8	3	1	1	—	—	5	3	2	1	15	4	1	1
1	9	3	2	1	6	3	—	—	3	1	—	—	—	—	5	3	2	1	14	3	1	1
—	3	1	—	—	—	—	2	1	2	1	1	1	—	—	—	—	—	—	—	—	—	—
—	4	1	—	—	—	—	—	—	2	1	—	1	—	—	5	1	5	1	4	2	—	—
—	4	1	22	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	93	20	40	13	29	16	115	8	274	8	—	7	29	8	188	21	206	13	187	24	43	10

Nos.	20		21		22		23		24		25		26		27		28		29	
Locality and kind of vegetation	Sebesy Littoral zone		Sebesy Littoral zone		Sebesy Casuarine forest		Sebesy Casuarine forest		Sebesy Casuarine forest		Sebesy Casuarine forest		Sebesy Virgin forest		Sebesy Virgin forest		Sebesy Virgin forest		Sebesy Virgin forest	
Altitude	0 M.		0 M.		0 M.		0 M.		0 M.		0 M.		0 M.		0 M.		100 M.		700 M.	
Month.	April		Oct.		Jan.		April		Sept.		Oct.		Sept.		Oct.		April		April	
Layer of leaves and mould (in cM.)	5 cM.		2 cM.		3,5 cM.		3 cM.		5 cM.		7 cM.		5 cM.		2,5 cM.		2 cM.		2 cM.	
Number and species on 1 M²	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.	n.	s.
Hymenoptera	—	1	—	4	—	4	—	3	—	2	—	4	—	4	—	3	—	3	—	3
Formicidae	—	1	—	4	—	4	—	3	—	2	—	4	—	4	—	3	—	3	—	3
Coleoptera	—	—	*4*	1	*7*	2	—	—	*8*	3	*2*	1	*1*	1	*13*	5	*1*	1	*1*	1
Carabidae	—	—	—	—	—	—	—	—	*1*	1	—	—	—	—	*9*	1	*1*	1	—	—
Staphylinidae	—	—	—	—	—	—	—	—	*1*	1	—	—	*1*	1	*1*	1	—	—	—	—
Pselaphidae	—	—	—	—	*5*	1	—	—	*6*	1	*2*	1	—	—	—	—	—	—	—	—
Tenebrionidae	—	—	*4*	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Curculionidae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Diptera (larvae)	—	—	*8*	1	*4*	1	—	—	—	—	—	—	—	—	*1*	1	—	—	—	—
Rhynchota	—	—	—	—	*7*	2	*1*	1	*2*	2	*1*	1	—	—	—	—	*1*	1	—	—
Heteroptera	—	—	—	—	*7*	2	*1*	1	*2*	2	*1*	1	—	—	—	—	*1*	1	—	—
Lepidoptera (larvae)	—	—	*6*	2	*13*	2	*1*	1	*7*	1	*1*	1	—	—	*2*	1	—	—	—	—
Orthoptera	*8*	3	*2*	2	*1*	1	—	—	*1*	1	—	—	—	—	*8*	2	*8*	1	*2*	1
Blattidae	*4*	2	*2*	2	—	—	—	—	—	—	—	—	—	—	*2*	1	—	—	—	—
Forficulidae	—	—	—	—	*1*	1	—	—	*1*	1	—	—	—	—	*6*	1	—	—	*2*	1
Isoptera	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Aptera	—	—	—	—	*1*	1	—	—	—	—	—	—	—	—	*1*	1	—	—	—	—
Crustacea	*1*	1	*2*	1	*17*	2	*7*	2	*33*	1	—	—	*5*	1	*3*	1	—	—	*5*	1
Oniscoida	*1*	1	*2*	1	*17*	2	*7*	2	*33*	1	—	—	*5*	1	*3*	1	—	—	*5*	1
Amphipoda	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myriapoda	*2*	1	*1*	1	*11*	1	—	—	*7*	2	*5*	2	*42*	6	*11*	2	*1*	1	—	—
Chilopoda	—	—	*1*	1	—	—	—	—	*6*	1	*1*	1	*3*	2	*1*	1	—	—	—	—
Diplopoda	*2*	1	—	—	*11*	1	—	—	*1*	1	*4*	1	*39*	4	*10*	1	*1*	1	—	—
Arachnoidea	*3*	2	*6*	4	*29*	7	*5*	3	*15*	6	*14*	2	*7*	2	*25*	4	—	—	*5*	4
Araneae	*3*	2	*5*	3	*20*	4	*5*	3	*15*	6	*14*	2	*7*	2	*9*	3	—	—	*2*	2
Acarina	—	—	*1*	1	*7*	2	—	—	—	—	—	—	—	—	*16*	1	—	—	*1*	1
Mollusca	—	—	—	4	*4*	3	*5*	1	*1*	1	*11*	4	*2*	2	*5*	3	—	—	*7*	3
Vermes	—	—	*2*	1	—	—	—	—	*2*	1	—	—	*2*	1	*11*	1	—	—	—	—
Total	*14*	8	—	21	*94*	26	*19*	11	*76*	20	*34*	16	*59*	17	*80*	24	*11*	7	*20*	13

found on Sebesy being only a little higher than on Krakatau and species, the dispersal of which by the sea is difficult, being not strikingly more abundant on Sebesy, proves, in my opinion, that at the eruption of 1883 the fauna of Sebesy was destroyed to the same degree as on Krakatau.

The difference in the total number of animals, and especially the great difference of species, can be attributed to Sebesy being so much nearer the Sumatra coast, and to the much more normal flora than that of Krakatau, as well as to the constant traffic in consequence of the reinhabiting of this island in 1890. This all must be taken into account far more than the possibility that more animals survived the eruption on Sebesy than on Krakatau.

However interesting the study of the fauna of Sebesy has proved, it has not yet given us an answer to the question how far the fauna of Krakatau is still abnormal and further research will have to be made to solve this problem.

III. From where does the present fauna of Krakatau come and how have the animals reached the island?

An exact answer to the above question cannot be given for the moment and has also to be postponed for future research.

Most of the species found on the islands are widely spread, but of others our knowledge of their distribution is still so limited that it is not wise to draw conclusions.

We collected several species on Krakatau and Verlaten I. which are not known to occur either in Java or Sumatra. So *Lepidodactylus lugubris* is not recorded yet from these islands but from Riou and Borneo. Mr. LEEFMANS has identified a Rutelid from Krakatau as *Parastasia heterocera* OH., a species mentioned as from the Andaman Islands only. The nearest locality in which *Stibaroptera longipes* is known is the Tengger mountains in E. Java; of *Stylopyga picea*, Borneo and Singapore.

That all these animals should have come to Krakatau from such a remote place is difficult to suppose. We must rather surmise that the distribution of these species is very incompletely known. In this connection I would observe that the fauna of Southern Sumatra, especially the Lampongs, is poorly explored and many a species from Krakatau, till now only recorded from far away, may probably be found at this near locality.

With regard to the problem as to how the animals have reached the islands, we can only make suggestions. We hope that a special study of this subject later on will shed more light upon this matter.

Considering different possibilities, the animals may have come to the islands as follows: — by active flying or swimming; by the air or wind; by ocean currents, and through the medium of other animals or man.

Now computing how many winged animals there are on Krakatau, Verlaten I. and Sebesy, we get resp. 81%, 83% and 79% of the total amount.

This high percentage proves, I think, that flight or sailing on the wind plays an important part in the re-population of the islands by animals.

It is true that many insects may have reached the islands not on the wing, but on drifting wood or plants in the form of egg, larva or pupa. However, I believe we must attribute a greater share to the dispersal by air than is usually done, for let us see how many wingless animals there are on the islands?

We find a percentage of 19, 17 and 21 resp. for Krakatau, Verlaten I. and Sebesy.

List of wingless animals.

	1908			1921			
	Krakatau	Verlaten I.	Kr. + Verl. I.	Krakatau	Verlaten I.	Kr. + Verl. I.	Sebesy
Muridae	0	0	0	1	0	1	2
Reptilia	2	0	2	4	5	6	7
Insecta	6	0	6	11	10	18	11
Mutillidae (♀♀)	0	0	0	2	1	2	1
Psychidae (♀♀)	3	0	3	1	3	3	1
Coccidae (♀♀)	1	0	1	5	6	10	4
Blattidae (♀♀)	1?	0	1?	1	0	1	1
Rhaphidophora	0	0	0	0	0	0	3
Aptera	1	0	1	2	0	2	1
Myriapoda	6	0	6	4	1	4	9
Arachnida	18	0	18	73	37	82	82
Araneae	15	0	15	45	21	52	48
Crustacea	3	0	3	3	2	5	4
Mollusca	2	0	2	5	3	5	10
Vermes	1	0	1	6	0	6	6
Total	38	0	38	107	58	127	131

The agent for the dispersal of all these animals need not be ocean currents only; many among them may have come to the islands by other means.

