

SECOND CONTRIBUTION TO A STUDY OF THE TROPICAL SOIL AND SURFACE FAUNA.

By

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The first contribution to this subject by the author appeared more than ten years ago ¹⁾; some explanation for the long interval will, therefore, not be out of place.

The method described in my first paper, although giving comparatively reliable results, proved to be rather unsatisfactory, for in spite of the extensive labour with which the investigations are attended the results are too indefinite and too liable to variation. Another drawback is that a more detailed study is almost excluded owing to the fact that many of the species and even whole groups of animals brought to light by our researches remained unnamed, as the great bulk of the material collected consists of very small species or belongs to groups very hard to get identified by any specialist.

The investigations have been continued during a long period but we abandoned the more systematic researches practised during the preparation of our first paper and restricted ourselves to incidental researches when coming upon rather deviating habitats, or visiting some outlying localities.

With this paper we will conclude our investigations on the tropical soil and surface fauna. All results now under discussion were obtained by the same method as adopted in my first contribution (Treubia VI, p. 107).

1. The total number of species and individuals found on one square metre.

In my first paper I accepted an average of 25 species living on 1 m²; now, by calculating the mean figure for all localities examined it proves to be 24 (See Synopsis B. p. 139). These figures have some value owing to their agreement, notwithstanding the fact of the entirely different habitats and localities having been investigated before and after 1925, the year when the first contribution was published.

As to the number of individuals found on the same area the average comes to 90 specimens or nearly 4 individuals pro species (ants and termites are excluded, these being groups of which the number of species only has been ascertained).

These figures are rather low but one has to keep in mind as already mentioned that the numbers are not exact, the method practised revealing only a part of the whole biocönosis living on a certain area.

¹⁾ Cfr. Treubia Vol. VI, p. 107.

Below this average there remain still the figures obtained for the **KRAKATAU ISLANDS** in the Sunda Straits (Krakatau proper and Verlaten I.) The numbers, resp. 18.7 and 13.8, seem to indicate a little improvement during the lapse of time between our first investigation made on these islands and later on (1920 and 1933). But this improvement is mainly due to the surface fauna of the Casuarina (chemara) forest on both islands having become apparently richer in the period under consideration, whereas in the virgin (mixed) forest on Krakatau this fauna remains practically constant; on Verlaten I., however, a decline has been established.

The figures have become more uniform. The present investigation yielded one case only of less than 10 species to 1 m² whereas previously six were recorded. On the other hand our earlier records include five cases in which more than 20 species were collected, whereas now only two such cases occur. All the other places gave figures between 10 and 20.

In calculating the above-mentioned averages we have excluded nos. 18 and 19 of Appendix C relating to a part of devastated forest.

In July 1930 very heavy eruptions lasting for several weeks burst forth from the new volcano, Anak Krakatau, which some three years back rose from the ocean floor in the midst of the three islands of the Krakatau group. By these outbursts a part of Verlaten I. was covered by a layer of very fine volcanic ash causing the leaves to fall and killing the young twigs and buds and to a great extent the lower undergrowth. When we visited the island about a week after the last explosions the devastation was very clearly to be seen, the whole forest looking like a landscape in wintertime or as though destroyed by fire. On the northern part of the island the line of demarcation between the devastated and the unruined sections coincides closely with the boundary between the mixed forest south of the lake and the Casuarina forest north of it; this Casuarina forest remained practically undisturbed by the ash-tornado.

In a future paper dealing with the fauna of the Krakatau islands we will discuss in detail the influence of such volcanic action upon the fauna as a whole, but here I will restrict myself to its influence upon the surface fauna.

During our short stay we were able to examine four places: one in the midst of the devastated region (No. 18 of our list), one on the border (No. 19), one outside the ruined area, but still in mixed forest (No. 20) and one in the chemara wood (No. 21).

In the devastated forest the influence of the volcanic action was very conspicuous: here only 7 species could be found on 1 m² and no more than 12 individuals, all the softer and more delicate animals, such as the larvae of Diptera and moths, spiders, mites and molluscs, even bugs and myriopods had disappeared. On the border the number of species and individuals became doubled; a single bug and a few spiders and one other arachnid, a Pseudoscorpionid, had to be added to the animals escaping destruction.

In the apparently untouched mixed forest no higher number of species could be detected, the only new element being a species of mollusc. But the

number of specimens reached a much higher level resulting in about 10 individuals pro species. In the Casuarina forest, however, the number of species on 1 m² increased to 20 and that of individuals to 211. Here representatives of several new groups came upon the scene: earwigs, myriopods and mites.

In our researches later on when the mixed forest seemed to be wholly restored we could not discover on the average very many more species and individuals, except in one case (No. 24), caused by the finding of an extraordinary number of woodlice.

If we compare the results of our second investigation of the Krakatau islands with those made previously (1919-'20) we find only a rather conspicuous reduction in the number of beetles (Staphylinidae, Pselaphidae and Tenebrionidae) and molluscs. On the other hand the number of ants and arachnoids, mainly spiders, has increased and even some groups formerly not represented, such as myriopods, mites and Oligochaeta (Enchytraeids), are now recorded for the first time.