In the first place, rats were certainly brought to their new habitat by man. Of the Reptiles, *Python* and *Varanus* are probably quite able to swim over the distance separating Krakatau or Verlaten I. from Sebesy or other islands in the neighbourhood. Both reptiles, if pursued, get easily out to sea and swim with great agility. JACOBSON noticed during his visit also a *Varanus* swimming alongside the ship. Pythons seem to cover long distances when in need of food.

Among the insects, we have the wingless females of *Mutillidae,* which cannot have reached the islands by their own flight. But the male is a strong insect and can fly easily with the female clasped to his thorax, as it is accustomed to do when mating, therefore it may be suggested that the female Mutillids are thus carried to the islands through the medium of the males.

The other insects of which females or both sexes remain wingless, must have been dispersed by drifting wood or things of a like nature. Only the very young larvae of *Psychidae* may possibly have arrived sailing on air currents like so many other young caterpillars do. In the same way very young spiders migrate, and the abundance of this group on the islands is certainly due to this easy means of dispersal.

Free-living mites and the other Arachnids have probably drifted ashore with vegetable debris; but the very small gall mites may have been for the greater part dispersed by the wind again, although others may have been introduced with the galls themselves or through the medium of other animals.

DOCTERS VAN LEEUWEN has found that the proportion of gall mites and gall midges is about the same on Java, whereas on Krakatau it is 18 : 8 and on Verlaten I. even 12 : 4. If these animals had reached the islands in their galls by sea it is not clear why mites should predominate. But if we suppose that the majority of these gall-producers have arrived through the air, evidently gall mites carried along by wind could reach the islands more easily than the active flying Diptera.

The terrestrial Crustacea and Mollusca also, as well as the Vermes, will certainly have come to the islands by ocean currents. But as to the moss fauna, dispersal by air is possible with these very tiny animals.

Now if we exclude from the table on p. 84 all the above-mentioned animals which possibly have reached the islands by wind or human agency, there still remain a certain number of species which apparently could not have reached the islands by any other means than by drifting wood. For the three islands, Krakatau, Verlaten I. and Sebesy, we find; then, that this number is 10 %, 9 % and 12 % of the total number of species occurring there, the highest figure being for Sebesy, which is the shortest distance from the Sumatra coast, and the lowest figure for Verlaten I. North. Although the latter island is not farther away from Java or Sumatra than Krakatau, it must be taken into account that this part of Verlaten I. is more recent land, the reoccupation by animals going on there for a shorter time.

All this proves, I believe, that new land is first invaded by flying animals, drifting wood or plants becoming more important in the long run only. In this connection it is interresting to note that among all the species recorded by JACOBSON in 1908 for Verlaten I. there is not one wingless animal.

According to the above supposition we would expect that the number of wingless animals on Krakatau has also increased since 1908, but computing the figures for the different years, we get 80 % winged animals in 1908

and 20% wingless ones, of which number half have certainly come to the island by ocean currents, against 81%, 19% and 10% in 1920—1921. The difference is too slight to draw any conclusion for or against our presumption. In this respect, also, it is most regrettable that investigations into Krakatau's fauna have not been made right from the start.

DE MEYERE, however, in his paper on the Diptera from Krakatau collected by JACOBSON, concluded that wind or air currents are not of such importance. All the *Diptera* found in 1908, in his opinion, have reached the island probably by sea as egg, larva or pupa. It is true that the short distances between Krakatau or Verlaten I. and Sebesy, and between Sebesy and Sumatra, will facilitate the dispersal of animals by drifting wood, but this is also favourable for those animals which come to the islands on the wing.

The north point of Verlaten I. is not more than 15 K.M. from Sebesy, and Krakatau only 19 K. M. The sea between Krakatau and Java or Prinsen Island is about 40 K. M. wide. We need not suppose that the new fauna of Krakatau has come direct from the Sumatra or Java mainland; the animals have arrived rather by way of Sebesy and Sebuku. These latter islands, only partly destroyed in 1883 and more quickly restored, are a suitable halting place for the new fauna on their way to the Krakatau islands.

The short distances between the islands are easily accomplished by most insects or other flying animals; not only by those which have strong powers of flight or migrate lengthly, like *Odonata* and *Lepidoptera*, but also by sluggish flying species. The latter can reach the islands sailing on the wind, just as so many delicate and wingless animals do. In this way very young caterpillars are known to accomplish rather large distances, even more than 20 K. M., as is the case with the caterpillars of the gipsy-moth in the United States. Neither violent winds nor storms are of much importance in this respect but, on the contrary, moderate and constant air currents. Even when the sky was bright and there was only a slight breeze at sea, we often observed insects (dragon-flies, butterflies and different species of Diptera) following our motor or rowing boat for quite a distance.

DE MEYERE brings forward the Dipteron *Plecia* as a species which certainly has not come to Krakatau on the wing. I do not think this is impossible, *Plecia* coming readily to light and being seen often in the evening sailing on its wings. DE MEYERE stated further that among the Diptera from Krakatau those which are swift of flight and have strong wings, like *Syrphidae* and *Asilidae;* have not come first nor are they more abundant. The majority of the Diptera collected by JACOBSON are species the larvae of which live in mould and vegetable debris or fungi. Now we must take into consideration that these predaceous flies on arriving at the island will not always find their proper food there, whereas for these scavengers there were, even quite early, plenty of suitable breeding places. Moreover

the strong fliers which occasionally arrive and do not find the island a good habitat, will probably migrate further, but the sluggish species, having been carried unintentionally to their new home, are by no means so easily off again.

Also, I believe, ships are playing a more important part in the dispersal of animals than is generally admitted. Many insects and other winged animals rest on, or follow, ships for a short time. When a ship is at anchor in a harbour or in a bay there are always some animals coming aboard, especially at night when they are attracted by the lamps. Sailing out to sea the ship will probably carry along some of these species. Most of them disappear again after a few hours but by this time, being already some miles from the coast, they fly to islands in the vicinity if these are nearer than the mainland. Now in Sunda-Strait there is always a constant traffic, not only of big steamers but also of many native vessels as well, in the direction north-south, east-west and vice versa. This traffic must not be neglected as a factor in the reoccupation of Krakatau by a new fauna.

That in 1908 aquatic insects, or insects the larvae of which live in fresh water, were nearly wholly absent, is, I suppose, not due to the fact that such larvae cannot be dispersed by sea, but can be put down to the proper conditions for the existence of these animals not being present. The rather rich insect fauna of the lake on Verlaten I. North having been invaded in a few years only, just proves, I think, that in the first place the islands are reached by winged adults.

A special investigation with regard to the different means of dispersal of animals is planned by the author, and it is hoped that by future researches it will be settled how far the above suggestions are right.

Also the problem has to be investigated as to how long different animals (adults as well as their different stadia) can stand drifting on sea?

In this connection we may mention here the experiments made by LEEFMANS (see his above quoted paper). He found that *Oryctes*-larvae, bored in wood, could stand immersion in seawater for 24 hours. By this time even drifting wood can easily cover the distance from the Java coast to Krakatau, the ocean currents in Sunda-Strait being very fast.

IV. Are there already local forms originated on the islands?

Theoretically Krakatau and Verlaten Island, perhaps also Sebesy, could give rise to new local or insular forms, as so many are already known to exist on other islands of the Malay Archipelago.

Now if one finds a new species or a new aberrant form on one of these devastated islands, it would be unwise to pretend that this form must have originated on the spot. In all probability the same form will inhabit other islands in the vicinity or the adjacent mainland; it only has not yet been collected there. In this connection we may repeat that especially our knowledge of the fauna of the islands in Sunda-Strait and of the land surrounding it, is scanty.

But still there is a possibility that something new may be found on one of these islands, a form confined to it and not existing on the other islands.

First of all such a form may originate by environmental changes. A certain form having invaded Krakatau, or one of the other islands, may find the conditions there different from those it is used to. The new environmental conditions can effect a constant aberration of the original form as long as these new conditions last. On Krakatau and Verlaten I. the flora is still far from normal, and the abnormal vegetation perhaps gives rise to new forms, but in future the forest will become less and less different from that on other islands.

But also other conditions may be of influence, for instance the absence of fresh water on Krakatau or the different food animals find there.

It will be also important to see how the newly introduced house rats will behave in future. If Krakatau remains uninhabited and uncultivated, these rats will find there quite other conditions than ordinarily, accustomed as they are to live in houses, to nest especially in the upper half of buildings, and to take for food the easily accessible stores in or around dwellings. There is a chance this subspecies will revert then to the original forest-dwelling species of rat, from which both house rats and country rats have originated.

Another mode of origin of new subspecies or races is by isolation. A species spread over a large area of land with uniform local conditions, and having a tendency to differentiation, is as a rule a mass of forms, a certain "population"; only it is impossible to separate these forms from each other except perhaps by breeding. Now new land is not invaded by such a species as a whole, but more probably by some straggling individuals. These individuals are likely to lack some characters of the species or to exhibit some others; if they remain isolated these forms become more and more fixed and may be easily separated then from the species of which they are offsprings.

The third possibility is that a new form comes into existence by the hybridization of two or more species or subspecies invading the island at the same time or shortly after each other.

All the above mentioned modes may be combined, each with one or two of the others.

Recently Mr. MOULTON has been describing two new Danaines from Krakatau and Verlaten I., viz. *Danaida juventa* CR. *krakatauae* and *D. melanippus* CR. *insularis*, the first subspecies from Krakatau and Verlaten I., the second from Krakatau only. Of *D. m. insularis* Mr. MOULTON writes: — "This Krakatau form suggests a possible hybrid between *hegesippus* and *melanippus*. Possibly stragglers of *melanippus* from Java and *hegesippus* from Sumatra have reached Krakatau since the great eruption and have given rise to this new race."

In the second lot of Danaines I sent to Mr. MOULTON, there was a ♂ of *D. melanippus melanippus* CR. from Krakatau and Mr. MOULTON wrote me, therefore (17th Aug. 1921):— "This ♂ is identical with Java examples and I fear that on that account my name *insularis* for the first example you sent me from Krakatau can only indicate an 'aberration' or 'form' not a 'geographical race' or 'subspecies' from Krakatau as I thought when describing it."

About *D. juventa krakatauae* he wrote me in the same letter: — "On seeing this further series I am now rather doubtful whether *krakatauae* is a good subspecies; I think it may prove inseparable from the Java form", (*D. juventa juventa* CR.).

Of course as a rule two subspecies of the same species cannot occur together in the same area. This is only possible if the one is a resident form and the other a migrant; or if the two are confined to different habitats, like house rats and country rats.

But are we perhaps watching the growth of new subspecies on Krakatau? Is it not possible that "*insularis*" and "*krakatauae*" are new subspecies in the making, not yet sufficiently fixed, and that the typical "*juventa*" and "*melanippus*" are newly arrived invaders? It is interesting to note in this connection that PIEPERS identified one of the Danaines which JACOBSON collected on Krakatau in 1908 as *D. melanippus hegesippus* CR., the Sumatran form of *D. melanippus*. If this specimen is in the Leyden Museum, it will be of great interest to see if this form is the true *hegesippus*; if so Mr. MOULTON may be right in suggesting *insularis* as a hybrid between *hegesippus* and *melanippus*.

Many other cases of the same kind may come to light when all the material collected on the islands has been worked out.

V. The Fauna of the brackish-water lake on Verlaten Island.

The fauna of this small lake of brackish water is of much interest because only recently it became cut off from the sea. The northern part of Verlaten Island is low and sandy land and did not exist shortly after the eruption of 1883. The coast-line was then about where now the hilly land begins (at c, fig. 2). Later on a separate shoal came into existence north of the old coast-line. In May 1908 there was a lagoon (at a) still in connection with the ocean; after that this arm of the sea became enclosed, the connection being filled up with sand and now clothed with Casuarine forest; a swampy depression (at b) is all that remains now of the former junction with the sea. The water of this pool is also brackish, but the area is subject to seasonal variations. In October 1919 the ground of pumice-stone was almost dried up and covered with a thin film of salt; the greatest height of the water was observed in April 1920.

The lake itself (a) is separated from this pool by a narrow and low strip of land, but at high water, or with violent winds, the waves of the lake

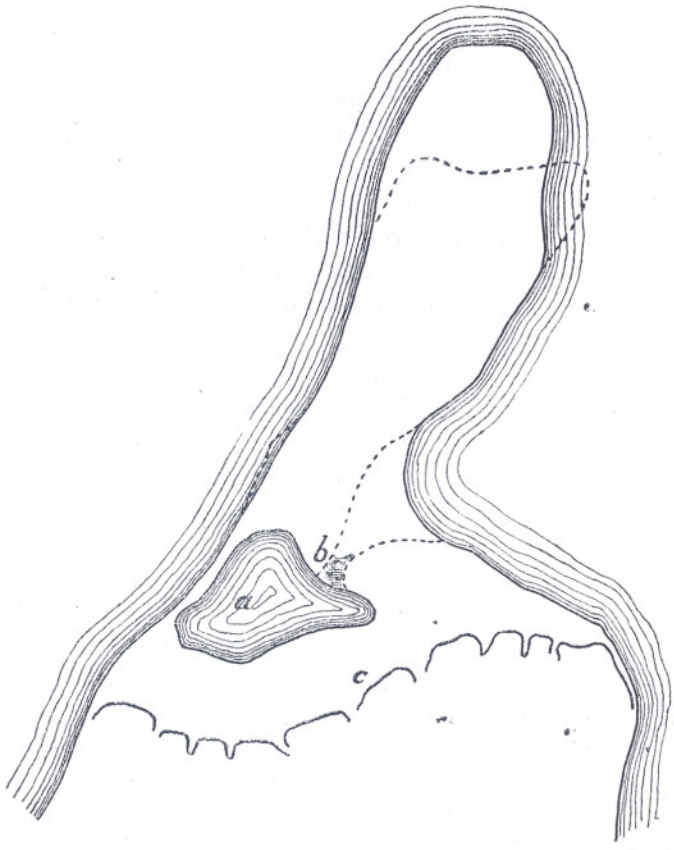

Fig. 2. Map of Verlaten Island North, Scale 1 : 30.000. a, brackish-water lake; b, brackish pool. The dotted lines indicate the coast-line of 1908; at c begins the hilly land; hereabouts was the coast-line shortly after the eruption.

break over the land connection.

Between the lake and the ocean is a narrow neck of land consisting of nearly barren dunes. The deepest place of the lake is at the western end; the soundings which Dr. SUNIER, Chief of the Laboratory for Marine Investigations, took here in April 1919 gave a depth of 5,7 M. (19 feet).

At the eastern end the water is very shallow and it seemed to me that the shore at this place is moving forward and becoming more and more overgrown by small Casuarina trees. The greatest length of the lake is about 800 M. Dr. ESCHER is of opinion that the lake will disappear in the end, the dunes at the west end moving inwards and the whole land shifting in an easterly direction.

The level of the lake changes a little in different seasons, also the salinity of the water undergoes seasonal changes (see table below), but is always less than that of pure sea-water.

Dr. SUNIER has been kind enough to take the following analyses for me.

Salinity.

	Lake a.	Pool b.
April 1919	22.8 $^0/_{00}$	22.5 $^0/_{00}$
Dec. 1919	25.3 „	—
April 1920	20.6 „	12.85 „
Sept. 1920	23.3 „	24.6 „
April 1921	21.4 „	16.4 „
Oct. 1921	29.0 „	27.9 „

We see that the lake is least saline at the end of the rainy monsoon (April-May); the highest salinity is observed at the end of the dry season (Oct.-Nov.), on account of the strong evaporation during several months, when there is little or no flowing in of fresh water. The salinity of the small pool is, of course, greatly influenced by the rains.

The rain-fall at Verlaten I. or Krakatau is not known and is hard to deduce from the figures noted at different stations on the Java and Sumatra coast along Sunda-Strait (see table on following pages) but certainly on these islands there is still a marked difference between the rainy season and the dry monsoon just as in Java.

The following observation is also of interest:— In April 1920 at high-tide there was a small but constant stream of water running into the lake out of the northern part of the dunes which separate the lake and the ocean. After analyzing it proved to be only 16.5 $^0/_{00}$ saline; probably the water was a mixture of fresh ground-water and sea-water as the ocean breakers were running so high that they were even flowing over the top of the dunes. The ground-water in the neighbourhood of the lake, even at a few feet distance from the shore, was always perfectly fresh.

The fauna of the lake is a very interesting one as no less than 51 species of animals have been collected or observed (see List below). Many marine forms were found which undoubtedly were enclosed after the connection of the lake with the sea came to an end.