These changes in the faunal elements of the mixed forest can hardly be ascribed to the influence of volcanic action as there is an augmentation of the last-named groups and the spiders, groups which, as has been demonstrated above, are most liable to be affected by volcanic ashes, whereas on the contrary the more hardy beetles have diminished.

There is, however, some improvement in so far as some groups not found in 1919-'20 have now been brought to light as elements of the surface-fauna.

On Krakatau as already mentioned the number of species in the mixed forest remained practically constant. But here again we find also a rather strong decline of Coleoptera (Carabidae, Staphylinidae, Pselaphidae, Tenebrionidae), bugs and molluscs, whereas there is found an increase in the number of species of ants, lepidopterous larvae, and spiders. The only group making its appearance as a new element of the forest-floor fauna is the earwigs.

The decline of nearly the same groups of animals on Verlaten I. as well as on Krakatau, which latter island remained undisturbed by the eruptions of the new volcano, is the reason we cannot ascribe this reduction to volcanic action. It may be that the keen competition of ants has something to do with the falling-off in the number of beetles, both groups arriving at a more normal proportion in regard to each other.

In the Casuarina forest on Krakatau we established the same fact: a strong increase of ants coinciding with a decline of the beetles; but in the same type of forest on Verlaten I. both groups have increased, although the Coleoptera in a far less degree than the ants. On both islands in this kind of biotope there are some groups which reveal a noteworthy augmentation, e.g. myriopods and spiders.

We have to bear in mind that all that has been mentioned previously relates to the number of species and not to the number of individuals. As to the latter we observed on both islands a decrease of the number of specimens. On Krakatau, taking the surface-fauna as a whole, the proportion of individuals

to species shifted from 3.3 to 3; in the virgin forest, these figures were 3.4 and 2.2. On the other hand in the Casuarina forest this proportion increased from 2.7 to 4.2, one exceptionally rich finding, (No. 16 of our list), in which a large number of woodlice and spiders was found, being mainly responsible for this increase.

On Verlaten I., however, we achieved somewhat opposite results, the whole surface-fauna falling off from 12 to 9 specimens pro species and that of the Casuarina forest from 18 to 5; but here the virgin forest shows an increase from 9.2 to 13, this being almost entirely due to the very high numbers of woodlice collected in all cases.

At DEPOK, a small village situated half-way between Buitenzorg and Batavia, a small area of forest has been preserved since 1913, surrounded by a fringe of bush in which the useful wood is regularly cut.¹⁾ The object was to ascertain whether there exists a difference between the surface-fauna inside and outside the nature-reserve, and whether there will be an improvement in this respect inside the reserve after a lapse of some years of preservation.

Our former investigation in this locality, which took place mainly during 1923, brought to light some difference to the advantage of the reserved forest. In 1930, seven years later, there is still some difference although it is a very slight one. But contrary to our expectations both inside the nature reserve and outside it the number of species as well as of the individuals has been reduced to about half that found formerly.

The Coleoptera have decreased the least, nearly all other groups showing on the other hand a considerable reduction in species as well as in individuals, especially ants, blattids, arachnoids and molluscs. A remarkable feature too is the almost complete disappearance of bugs, earwigs and myriopods. We have no definite idea what may be the cause of these contradictory results but I think it may be the very wet weather during the months of February and May of 1930, when our investigation took place (See table).

Rainfall (in mm) of Depok.

	Jan.	Febr.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
average	340	324	302	313	257	184	125	137	198	263	336	281
1923	198	272	205	171	212	321	301	0	35	49	325	290
1930	86	348	293	407	390	92	102	66	124	166	356	128

The great humidity probably has been not only unfavourable to the detritus fauna itself but also detrimental to the method adopted by us. The material to be sifted, especially the soil, being too wet, clotted together, enwrapping many species and crushing others.

The surface-fauna at the IDJEN-MASSIF in East Java proved to be rather rich. By excluding divergent habitats, like the nearly bare volcanic mass, the

¹⁾ For more particulars see Treubia VI, p. 113.

grass and moss-covered places, we find in the forest between 950 and 1400 m, an average figure of about 50 species and 180 individuals on 1 m², the maxima being respectively 66 and 258. These numbers, although being twice the total average, remain below those compiled for Tjibodas at about the same elevation in West Java, where the figures are 60.9 and 88 species, the highest records observed, and 237 and 505 specimens. But the forest at Tjibodas is a very luxuriant mixed jungle, the forest on the Idjen on the other hand being poorer and differentiated by the more monotonous chemara woods.

Going higher up the mountains we observe in both localities a reduction in the number of species, at the same time the dissimilarities becoming less. The number of individuals is still high and on Mt. Gede in the forest above Tjibodas at an altitude of 2400 m the highest figures ever recorded are found, this, however, being chiefly caused by an extraordinary number of small molluscs living here among the vegetable debris.

The main feature of the higher altitudes is the gradual disappearance of certain groups: termites vanishing at about 1400 m and ants at 2000 m as elements of the surface-fauna.

Our records from two coastal islands in the Java Sea, KARIMON JAVA and BAWEAN, the one lying off the coast of Central and the other of East Java, give evidence of a rather poor surface-fauna the numbers remaining far below the average. On these islands this particular fauna is only a trifle richer than that on the barren coral islands in the Batavia bay.

At SUMBA, an island situated west of the Timor archipelago, the most outlying locality in which we collected data, the forest-floor fauna varies in the number of species about the total mean figure, the number of individuals remaining far below the average. We are dealing here with that island-chain the fauna of which becomes poorer and poorer in proportion to the distance from Java.

As to the number of individuals (excluding ants and termites) some very low figures, less than ten, have been recorded from a few localities only, e.g. from Durian and Depok. In other instances such faunal poverty is exhibited only in some extreme habitats, such as rocky mass or moss-vegetation at 1700 m on the Idjen massif or grass wildernesses on Sumba. As a matter of course these low figures concerning specimens are correlated with the lowest numbers of species found on 1 m², the minimum being four species yielded by the above mentioned moss-vegetation on the Idjen mountains. Here one species of ant, one Coleopteron (a Staphylinid) and two species of spiders were brought to light.

2. The influence of soil and vegetation.

Soil and vegetation are so intimately connected with each other that we propose to discuss their influence on the detritus fauna at the same time. This fauna is mainly dependent on the richness of vegetable debris and the formation of mould, both being formed best and to the largest extent by the tropical primeval forest, the real tropical jungle composed of numerous varieties of

trees and plants. The richest layers of mould we find in the mixed forest on a fertile volcanic soil higher up the mountains where the disintegration of the vegetable litter progresses at a slower rate than in the lowlands. As our researches did not include enough experimental places at different altitudes we cannot give an opinion on the optimum elevation at which the richest humus and consequently the richest soil and surface-fauna is to be found. For the moment we have to restrict ourselves to remarking that the most abundant finds are recorded from the mixed forest at Tjibodas at an altitude of 1400 m with an average of nearly 61 and a maximum of 88 species on 1 m². Hardly less are the figures for the same type of forest on the Idjen with an average of nearly 50 and a maximum of 66 species. Also in these localities the number of individuals is high although not exceeding the normal proportion of 4 specimens to 1 species. As to the different elements of the surface fauna almost all groups are well represented here except termites and Tenebrionids.

The first-named insects stop their activity at higher altitudes whereas the Tenebrionids are more adapted to less humid habitats. It is not a question of altitude, for on the Idjen mountains representatives of the latter family, not having been recorded from the surrounding forest, were present again on the nearly bare rocky mass, a very arid spot without any mould.

Next to these rich mountain habitats comes the virgin forest of the lowlands but wherever this forest shows a more secondary character owing to the poor and unfertile soil the figures fall below the average. Thus on Durian, Karimon Java and Bawean, all three islands consisting of old denuded rock, the number of species on 1 m² does not even reach twenty, the number of individuals being only one and a half times the number of species, or even less than that. The surface-fauna of these islands is rather poor in Staphylinids, bugs and earthworms and striking by the total absence of Lepidopterous larvae.

We have already mentioned something of the difference between the surface-fauna of the mixed forest and the Casuarina forest on the Krakatau islands; moreover the conditions here being not yet normal, we will turn to these types of forest on the Idjen.

In the total number of species and individuals we find hardly any difference at all, but the Casuarina forest seems to be somewhat richer in beetles, bugs and earwigs, whereas in the forest of foliage-bearing trees Apterans, myriopods and earthworms prevail.

The last biotope we have to take into consideration is the grassy plain. On the Idjen massif we examined only two samples of this kind of soil-covering which show figures far below the average especially with regard to the number of specimens. Concerning the different elements of the surface-fauna there is some lack of beetles, Apterans, myriopods, molluscs and earthworms, this type of vegetable growth being remarkable too by the absence of woodlice, a group of animals otherwise represented nearly everywhere.

On Sumba we established the same fact of the poorness of the grassy plain as compared with the true forest. Also with reference to the various

elements of the surface-fauna we find a decrease of the same groups as mentioned above, with the exception of the beetles, the latter group showing an average of 4.1 species on 1 m² against 4.7 in forest-clad places.

3. The surface-fauna and its components.

The surface or detritus-fauna is mainly composed of two groups of animals: scavengers and predatory ones. The majority of the elements of this biocönosis belongs to the first-named group. The larvae of Diptera and Lepidoptera, termites, Aptera, Crustacea, molluscs and earthworms and other Oligochaeta, all live on the vegetable mould covering the soil. Some groups such as the termites, members of the Orthoptera, and some lepidopterous larvae, crustaceans and molluscs attack the vegetable litter in a less desintegrated state, even wood and freshly fallen leaves being occasionally devoured.

Other groups are not uniform in their mode of life, so that among the beetles the Tenebrionids, the weevils, many Staphylinida, the Lamellicornia and Elateridae and the main bulk of the so-called micro-coleoptera feed on decaying vegetable matter. The Heteroptera or bugs, the Orthoptera, myriopods and Arachnoidea include both carnivorous and saprophytic species.