List of species found in the lake.

Pisces	13
Teleostei	10
Insecta	17
Coleoptera	6
Diptera	3
Heteroptera	3
Odonata	5
Crustacea	5
Arachnoidea	1
Mollusca	4
Vermes	4
Bryozoa	1
Echinodermata	3
Coelenterata	2
Porifera	1
Total	51

The most remarkable fishes observed in the lake are a saw-fish (*Pristis* spec.) of about 2,5 M. in length; some three sharks, noted by Mr. SIEBERS April 1921; and a ray of 0.75 M. in length, with blackish-brown upper

Monthly rai

	1919		1920						
	Nov.	Dec.	Jan.	Febr.	Mrch.	April	May	June	Ju
Bantam, W. Java.									
Java's 1e punt	548	240	424	147	304	513	92	131	
Anjer Kidoel.	281	161	435	257	286	146	60	38	
Laboean	369	594	912	281	372	148	223	168	
Tjiteureup.	463	507	965	298	338	379	171	111	
Tjamara	457	446	828	300	301	229	94	41	
Lampongs, S. Sumatra.									
Kota Agoeng	325	226	133	118	147	205	67	95	1
Poetih Doh	147	320	240	298	279	250	94	146	4
Telokbetong	51	161	388	276	280	94	73	54	
Kalianda	413	456	434	389	395	359	118	175	

surface, and a tail the length of which was 2,5 times that of the body. I saw this species lying on the ground as I was wading through the shallow part of the lake in October 1921. I was unable to catch any of these animals.

Of the Teleostei some have been identified by Dr. SUNIER, viz. *Gerres filamentosus* C. V., *G. abbreviatus* BLKR., *Equula ensifera* C. V., *Apogon* 3 species, and one unknown species.

Besides these species three others have been observed by the author: — One, a big and heavy fish of 0.5 M. in length, bluish along the back with undulating dark stripes on the upper half posteriorly, is apparently *Thynnus thunnina* C. V. A smaller fish was seen of about 20 c.M. in length with dark bands on back and sides, probably *Therapon jarbua* FORSK; the third species, which was much smaller, was impossible to identify.

It is particularly interesting to note that nearly all these fishes are known to live in estuaries or brackish water *(Therapon, Gerres, Apogon)* or to ascend rivers *(Pristis, Equula)*. There also exists a shark, *Carcharias gangeticus* M. et H., distributed from India to Japan, which is ascending rivers to above tidal influence, and two species of *Raja* are recorded from fresh water.

There is some evidence from the above-mentioned facts, that all these marine fishes haunted the lagoon of 1908 and became imprisoned later on, and that they or their eggs have not got into the lake from the ocean during stormy weather.

The insects of the lake are of interest because they cannot have invaded the lake as larvae, but had to reach it on the wing. No less than 17 species of insects became inhabitants of this lake in about 12 years.

ıll in mm.

					1921									
ug.	Sept.	Oct.	Nov.	Dec.	Jan.	Febr.	Mrch	April	May	June	July	Aug.	Sept.	Oct.
290	168	395	173	331	510	618	327	118	41	74	40	41	42	206
203	113	55	59	292	442	241	341	173	60	77	188	154	58	64
169	363	297	335	564	826	665	386	142	0	287	210	61	93	125
145	814	539	383	73	585	1221	903	267	0	10	205	60	53	278
71	250	311	471	623	550	—	—	120	—	150	—	—	—	—
489	525	226	446	119	203	120	114	106	82	114	121	462	196	409
626	657	759	554	119	539	280	126	96	199	85	258	54	523	234
221	208	115	168	158	366	292	263	115	115	126	202	109	151	85
396	271	320	279	92	272	230	177	95	40	51	176	73	130	104

The Coleoptera are represented by 3 Dytiscides (1 *Cybister*), 2 Hydroporides and 1 Hydrophilid; the three species of Diptera are all Culicid-larvae; the aquatic bugs consist of 1 *Corixa* spec., 1 *Gerris* spec. and 1 Naucorid, of which two specimens came flying aboard the ship one evening when we were at anchor in the bay on the east side of Verlaten I. North (April 1921). Of the Odonata 4 species belong to the Aeschninae, one to the Agrioninae.

Five Crustacea were found:— An Asellid was abundant between the weeds and Algae in shallow water; a Balanid was found fixed to logs and branches under water. Two species of crabs were present, a smaller one and a very big one with a carapace-breadth of about 20 cM.; a mating pair of the latter I observed in the deep part of the lake. Nearly quite transparent shrimps were always collected together with the Asellids; the same species abounds in small streams on Sebesy in the proximity of the sea, where the water is still under tidal influence.

The Arachnid mentioned in the list is not a true aquatic species, but a spider living on the water and running along its surface with great agility.

The Mollusca consist of one very small bivalve and three snails, one of which is a *Litorina.*

Of the Vermes 3 species are Polychaetes, two of which seem to belong to the *Nereidae;* one species is a Planarian.

The Bryozoe is a small form growing on submerged leafs.

The Echinodermata are represented by an Asteroid, *Archaster* spec., which is very abundant in the shallow part of the lake; by an Ophiuroid and a Synaptid, apparently *Chondrocloea aspera* SLUITER.

One Antipathid and a small Sea-anemone make up the Coelenterata.

The sponges found in the lake consist of cushion-shaped masses growing around submerged branches or covering pumice-stones.

To the above-mentioned species we will have to add the plankton organisms; tow nettings have been taken by Dr. SUNIER in April 1919 and the catch has been sent to Europe for determination.

It will be noticed that the fauna of the lake is very remarkable as it consists of marine-littoral and estuarine species belonging to genera of which representatives are known to live in fresh water, and besides there are many aquatic insects which are purely fresh-water forms, having invaded the lake after 1908.

It will be of much interest to follow the process going on here; to study how this association of animals will behave and change on account of the water of the lake getting perhaps less and less saline, and its depth and area also altering in future years.

Conclusions.

The present investigation with regard to the fauna of Krakatau is not at all ended. It is mainly a statement of facts on which future researches can be based, but the following conclusions may be drawn already, though the correctness of some of these has to be more thoroughly affirmed by later investigations: —

1. New land is probably first invaded by winged animals, the dispersal by drifting wood or plants only becoming afterwards of more importance. The same is true as to newly-formed fresh-water or brackish lakes; the first inhabitants belonging to the true fresh-water fauna are winged insects.
2. Many more species certainly came to the islands than those now present, but the absence of the proper environmental conditions prevented their settlement.
3. The first settlers were doubtless scavengers of decaying vegetable matter, the most suitable conditions existing for this group of animals right from the start. For those feeding on live plant tissue the chances are less favourable, the stage of the flora being in this case of the utmost importance. The most difficult is the settlement for predaceous and parasitic animals, it depending on the occurrence and abundance of the proper host in the right stadium.
4. The newly-arrived species increase at an abnormal rate as long as their parasites and enemies are absent. On new land at the beginning the number of species is slight but specimens abound.
5. The question of how far the present fauna of Krakatau is to be considered as normal cannot be settled; it must be still abnormal as long as the flora has not been restored wholly.

The comparison with the fauna of Sebesy proved that the fauna of this island is only slightly in advance of, and has been destroyed apparently in the same degree as, that of Krakatau at the eruption of 1883.

6. Dispersal through the air either actively by animals on the wing, or passively by wind or air currents, probably carries most weight, but also by ocean currents far more animals, like Myriapoda, Arachnida and terrestrial Crustacea and Mollusca, can be dispersed than is generally accepted.
7. From the presence of the last-mentioned animals on an island it may not always be concluded that there has existed in past times a land connection with other islands or a continent. Also the existence of archaic species on an island does not always prove that it is of great age.
8. There is some evidence that we can witness the origin of new insular forms on Krakatau, but the lapse of time between the eruption and the present investigation is certainly too short for observations of this kind.

Conclusions of the same kind, as put in the above theses 4, 6 and 7, have already been drawn by JACOBSON from his investigations in 1908.