The sustenance of some other species consists of the fungous growth found abundantly in the humus. Specially adapted to this kind of food are some polyphagous and clavicornous beetles and many mites.

Essentially predaceous on the other hand are the great majority of the ants, the Carabidae, a number of Staphylinids too, the Reduviidae, and some members of a few other families of minor importance, among the bugs, the Chilopoda, the spiders, various species of mites and the Pseudoscorpiones and the Opiliones among the Arachnoids.

Both groups are subject again to attacks by parasitic animals, such as Hymenoptera parasitica, but their presence is very seldom rendered evident by the method that we practised.

Hymenoptera.

As already mentioned other Hymenoptera than ants do not play an important part in the faunal element of the forest-litter. In our previous paper we remarked on the occurrence of parasitic Hymenoptera in 3 percent. only of all our researches. In our new series of investigation we came across only one such insect. Now certainly a great number of the animals occurring on the soil is liable to be attacked by parasitic wasps, but the adult insects seem to be found rarely among the vegetable debris in search of their hosts or else they escape readily from the material gathered together before it has been investigated.

Ants on the other hand are one of the most constant components of the detritus-fauna and are represented in the most divergent biotopes. In no more than 12 percent. of our discoveries were they found missing. As already mentioned they are not met with, at least as an element of the surface-fauna, above

about an altitude of 2000 m, but otherwise species are only wanting in abnormal habitats like Krakatau, or in poor localities such as small islands like Karimon Java.

The mean number of species found on 1 m² is 3.3 the maximum being 7, which figure is recorded from Durian, Krakatau and Sumba. Formerly mention has been made of much higher numbers from the same area as no less than 13 species were once found at Depok and 11 at Tjibodas.

As to the different species we often observe ants on the soil, which cannot be reckoned as belonging to the true detritus-fauna, as they are occasional visitors only, wandering to or from their nests. Even such a typical ground-loving species as *Plagiolepis longipes* does not pass its whole life among the detritus of the forest-floor. Such a mode of life is probably only exhibited by a number of very small species which live in concealment among the leaves and nest in the ground, finding all the necessary food in this particular secluded spot. As representatives of this peculiar group we may mention in the first place the genera *Ponera*, *Euponera* and *Prenolepis*. Also often found among forest-litter are *Pheidole megacephala* F., a well known harvesting ant, the soldiers being characterised by their enormous heads, and the very minute *Monomorium pharaonis* L., a cosmopolitan species.

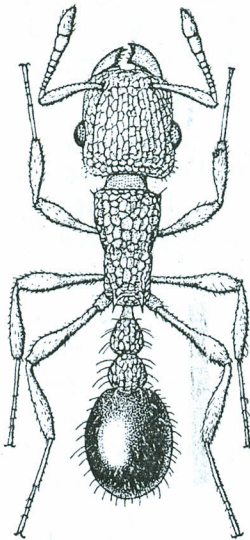


Fig. 1. *Tetramorium guineense* (× 20).

Other species are conspicuous on account of the rugosely sculptured upper surface of the body, like *Tetramorium guineense* F. (fig. 1).

Coleoptera.

Beetles are found in nearly the same percentage as the ants, being present in 87% of our researches. But they are not so ubiquitous as the last-named insects although they can be collected up to the summit of the highest mountains. There are a number of localities with places where no beetles can be found as on Durian, Krakatau, Verlaten I., Karimon Java and Bawean.

The number of species on one square meter is on the average 4.3, the maximum 29, which number we found in the rich forest-fauna of the Idjen plateau at an elevation of 1400 m, the same maximum having been recorded formerly from Tjibodas at the same altitude.

The richest locality is again the mixed forest on the Idjen mountains with reference to the number of specimens found on 1 m² with a maximum of 61 and an average of 31 beetles against a mean average of only 8.3.

Far below the average both of species and individuals remain still the Krakatau islands, Karimon Java and Bawean.

Carabidae are not numerous in our samples, as in less than 40% of our researches did we come across members of this family. Also the maximum

number of both species and individuals is low, being resp. 4 and 6. Both these maxima were found on the Idjen mountains in mixed forest at 1400 m altitude.

A remarkable fact worth mentioning is that formerly (1920) Carabids were very seldom missing in our samples from Krakatau I. whereas during our last investigations they were wholly absent; on Verlaten I. Carabids are not seldom found on the forest-floor. Also from the Karimon Java islands members of this beetle family are not recorded.

Ground-beetles do not display in the tropics such a variety of forms nor reach as a rule such a size as in temperate regions, the majority of the species being small and inconspicuous. An exception is *Catadromus tenebrioides* OLIV., a large black beetle of 55 mm length which was sometimes brought to light. Among the smaller species we may mention the members of the genus *Trichotichnus*, *Patellus drimostoides* CHAUD. and the metallic green *Catascopus elegans* WEB. (fig. 2).

The *Staphylinidae* or rove-beetles play a much more important part as an element of the detritus-fauna than members of the foregoing family, being recorded in about 60 percent. and present in all localities and at all altitudes. The maximum number of species found on 1 m² was 14, this figure being yielded by the virgin forest on the Idjen massif at an elevation of 1400 m, the highest number of specimens, 56 being found in the same biotope but higher up the mountains at 1850 m. During our previous researches the maximum number of species, 11 recorded from Tjibodas, comes quite near the figure mentioned above, but then a much larger number of individuals was found in one sample from Tjibodas, no less than 238 rove-beetles being counted once on one square meter.

With reference to the different species the *Staphylinidae* are such a characteristic group among the special kind of animals with which we are dealing that it is hardly possible to enumerate all the genera represented among the forest-litter.

Pselaphidae are not an unusual component of the surface-fauna, formerly 39% of our samples yielded members of this family now being met with in only 26%. Whereas during our previous researches a maximum of 6 species and 41 specimens on 1 m² was recorded from Depok, now these members do not reach higher figures than resp. 4 and 7, found in the same locality. On Karimon Java and Bawean these beetles were altogether absent.

The presence of *Pselaphids* is not always correlated with the occurrence of ants in association with which, however, many species do live. From altitudes where ants are absent these beetles are still recorded proving that some species at least are not myrmecophilous, a fact emphasized already in my previous paper.

Few of the species have been worked out, but the great bulk of the material still remains to be named.

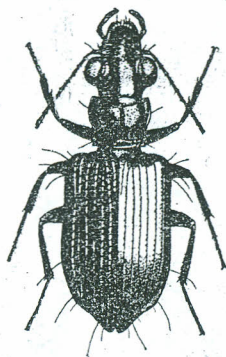


Fig. 2. *Catascopus elegans* ($\times 4$).

The *Tenebrionidae* are represented in our findings in about the same percentage as the *Pselaphidae*. These beetles usually abound in dry and arid places therefore none was collected in the humid floor-covering of the virgin forest on the Idjen mountains just as was the case with the moist forest of Tjibodas. But also on Karimon Java their absence is a noteworthy feature. Remarkable too is the richness of the Krakatau islands in this group of beetles, from Krakatau itself they were recorded in 40% of our samples, and from Verlaten I. even in 60%. Also on the latter island the maximum number both of species and specimens on 1 m² has been found, viz. 2 species and 7 specimens. Formerly in 1920 a much higher maximum of individuals, that is 36, was observed. I suppose, however, that in the long run this special element of the fauna on the Krakatau islands will attain a more normal proportion as the vegetation and forest-floor covering becomes moister and richer in mould.

The same maxima of species and individuals as mentioned above for Verlaten I. are recorded too from Sumba, an island also characterised by its arid nature.

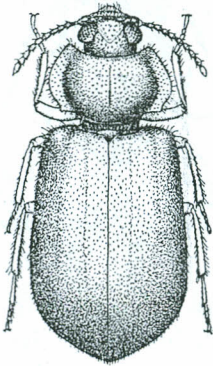


Fig. 3. *Pseudolyptrops forticornis*
FAIRM. (× 5).

Representatives of a great number of genera are to be collected, such as the rather bulky *Heterotarsus inflatus* LAC.; most of the other species are inconspicuous dull creatures belonging to the well-known genus *Gonocephalum* or to *Uloma*, both with a large number of species. More striking by the dense covering of hairs are the species of *Pseudolyptrops* (see fig. 3).

Weevils or *Curculionidae* are a rare feature among the surface-dwelling animals; this time they were only met with in some numbers on the Idjen-plateau. Here they were not bound to a special habitat being found as well in the forest as in grassy fields or on rocky mass.

As to the remaining families of the *Coleoptera* representatives of a few more should not be passed over without mention. In the first place *Scydmaenidae* are not an unusual element of the detritus-fauna, the species of which family bear some resemblance to the *Pselaphids* and are often found in company with them. Also *Elateridae* or click-beetles are not rare but here it is mainly the larvae only and seldom the adults which are seen. Even more abundant than species belonging to the two above mentioned families are the very small beetles belonging to that large group of polymorphous *Coleoptera* with which is reckoned also the family of the *Scydmaenidae*. Little more can be said of these tiny creatures as it proved to be quite hopeless to get these micro-coleoptera identified.

Diptera.

Dipterous larvae are not such an essential component of the surface-fauna, their percentage not attaining a higher figure than 20. But as already pointed out in my previous paper this low percentage is certainly partly due to our

method of research not being suitable for the collecting of these delicate animals. Drier or more unfertile localities, such as Depok, Karimon Java, Bawean and Sumba, are characterised by the absence of this kind of larvae which on the other hand in the luxuriant forests of the higher altitudes is seldom missing in our findings. On the Idjen mountains the grassy plains harboured the maximum numbers of species and individuals.

Lepidoptera.

Whereas probably surface-dwelling lepidopterous larvae are less numerous than dipterous larvae our special method of investigation revealed more often the occurrence of the first named insects. Their total absence was stated for such poor islands in faunistic respects as Durian, Karimon Java and Bawean.

Not more than two species at the same time were now counted on an area of 1 m² this being far less than the maximum number of 6 species formerly recorded from Tjibodas.