A. List of animals from Krakatau, Verlaten Island and Sebesy.

	1908			1921			
	Krakatau	Verlaten I.	Kr. + Verl. I.	Krakatau	Verlaten I.	Kr. + Verl. I.	Sebesy
Mammalia	0	0	0	3	1	3	4
Chiroptera	0	0	0	2	1	2	2
Muridae	0	0	0	1	0	1	2
Aves	14	3	14	34	38	44	42
Reptilia	2	0	2	4	5	6	7
Lacertilia	2	0	2	3	4	5	4
Ophidia	0	0	0	1	1	1	3
Insecta	150	26	164	441	238	565	474
Hymenoptera	51	8	53	66	28	80	57
Hym. parasitica	11	4	13	20	2	21	3
Formicidae	20	2	20	23	12	26	25
Coleoptera	23	2	24	115	68	146	94
Cicindelidae	0	0	0	0	0	0	5
Col. aquat.	0	0	0	2	6	7	0
Lepidoptera	10	0	10	84	43	113	110
Rhopalocera	5	0	5	27	11	29	35
Heterocera	5	0	5	57	32	84	75
Lep. cecidia	0	0	0	0	1	1	2
Diptera	32	11	40	54	23	66	56
Dipt. cecidia	0	0	0	8	4	11	16
Rhynchota	15	4	18	74	41	96	84
Heteroptera	8	1	9	37	21	48	42
Cryptocerata	0	0	0	1	2	3	0
Homoptera	6	3	8	28	11	33	30
Aphidae	0	0	0	1	2	2	1
Coccidae	1	0	1	5	6	10	4
Phytophth. cecidia	0	0	0	4	6	8	9
Thysanoptera	0	0	0	10	4	12	13
Thys. cecidia	0	0	0	0	0	0	4

	1908			1921			
	Krakatau	Verlaten I.	Kr. + Verl. I.	Krakatau	Verlaten I.	Kr. + Verl. I.	Sebesy
Orthoptera	14	1	14	27	22	35	51
Forficulidae	1	0	1	1	2	2	4
Blattidae	3	0	3	6	4	6	7
Mantidae	0	0	0	1	0	1	1
Phasmidae	0	0	0	0	0	0	1
Acridiidae	5	1	5	7	8	11	15
Locustidae	1	0	1	7	5	8	11
Gryllidae	4	0	4	5	3	7	12
Odonata	1	0	1	4	6	8	5
Neuroptera	1	0	1	3	1	4	0
Isoptera	2	0	2	2	2	3	3
Aptera	1	0	1	2	0	2	1
Myriapoda	6	0	6	4	1	4	9
Diplopoda	3	0	3	2	0	2	5
Chilopoda	3	0	3	2	1	2	3
Arachnida	18	0	18	73	37	82	82
Scorpionidea	1	0	1	0	0	0	2
Pedipalpi	1	0	1	2	1	2	3
Araneae	15	0	15	45	21	52	48
Acarina	0	0	0	23	14	25	25
Acar. cecidia	0	0	0	18	12	20	22
Crustacea (terr.)	3	0	3	3	2	5	4
Isopoda	3	0	3	3	1	4	2
Amphipoda	0	0	0	0	1	1	0
Mollusca (terr.)	2	0	2	5	3	5	10
Vermes	1	0	1	6	0	6	6
Oligochaeta	1	0	1	2	0	2	2
Total	196	29	210	573	325	720	638

B. List of animals from the Krakatau group, collected by E. Jacobson in 1908 and identified by various specialists.

(K. = Krakatau, V. = Verlaten Island, L. = Lang Island).

Hymenoptera.

Formicidae (FOREL).

Euponera (Brachyponera) luteipes MAYR	K.		
Tetramorium pacificum MAYR	K.		
Monomorium minutum liliukalauii, var. javana FOREL.	K.		
Cremastogaster artifex MAYR	K.		
Sima siggii FOREL	K.		L.
Sima rufonigra JERDON	K.		
Sima nigra thagatensis FOREL	K.		L.
Bothriomyrmex wroughtoni, var. javana FOREL.	K.		L.
Plagiolepis longipes JERDON.	K.	V.	L.
Prenolepis longicornis LATR.	K.		
Oecophylla smaragdina F.	K.		L.
Camponotus (Colobopsis) vitreus angustatus MAYR	K.		
Camponotus reticulatus bedoti EMERY	K.		
Camponotus maculatus irritans SMITH	K.		
Polyrhachis rastellata LATR.			L.
Polyrhachis dives SMITH	K.	V.	
Polyrhachis bicolor SMITH	K.		L.
Polyrhachis armata LE GUILLOU	K.		
Polyrhachis orsyllus SMITH	K.		
Polyrhachis mayri ROG.	K.		
Polyrhachis proxima ROG.	K.		

Braconidae (SZÉPLIGETI).

Orgilus spec.	K.		
Eubadizon luteum SZÉPL.	K.		

Ichneumonidae (SZÉPLIGETI).

Trichomella insularis SZÉPL.	K.		
Ichneumon albatorius F.	K.		
Gambrus adornatus TOSQ.		V.	
Gambrus similis SZÉPL.	K.		L.
Gambrus rufithorax SZÉPL.	K.		
Hemiteles spec.	K.		
Xanthopimpla facialis SZÉPL.	K.		L.

Lepidoptera (PIEPERS).

Danais melanippus hegesippus CRAM.	K.		
Neptis aceris papaja MOORE.	K.		

Diptera (DE MEYERE).

Sciara spec.	K.		
Plecia fulvicollis F.	K.		
Stegomyia scutellaris WALK.	K.		
Dicranomyia spec.			L.
Microchrysa flavomarginata DE MEY.	K.		
Toxophora javana WIED.	K.		
Maira spec.			L.
Syndyas elongata DE MEY.		V.	
Syndyas brevior DE MEY.		V.	L.
Diaphorus cinctellus DE MEY.	K.		
Agonosoma nudifrons DE MEY.	K.	V.	L.
Agonosoma rectum WIED.		V.	
Agonosoma spec.		V.	
Sphaerophoria scutellaris F.			L.
Baccha chalybea DE MEY.	K.		
Baccha pedicellata DOL.	K.		
Baccha pulchifrons AUST.	K.		
Baccha bicincta DE MEY.	K.		
Platypeza argyrogyna DE MEY.	K.		
Phora sinensis SCHIN.	K.		
Sturmia provecta DE MEY.	K.		
Carcelia spec.	K.		
Exorista iridipennis V. D. W.	K.		L.
Prosopaea appendiculata DE MEY.			L.
Sarcophaga spec.	K.		
Macronychia navigatrix DE MEY.			L.
Lucilia spec.	K.		
Mydaea lineata STEIN	K.		
Mydaea pellucida STEIN	K.		
Atherigona trilineata STEIN	K.		
Pygophora maculipennis STEIN.		V.	L.
Telostylus trilineatus DE MEY.	K.		
Rivellia basilaris WIED.			L.
Stenopterina eques SCHIN.	K.		
Lonchaea cupraria DE MEY.	K.		
Lonchaea spec.	K.	V.	
Lauxania trypetoptera HEND.	K.		
Lauxania beckeri KERT.	K.		
Lauxania signatifrons KERT.		V.	
Lauxania viatrix DE MEY.	K.		
Lauxania simplicissima DE MEY.	K.	V.	L.
Hippelates spec.			L.
Chlorops incisa DE MEY.	K.		

Chalcidomyia punctifera DE MEY. . . . . V.
Agromyza provecta DE MEY. . . . . K.
Agromyza cornuta DE MEY.. . . . . V.
Physocephala limbipennis DE MEY. . . . . K.

Odonata (RIS).
Agrionoptera insignis insignis RAMB. . . . . K.
Diplacodes trivialis RAMB. . . . . L.

Thysanura (SILVESTRI).
Meinertellus jacobsoni SILV. . . . . K.

Arachnoidea.

Opiliones (ROEWER).
Epedanus javanus THOR. . . . . K.

Pseudoscorpionidae (TULLGREN).
Chelifer birmanicus THOR. . . . . K.

Vermes.

Oligochaeta (HORST).
Pheretima spec. . . . . K.

C. List of Birds from Krakatau, Verlaten Island and Sebesy

collected and identified by

M. BARTELS (Pasir Datar) and H. C. SIEBERS (Buitenzorg).

(The species with an * were observed by JACOBSON in 1908).

Accipitres.

Haliaetus leucogaster GM. . . . . K. V. S.
Verlaten I. April 1919 (B.); S. E. Krakatau and Verlaten I. one specimen, Sept. 1920; Sebesy, April 1921 (S.).

Haliastur intermedius GURN. . . . . K. V. S.
Krakatau April 1919 (B.); Krakatau Dec. 1919 (DAMMERMAN); Verlaten I. Sept. 1920; Sebesy, April 1921 (S.).

Astur or *Accipiter* spec. . . . . K.
An Asturine hawk was observed flying along the rocky wall at Zwarte Hoek, Krakatau, Sept. 1920, apparently an *Astur* or *Accipiter* species, probably a migrant (S.).