Rhynchota.

Among the Rhynchota it is only the *Heteroptera* or bugs which form an important part of the tropical surface-fauna, being recorded in about 60% of our samples. Their total absence was only noticed on the Karimon Java islands. The highest number of species on 1 m² was 7 and the highest number of specimens 61, both figures furnished by material collected in the forest on the Idjen at an altitude of 950 m.

The surface-dwelling bugs belong to two groups, viz. the true detritus-forms and raptorial species. Of the first-named group we should mention the small species of the Lygaeid genus *Cligenes* (see fig. 4) which are often met with and not infrequently present in some abundance. Another characteristic ground-dwelling bug is *Eumenotes obscura* WESTW. with a peculiar broad head armed with spines.

The predatory species are mostly *Reduviidae* but sometimes also species of other families such as the *Hemicocephalidae* are observed. A remarkable Reduviid conspicuous by its deep blue colouring and red markings, *Ectrychotes* (see fig. 5), an unusual feature among such animals living in dark and hidden places, has been collected on Krakatau in some numbers.

Other groups of Rhynchota made themselves only seldom apparent during our investigations. Once a Coccid was brought to light but here we are dealing certainly only with an occasional visitor of the habitat under consideration, or a root-sucking species from deeper layers.

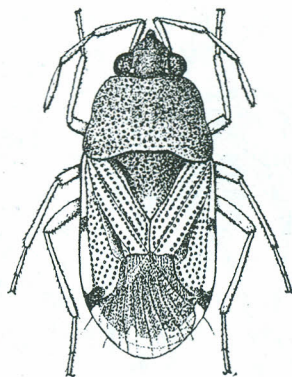


Fig. 4. *Cligenes signandus* (× 17).

Orthoptera.

Orthoptera constitute an essential element of the detritus-fauna coming in percentage of occurrence only a little behind the ants and beetles. They have been collected in 72% of the spots examined, being represented in all the localities. Six species, the maximum number observed on 1 m², and 54 specimens, the highest number too, were found in the Idjen forest at 950 m.

It is mainly the two families of *Blattidae* and *Forficulidae* which furnish the elements of this special biocönosis. The *Blattidae* or cockroaches are to be mentioned in the first place being found abundantly in vegetable debris. Their absence was noticed in less than 40% but this only so far as certain places are concerned, being met with in all localities investigated. There are only two localities which proved to be poor in this category of insects, viz. Depok and the grassy plains at Sumba. On Karimon Java the highest number of species, 5, was counted, the highest number of individuals being 26 which number is recorded from the forest at an elevation of 1850 m on the Idjen massif.

Except the species already mentioned in my previous paper (*Pycnoscelus surinamensis* L. and *Rhicnoda rugosa* B. v. W.) it is chiefly *Blatta orientalis* L. and the apterous *Stylopyga picea* BRUNN. which were collected from forest-litter.

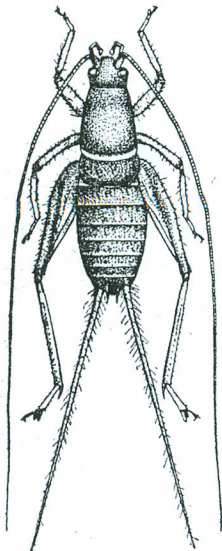


Fig. 6. *Cycloptilum majus* (× 2).

Thysanoptera.

By our former investigations we brought to light also some Thysanoptera and called attention to the fact of these delicate insects probably being not a

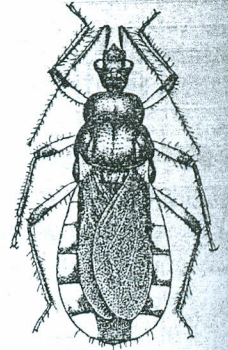


Fig. 5. *Ectrychotes coloratus* MAYR (× 3).

Forficulidae, the earwigs, are far less numerous than *Blattids*, here the percentage is nearly the inverse they having been recorded in less than 40%. These insects are also far from ubiquitous like the cockroaches, as there are a number of localities where we did not come across them: Verlaten Island, Depok, Karimon Java.

Three species and 39 specimens from one square metre, both maxima were observed again in the forest of the Idjen mountain at 950 m which proved in many respects to be one of the richest habitats.

The majority of the earwigs living in the vegetable mould are dull uniformly black or brown species.

Other orthopterous insects are a rare occurrence in the covering of the soil only representatives of the family *Gryllidae* sometimes making their appearance. Most of the species cannot be said to be truly surface-living but one, *Cycloptilum majus* CHOP. (fig. 6) is characteristic by dwelling between fallen leaves.

rare occurrence on the forest-floor but escaping notice owing to our special method of collecting. During our more recent research we have, however, never detected a specimen of these.

Isoptera.

This group of insects too does not belong to the true detritus-fauna, they often occur on the surface but only as occasional visitors, their real habitat being either deeper layers of the soil or wood.

Aptera.