Alcedines.

* *Halcyon chloris* BODD. . . . . K. V. S.
Not uncommon on Krakatau and Verlaten I. April 1919 (B.); idem Sept. 1920, a nest with young on Krakatau

24th Sept., on Verlaten I. a nest with three eggs 26th Sept.; common on Sebesy, April 1921 (S.).

* *Alcedo beryllina* VIEILL.
Recorded by JACOBSON from Krakatau 1908, not seen in 1919–1921.

Cuculi.

Eudynamis honorata L. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); the species seems to be commoner on Krakatau than on Verlaten I. Sept. 1920; abounds in the cocoanut plantations of Sebesy April 1921 (S.).

Centropus sinensis STEPH. . . . . V. S.
The note of this bird heard on Verlaten I. April 1919 (B.); on Sebesy this species seems to be more common than *C. javanicus*, April 1921 (S.).

* *Centropus javanicus* DUM. . . . . K. V. S.
Krakatau and Verlaten I., on Krakatau a nest with two eggs, April 1919 (B.); Krakatau S. E. and Zwarte Hoek, Verlaten I. Sept. 1920; Sebesy April 1921 (S.).

Cacomantis merulinus SCOP. . . . . S.
Not common on Sebesy April 1921 (S.).

Chalcococcyx basalis HORSF. . . . . S.
One specimen observed, certainly a migrant, April 1921 (S).

Caprimulgi.

* *Caprimulgus affinis* HORSF. . . . . K. V. S.
Common on Verlaten I. April 1919 (B.); abounds on Krakatau and Verlaten I., two ♀♀ collected at Zwarte Hoek and on Verlaten I., both with an egg covered by a thin shell in the oviduct, Sept. 1920; on Sebesy the species is less abundant than on Krakatau or Verlaten I. April 1921 (S.).

Cypseli.

Micropus pacificus LATH. . . . . V.
A number of four swifts with short forked tail and white rump were observed on Verlaten I. Sept. 1920 (S.).

* *Collocalia* spec. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. Sept. 1920, in the evening of the 25th Sept. about 6 p.m. these swifts, of which the rump was light-coloured, were abundant at Zwarte Hoek, but in the morning no specimen was seen at this place; several specimens at Sebesy S. April 1921 (S.).

Pici.

Jyngipicus auritus EYT. . . . . K. S.
One specimen noted on Krakatau S. E. Sept. 1920; not common on Sebesy April 1921 (S.).

Oscines.

Hirundo gutturalis SCOP. . . . . K. V.
Verlaten I. April 1919 (B.); Krakatau S. E. and Zwarte Hoek, Verlaten I. Sept. 1920, a migratory bird (S.).

Hirundo javanica SPARRM. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. Sept. 1920; Sebesy April 1921 (S.).

Cinnyris pectoralis HORSF. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. on this island a nest with two eggs, Sept. 1920; Sebesy April 1921 (S.).

Anthothreptes malaccensis GM. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau S. E. Sept. 1920; Sebesy, abounds in the cocoanut plantations April 1921 (S.).

Arachnothera longirostris LATH. . . . . S.
Common on Sebesy in the cocoanut plantations April 1921 (S).

Motacilla flava L. . . . . K. V. S.
Zwarte Hoek, Krakatau and Verlaten I. Sept. 1920; Sebesy 29th Sept. 1920; a migratory bird (S.).

Motacilla melanope PALL. . . . . S.
Sebesy 29th. Sept. 1920, one specimen, a migrant (S.).

Cittocincla tricolor VIEILL. . . . . S.
Sebesy April 1921 (S.).

Geocichla interpres TEMM. . . . . S.
A rare bird, one specimen Sebesy April 1921 (S.).

Copsichus musicus RAFFL. . . . . K. V.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. Sept. 1920 (S.).

* *Pycnonotus analis* HORSF. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. Sept. 1920; commonly breeding on Sebesy April 1921 (S.).

* *Pycnonotus aurigaster* VIEILL.
Recorded by JACOBSON from Krakatau 1908, not seen in 1919—1921.

Lalage terat BODD. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau S. E, Verlaten I. Sept. 1920; Sebesy April 1921 (S.).

Dicaeum trigonostigma SCOP. . . . . K. V. S.
One specimen (♀) noted on Krakatau, another (♀) on Verlaten I. April 1919 (B.); one ♂ on Verlaten I. April 1921; not common on Sebesy April 1921 (S.).

* *Artamus leucogaster* VAL. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau S. E. and Zwarte Hoek, more common on Verlaten I. Sept. 1920; Sebesy April 1921 (S.).

Pachycephala grisola BLYTH . . . . . K. V. S.
A rare bird on Krakatau and Verlaten I. April 1919 (B.); a couple on Krakatau S. E., a young ♀ on Verlaten I. Sept. 1920; one ♂ on Verlaten I. April 1921; rather common on Sebesy April 1921 (S.).

Siphia spec. . . . . S.
The back of the female of this species is bluish slate-colour, as in the male. After Mr. BARTELS this species has to be separated from *Siphia banjumas*, Sebesy April 1921 (S.).

Phylloscopus borealis BLAS . . . . . S.
One specimen of this migratory bird shot near the coast; another at an altitude of 600 M. Sebesy, April 1921 (S.).

Orthotomus spec. . . . . S.
A species of this genus, probably *O. cineraceus* BLYTH, is rather common on Sebesy, April 1921 (S.).

* *Lanius bentet* HORSF. . . . . K. V.
Krakatau, Verlaten I. April 1919, a very young specimen collected on Verlaten I., which proves that this shrike is breeding there (B.); a nest with 3 eggs at Zwarte Hoek, Krakatau Dec. 1919 (DAMMERMAN); Verlaten I. Sept. 1920 (S.).

Lanius superciliosus LATH. . . . . K.
An old and a young male collected at Zwarte Hoek, Krakatau 25th Sept. 1920, a migrant (S.).

* *Oriolus maculatus* VIEILL. . . . . K. V. S.
Abundant on Krakatau and Verlaten I., a nest with two eggs collected on Krakatau April 1919 (B.); Krakatau, Verlaten I. Sept. 1920; also common on Sebesy, April 1921 (S.).

* *Corone macrorhyncha* WAGL. . . . . K. V. S.
Not common on Krakatau and Verlaten I. April 1919 (B.); idem Sept. 1920; Sebesy April 1921 (S.).

Calornis chalybea HORSF. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I., here a nest with 2 young Sept. 1920; abounds on Sebesy, April 1921 (S.).

Munia nisoria TEMM. . . . . S.
Not very common on Sebesy April 1921 (S.).

Columbae.

* *Osmotreron vernans* L. . . . . K. V. S.
Krakatau, Verlaten I. April 1919 (B.); Krakatau, Verlaten I. Sept. 1920; common on Sebesy April 1921 (S.).

Myristicivora bicolor SCOPS. . . . . K. V. S.
Large flocks of this fruit-pigeon seen at Krakatau April 1919 (B.); idem Dec. 1919 (DAMMERMAN); idem Krakatau and Verlaten I. Sept. 1920; not so common on Sebesy, April 1921 (S.).

Geopelia striata L. . . . . K.
One specimen on Krakatau April 1919 (B.).

* *Chalcophaps indica* L. . . . . K. V. S.
Common on Krakatau and Verlaten I., a nest with 2 eggs collected on Krakatau April 1919 (B.); Krakatau, Verlaten I., at Zwarte Hoek, Krakatau a nest with 2 brooded eggs, a nest with 2 fresh eggs on Verlaten I. Sept. 1920; also breeding abundantly on Sebesy April 1921 (S.).

Limicolae.

* *Tringoides hypoleucus* L. . . . . K. V. S.
Two specimens observed on Krakatau, one on Verlaten I. April 1919 (B.); Krakatau S. E. and Zwarte Hoek, more common on Verlaten I. Sept. 1920; Sebesy April 1921; a migrant (S.).

Numenius phaeopus L. . . . . K. S.
One specimen of this migratory bird seen at Zwarte Hoek, Krakatau Dec. 1919; another in the small bay of Sebesy N. 29th Sept. 1920 (DAMMERMAN).

Orthoramphus magnirostris VIEILL. . . . . V. S.
One specimen shot on the shore of Verlaten I. 29th Sept. 1920; 3 specimens seen on Sebesy April 1921; a migrant (?) (S.).

Ochthodromus geoffroyi WAGL. . . . . V. S.
One specimen on Verlaten I. April 1919 (B.); several specimens seen on Verlaten I. Sept. 1920; not common on Sebesy April 1921; a migratory species (S.).