These insects again play an important part as surface-dwellers although they were recorded only in 20 percent., this low figure being certainly due to our special method. *Thysanura* especially have been collected, but *Collembola* only in a very few instances. They were absent in two localities: Verlaten I. and in the grassy fields of Sumba. The most prolific locality concerning this particular group is again the mountain forest of the Idjen, the highest number both of species and individuals being recorded there. All these figures being very low are without doubt much below the real number to be found by a more specialised method of collecting.

Crustacea.

Among the crustaceans the *Oniscoida* or woodlice are very seldom missing as an element of the special fauna we are discussing here. Their presence was recorded in 73 percent., of none of the localities investigated their absence having to be mentioned, only at Depok they are poorly represented. The number of species found on 1 m² is never high, the maximum being 3 is recorded from the Idjen forest at an altitude of 1400 m. Formerly the highest number of specimens from the same area was observed in the mangrove-wood at Batavia, our more recent researches yielding a much higher number, nearly 500; which figure was provided by the mixed forest on Verlaten I. of the Krakatau group.

Species often collected are *Cubaris* spp., which are capable of rolling up into a ball; other common forms belong to the genera *Nagara* and *Alloniscus*.

Other groups of the Crustacea are very seldom represented, though terrestrial Amphipods belonging to the genus *Orchestia* are sometimes met with. In our previous paper we have recorded them only from near the seashore and again from an altitude between 1400 and 2400 m but now we have found them also at Kananggar on Sumba at an elevation of 700 m only.

Myriopoda.

Myriopods play an important part in the tropics as surface-dwelling animals. As a whole the group was absent in 30% of our findings, coming in this respect only a little behind the woodlice. The poorest locality investigated concerning millipedes is again Depok. On the other hand the forest on the Idjen in East Java showed again the highest number of species and individuals on one square

metre. Seven species from the said area, 3 Chilopods and 4 Diplopods, have been found in the forest at 1850 m, whereas the maximum number of specimens, 46 being all Diplopods, was recorded from forest at an elevation of 1400 m.

The two elements composing this group, the carnivorous Chilopoda and the Diplopoda with a vegetable diet, are represented in about the same percentages but Diplopods or millipedes are more numerous especially as far as the number of individuals is concerned, the maximum number being 46 as already mentioned above and for the Chilopods only 9. The latter figure has been recorded from the forest at Kananggar in Sumba at 700 m. Much higher numbers were found formerly on the coral-islands in the Batavia bay.

Chilopods, the centipedes, were never absent from any locality examined but Diplopods are occasionally missing, *e.g.* on the island of Bawean. In 1920 Diplopods were not represented on Verlaten Island but during our recent investigation they were present in not less than 70 percent. of our findings, a remarkable increase.

Among the Diplopods besides the more common Juloidea the Polydesmids are not infrequently collected but members of other groups are seldom or never seen.

Unfortunately we have not yet succeeded in getting our material worked out.

Arachnoidea.

The Arachnoids form the most ubiquitous group among the surface-living fauna their absence having been recorded in only 5%. In very few places only on Verlaten I. and at Depok did they prove to be absent. The highest figures, 15 species and 66 individuals on 1 m², are again yielded by the Idjen forest at 1400 m.

Of the Arachnoidea the *Araneina* or spiders are a very common feature being represented in every locality. We may find as high a number as 9 species on 1 m² and as many individuals as 39. The maximum number of species was discovered again in the forest of the Idjen mountains but the maximum number of specimens was found on Krakatau I. The latter number seems to be abnormally high as the average number of specimens on 1 m² is only 6.5, but during our previous researches an even higher number has been recorded from Zuid-Wachter, a small island in the Java Sea.

Most of the ground-dwelling spiders are dull sober-coloured species, sometimes shining brown and black like *Oedignatha scrobiculata* THOR. and *Ariadna snellemanni* HASS. Others again are hairy, like the members of the family *Lycosidae*, which are true hunting spiders, to which also belongs the somewhat brighter coloured *Trochosa inops* THOR., a common feature of the fauna of the forest-litter.

Less frequently met with than spiders are the *Acarina* or mites, being found in 53 percent. (formerly 62%), but our special method of investigation does certainly not do sufficient justice to this group, many of the more delicate or tiny species not making themselves apparent. That they are more abundant

and more omnipresent was proved by the mechanical method of sifting described in my previous article. Also in temperate zones mites are often the chief faunal element of the forest-floor covering.

The maximum number of species detected at the same time was 7 and the maximum number of individuals 51, both figures again we found in the Idjen forest at an altitude of 1400 m.

Among the commonest forms found in mould are the velvety red species of *Trombidium* and allied genera, and the brown coloured Gamasids both being carnivorous and often living, in the larval stage, a parasitic or semi-parasitic life. But there are a number of other species, e.g. belonging to the family *Oribatidae*, the diet of which is probably of a vegetable nature.

Of surface-living Arachnoids other than spiders and mites we have to mention specially the *Opiliones* or Harvest-spiders and the *Pseudoscorpiones* or False scorpions. Both carnivorous groups have been recorded from nearly every locality but never in great quantities or in a large number of species.