Lari.

Hydrochelidon leucoptera M. et SCH. . . . . V.
Seen at sea between Verlaten I. and Krakatau, April 1919 (B.); seen at sea near Verlaten I. Sept. 1920 (S.).

Sterna fuliginosa GM. . . . . V.
This species or *S. anaestheta* SCOP. was seen at sea near Verlaten I. Sept. 1920 (S.).

Sterna bergii LICHT. . . . . V.
Several specimens on the shore of Verlaten I. North Sept. 1920 (S.).

* *Sterna melanauchen* TEMM. . . . . V. S.
Old and young specimens abundant on Verlaten I. North Sept. 1920; seen at sea near Sebesy April 1921 (S.).

* *Sterna dougalli* MONT. . . . . V.
Also common on Verlaten I. North Sept. 1920 (S.). One nest with 1 egg and two nests each with 2 eggs of a *Sterna* spec. were found on Verlaten I. 28th July 1919 by Dr. ESCHER.

Ralli.

Amaurornis phoenicura FORST. . . . . K. V. S.
Krakatau, Verlaten I., a young chicken on Verlaten I. April 1919 (B.); a young specimen at Krakatau S. E. and one adult on Verlaten I. Sept. 1920; Sebesy April 1921 (S.).

Ardeae.

Butorides javanica HORSF. . . . . V.
One specimen observed on Verlaten I. 26th Sept. 1920 (S.).

Demiegretta sacra GM. . . . . K. S.
One specimen on Krakatau and one on Bootsmansrots, between Krakatau and Verlaten I. April 1919 (B.); a small colony of the white phase was seen roosting on a tree at Krakatau S. E. Dec. 1919; a single specimen at Sebesy Sept. 1920 (DAMMERMAN); Sebesy April 1921 (S.).

Fregatae.

Fregata spec. . . . . K. S.
Three specimens of a Frigate bird were observed flying over Krakatau April 1919 (B.); also seen above Sebesy April 1921 (S.).

Procellarii.

Oceanodroma monorhis SWINH. . . . . V.
One specimen of this petrel came flying aboard the ship in the evening of the 23rd. Oct. 1921, when we were at anchor near Verlaten I. North (DAMMERMAN).

D. List of Reptiles from Krakatau, Verlaten Island and Sebesy.

(Except the species with an *, the others have been identified by Dr. NELLY DE ROOY, Amsterdam.)

Lacertilia.

Hemidactylus frenatus (D. & B.) . . . . . K. V.
Distrib. Throughout the Indo-Australian Archipelago.

Lepidodactylus lugubris (D. & B.) . . . . . K. V. S.
Distrib. Malacca to New Guinea, not found in Java or Sumatra.

Gecko monarchus (D. & B.) . . . . . S.
Distrib. Indo-Australian Archipelago.

* *Varanus salvator* (LAUR.) . . . . . K. V. S.
Distrib. S. E. Asia and Malay Archipelago.

Lygosoma atrocostatum (LESS.) . . . . . V.
Distrib. Malacca to New Guinea, not found in Sumatra.

Lygosoma bowringi (GTHR.) . . . . . S.
Distrib. Malacca to Celebes, not found in Sumatra.

Ophidia.

* *Python reticulatus* (SCHN.) . . . . . K. V. S.
Distrib. Malay Archipelago.

Coluber melanurus SCHLEG . . . . . S.
Distrib. Burma to Celebes.

* *Chrysopelia ornata* (SHAW) . . . . . S.
Distrib. British India to Celebes.

E. List of Danainae from Krakatau, Verlaten Island and Sebesy

identified by

J. C. MOULTON, Singapore.

Danaida juventa krakatauae MOULT. . . . . K. V. S.
Distrib. Krakatau, Verlaten I., Sebesy.

Danaida aspasia aspasia FAB. . . . . S.
Distrib. Malay Peninsula, Sumatra.

Danaida melissa microsticta BUTL. . . . . S.
Distrib. Borneo.

Danaida chrysippus bataviana MOORE, form *petilia* STOLL. V.
Distrib. North Australia to Timor, Mt. Slamat (Java).

Danaida plexippus intensa MOORE . . . . . K. S.
Distrib. Borneo, Java, Bali, Bawean.
Danaida plexippus intensa MOORE, form *sumatrana* MOORE. S.
Distrib. Sumatra.
Danaida melanippus melanippus CR. . . . . K.
Distrib. Java.
Danaida melanippus insularis MOULT. . . . . K.
Distrib. Krakatau.

F. List of Orthoptera from Krakatau, Verlaten Island and Sebesy

identified by

Dr. H. KARNY, Buitenzorg.

Blattoidea.

Pycnoscelus surinamensis L. . . . . K. V. S.
Distrib. Cosmopolitan.
Periplaneta australasiae F. . . . . K. V. S.
Distrib. Cosmopolitan.
Blatta orientalis L. (?) . . . . . K. S.
Distrib. Cosmopolitan.
Stylopyga picea B. v. W. . . . . K. V.
Distrib. Burma, Borneo.
Blattella notulata STÅL. . . . . K.
Distrib. Malacca, Java, Borneo, Tahiti.
Blattella contingens WLK. . . . . K. V. S.
Distrib. Java, Borneo.
Blattella 2 spp. . . . . S.
Anaplecta javanica SAUSS. . . . . S.
Distrib. Java.

Mantoidea.

Tenodera aridifolia STOLL (?) . . . . . S.
Distrib. E. and S. Asia, Indo-Australian Archipelago.
Hierodula patellifera SERV. (?) . . . . . K.
Distrib. S. E. Asia, Java, Lombok, Buru.

Phasmoidea.

Presbistus peleus GRAY. . . . . S.
Distrib. Malacca to Key I.

Gryllacridae.

Rhaphidophora cultrifera ZACH. . . . . S.
Distrib. Sumatra.

Rhaphidophora fulva B. v. W. . . . . S.
Distrib. Tenasserim, Java, Ceram.
Rhaphidophora nov. spec. . . . . S.
Distrib. Sebesy.
Gryllacris signifera STOLL. . . . . K. V. S.
Distrib. S. E. Asia, Malay Archipelago.
Gryllacris tibialis SERV. . . . . S.
Distrib. Java.

Gryllidae.

Euscirtus concinnus DE H. . . . . S.
Distrib. Ceylon, Singapore, Java, Philippines.
Trigonidium haanii SAUSS. . . . . K.
Distrib. Java.
Cyrtoxipha venustula SAUSS. . . . . S.
Distrib. Java, Burma.
Cyrtoxipha ritsemae SAUSS. . . . . S.
Distrib. Java, Burma.
Oecanthus indicus SAUSS. . . . . S.
Distrib. British India, Burma, Java.
Ornebius spec. . . . . K. S.
Ectadoderus spec. nov. (?) . . . . . S.
Acheta testacea WALK. . . . . K. V.
Distrib. E. and S. Asia, Malay Archipelago.
Acheta consobrina SAUSS. . . . . K.
Distrib. Africa, India.
Acheta clarella SAUSS. . . . . V. S.
Distrib. Java, Burma.
Loxoblemmus equestris SAUSS. . . . . K. S.
Distrib. Java, Celebes, Moluccas.
Nemobius javanus SAUSS. . . . . S.
Distrib. Java, Burma.
Nemobius novarae SAUSS. . . . . S.
Distrib. Java.
Nemobius spec. . . . . S.

Gryllotalpidae.

Gryllotalpa africana P.—B. . . . . V. S.
Distrib. Africa, Asia, Australia, New Zealand.

Locustidae.

Phaula nov. spec. 1. . . . . K.
Phaula nov. spec. 2. . . . . S.
Phaneroptera brevis SERV. . . . . K. V. S.
Distrib. Singapore to N. Australia.

Stibaroptera longipes DOHRN. . . . . S.
Distrib. Mt. Tengger, E. Java.
Mecopoda elongata L. . . . . K. S.
Distrib. E. and S. Asia, Indo-Australian Archipelago.
Hexacentrus, unicolor SERV. . . . . K. V. S.
Distrib. E. Asia, Malay Archipelago, Moluccas.
Xiphidion maculatum LE GUILLOU . . . . . K. V.
Distrib. Africa, E. and S. Asia, Malay Archipelago.
Xiphidion melan DE H. . . . . S.
Distrib. Sumatra, Borneo, Java, Celebes, Formosa, Japan.
Euconocephalus indicus REDT. . . . . K.
Distrib. India, China, Malay Archipelago, Australia.
Euconocephalus pallidus REDT. . . . . V.
Distrib. India to New Guinea.

Acrididae.

Acrydiinae 5 spp. . . . . S.
Acrydiinae 2 spp. . . . . V.
Phlaeoba antennata B. V. W. . . . . S.
Distrib. Burma, Cochin-china, Penang, Sumatra, Borneo.
Aiolopus tamulus F. . . . . V.
Distrib. Persia to Australia and Japan.
Trilophidia annulata THUNB. . . . . K. S.
Distrib. Africa, China, Japan, Philippines, Java.
Trilophidia cristella STÅL . . . . . V.
Distrib. India, China, Manila, Singapore, Java, Borneo.
Atractomorpha crenulata F. . . . . K. V. S.
Distrib. Africa?, India to Java.
Tagasta marginella THUNB. . . . . S.
Distrib. Java.
Oxya velox F. . . . . K. V. S.
Distrib. S. Asia to Australia.
Oxyrrhepes extensa WALK. . . . . K. V. S.
Distrib. China, India, Ceylon, Burma, Java, Gilolo.
Cyrtacanthacris nigricornis BURM. . . . . K. V. S.
Distrib. S. India, Singapore, Penang, Java, Lombok, Thursday I.
Eucoptaera cingulatipes BOL. . . . . S.
Distrib. Sumatra.
Catantops intermedius BOL. . . . . K. S.
Distrib. Indo-Australian Archipelago.
Catantops humilis SERV. . . . . K. S.
Distrib. China, India, Ceylon, Malay Archipelago.

G. List of the Thysanoptera from Krakatau, Verlaten Island and Sebesy

identified by

Dr. H. KARNY, Buitenzorg.

Terebrantia.

Cricothrips nov. spec.	K.		
Taeniothrips longistylus KARNY	K.	V.	S.
„ nov. spec.	K.		
Physothrips vitticornis KARNY	K.	V.	
Thrips nov. spec. 1.	K.		
„ „ „ 2.	K.		
Isoneurothrips nov. spec.		V.	S.
Nov. gen. (*Rhamphothripinae*)	K.		S.
„ „ (*Belothripinae*)	K.		

Tubulifera.

Dolichothrips longicollis KARNY	K.		S.
Haplothrips soror SCHMUTZ.		V.	S.
„ nov. spec.			S.
Eothrips taurus (KARNY)			S.
Androthrips melastomae (ZIMM.)			S.
Gynaikothrips chavicae (ZIMM.)			S.
„ *gracilis* KARNY			S.
„ *pallipes* KARNY			S.
Cryptothrips nov. spec. (?)	K.		
Dinothrips sumatrensis BAGNALL			S.
Gigantothrips elegans ZIMM.			S.

H. List of Phytophthires from Krakatau, Verlaten Island and Sebesy [1])

identified by

P. VAN DER GOOT, Buitenzorg.

Psyllidae.

Psyllid spec. 1 larvae on Ficus ampelas, IV 1921, Damm., Sebesy	S.
Psyllid spec. 2 larvae on Ficus hispida, 25 IV 1921, Damm., Sebesy	S.

[1]) The gall-producing species collected by Dr. DOCTERS VAN LEEUWEN are not included in this list.

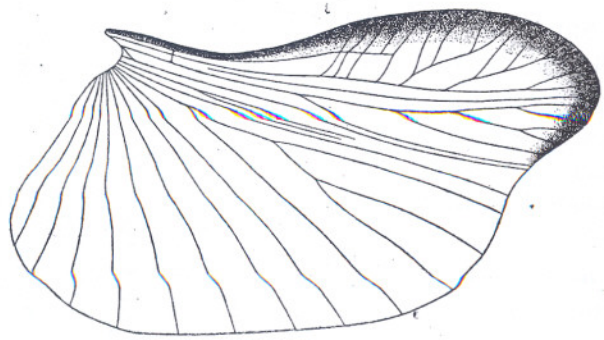

Fig. 2. *Phyllodromia diagrammatica*, n. sp. Right wing.

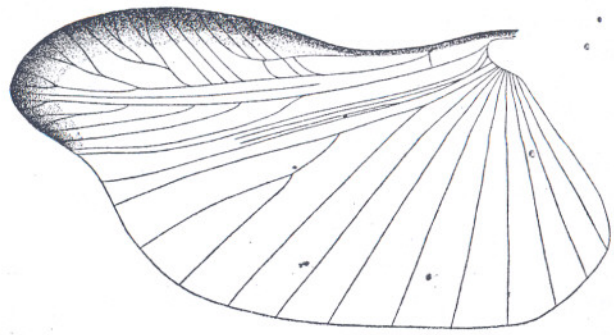

Fig. 3. *Phyllodromia diagrammatica*, n. sp. Left wing.

bifurcated. Considering that e. g. a forked median vein is one of the characters of *Ellipsidion*, Saussure (= *Apolyta* Brunner) to distinguish it from allied genera with simple veins, it shows with what caution such-like differences must be employed for generic distinction. Finally the ulnar vein of the left wing gives off 5 branches, of which the 4th is bifurcated, the others simple; the right ulnar has 4 branches, of which the third is bifurcated, the others simple.

The armature of the front femora conforms with Shelford's type "B", in his *"Preliminary Diagnose of some new genera of Blattidae"* [1]) where he proposes to split up *Phyllodromia*, Serville into six genera. This, together with the ramose character of the ulnar vein of the wings and the only slight development of the apical triangle, would bring this species under the genus *Eoblatta*, Shelford, of which *Blatta notulata*, Stål, is the type.

Phyllodromia sp.

1 ♀, immature, Buitenzorg (October 1920).

Antennae setaceous, long, about 12 mm., light at their bases, dark at their tips. Pronotum shining black, with a border of transparent light brown, narrow in front,

[1]) Entom. Mo. Mag. (2), Vol. XXII, pp. 154—156 (1911).

wider at the sides, broadest behind. Mesonotum with a large black saddle-shaped blotch, leaving a crescent-shaped transparent light-coloured margin in front, and broad irregular margins at the sides. Metanotum transparent light brown, with a few dark blotches along its posterior border. Abdomen mottled light and dark. Legs light-coloured, transparent, with black blotches at the joints, and small black spots at the bases of the spines. Tegmina and wings not yet developed.

Length 10 mm; width 5 mm.

The O. U. M. contains two exactly similar specimens, also immature, not named, from the Botanic Gardens, Singapore, collected by Mr. RIDLEY in 1906.

Ellipsidion terminale, n. sp.

1 ♀, Merauke, New Guinea (1904).

As the specimen in question is slightly damaged, the following description is taken from an exactly similar example, ♂, unnamed, in the O. U. M., labelled "Purchased from Mr. EXTON, New Guinea, 1.7.1891" "Presented 1907 by the National Museum, Victoria".

Vertex of head orange, remainder black. Basal half of the antennae hirsute, black; distal half setaceous, orange. Pronotum orange. Tegmina orange, with the exception of their tips, their inner margins, and the basal portion of the anal area, which are black. Abdominal sterna cream-white at their lateral edges and along the central portion of their posterior margins; otherwise shining black. Coxae black; femora orange, their distal ends black; tibiae orange; tarsi black.

Total length 14 mm; body 9.5 mm; pronotum 3.5 × 5 mm; tegmina 11 mm.

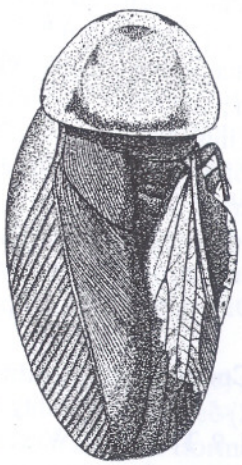

Fig. 4. *Ellipsidion terminale,* n. sp. 4×.

This species is closely allied to *E. aurantium*, Sauss. [1]) from Australia, which, however, differs from *E. terminale* by the basal portion and the inner margins of the tegmina being orange, instead of black, and by the lateral white borders of the abdominal sterna being continuous with the white borders of their posterior margins.

This is apparently only the second species of *Ellipsidion* so far described from New Guinea the other being *E. castaneum*, Shelford, A.M.N.H. (7), Vol. XIX, p. 28 (1907), the genus being typically Australian.

Subfamily EPILAMPRINAE.

Homalopteryx adusta, WALKER.

1 ♂, Edam, Bay of Batavia (DAMMERMAN, November 1920).

This species, having originally been described from Sarawak (Wallace's collection) is now for the first time recorded from Java. Besides

[1]) Rev. Zool. (2), Vol. XVI, p. 312 (1864).