Besides the two last-mentioned orders, still other groups belonging to the Arachnoidea are a rare occurrence on the forest-floor. Occasionally a true scorpion or a Telyphonid or whip-scorpion is met with, otherwise creatures more often found under stones or logs.

Mollusca.

Molluscs are an essential element of the tropical detritus-fauna, formerly they were present in no less than 73 percent., but during our more recent researches only half the number of places examined revealed representatives of this group. This is mainly due to some localities now investigated proving somewhat deficient in this particular group of animals, e.g. Durian, Verlaten I., Depok and the grassy plains of Sumba. Also the maximum numbers of species and individuals formerly recorded were much higher, the first-named maximum now being 6 and the last-mentioned one 146; in the forest on the Idjen-massif at 1850 m these figures were observed again.

As to the different species we may refer to our previous paper where we have already enumerated some of the more common genera: *Kaliella*, *Opeas* (see fig. 7), *Prosopeas*.

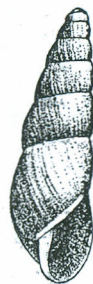


Fig. 7. *Opeas gracile*
($\times 2\frac{1}{2}$).

Oligochaeta.

As a matter of fact many groups of worms are found living in vegetable mould but only two could be collected by our method in any numbers, viz. the true earthworms and the smaller *Enchytraeids*. As already mentioned the earthworms, moreover, would for the greater part retire into deeper soil as soon as the covering of leaves and mould was gathered together. Therefore our figures have only a relative value.

Durian was the only locality yielding no worms at all. On Verlaten Island the absence of true earthworms is noteworthy, but our recent investigation revealed small Enchytraeids. When the previous search was made these were also absent. That rich locality, the Kendeng forest on the Idjen plateau, harboured again the highest number of individuals, 91 Enchytraeids on one square metre. Localities which show a deficiency in worms are the forest at Depok and the grassy plains of Sumba.

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APPENDIX A.

List of localities where the surface-fauna has been examined.

Loc. Nos 1-7. **Durian Island**, Riau Archipelago.

Soil: a yellow laterite quartzzy soil.

Vegetation: mixed forest, partly secondary growth (Nos 1, 2 and 3).

Data: 13-17 VI 1923 (Nos 1, 2, 4 and 7) and 11-16 XI 1923 (Nos 3, 5 and 6).

Loc. Nos 8-17. **Krakatau**, S.E. coast, Sunda Straits.

Soil: recent volcanic ash and pumice.

Vegetation: mixed forest (Nos 8-13); Casuarina forest fringing the sea-shore (Nos 14-17).

Data: 10 XI 1932 (Nos 12 and 13); 7 I 1933 (Nos 14 and 15); 28-29 IV 1923 (Nos 8, 9, 16 and 17); 7 IV 1934 (Nos 10 and 11).

Loc. Nos 18-31. **Verlaten Island**, N. coast, Sunda Straits.

Soil: recent volcanic sand and pumice.

Vegetation: devastated forest (Nos 18 and 19); mixed forest (Nos 20, 22-26); Casuarina forest (Nos 21, 27-31).

Data: 22-24 VIII 1930 (Nos 18-21); 5-6 I 1933 (Nos 22, 23, 27 and 28); 30 IV 1933 (Nos 24 and 29); 9-12 XII 1933 (Nos 25, 26, 30 and 31).

Loc. 32-39. **Depok**, between Batavia and Buitenzorg, alt. 100 m.

Soil: quaternary tuff, a poor red laterite soil.

Vegetation: mixed forest inside the nature reserve (Nos 32-35); idem, outside the nature reserve (Nos 36-39).

Data: 2 II 1930 (Nos 32, 33, 36 and 37); 25 V 1930 (Nos 34, 35, 38 and 39).

Loc. Blawan, **Idjen** massif, E. Java, alt. 950 m.

Soil: recent dark volcanic ash.

Vegetation: mixed forest (Nos 40 and 41); rocky mass with very scanty vegetation, no mould (Nos 42 and 43).

Data: 1 VI 1924 (No 40); 4 VI 1924 (Nos 42 and 43); 7 VI 1924 (No 41).

Loc. Kendeng, **Idjen** massif, E. Java, alt. 1400 m.

Soil: recent dark volcanic ash.

Vegetation: mixed forest (Nos 44 and 45).

Data: 15 VI 1924 (Nos 44 and 45).

Loc. Telaga waroe, **Idjen** massif, E. Java, alt. 1700 m.

Soil: recent dark volcanic ash.

Vegetation: a very thin layer of moss (No 46).

Datum: 25 V 1924 (No 46).

Loc. Ongop-ongop, **Idjen** massif, E. Java, alt. 1850 m.

Soil: recent dark volcanic ash.

Vegetation: mixed forest (Nos 47 and 48); Casuarina forest (Nos 49 and 50); grassy plain and ferns, mould very scarce (Nos 51 and 52).

Data: 18 V 1924 (Nos 49 and 50); 20-21 V 1924 (Nos 47, 48, 51 and 52).

Loc. **Karimon** Java Island, Java Sea.

Soil: old laterite.

Vegetation: mixed forest (Nos 53 - 56).

Data: 11 - 12 V 1926 (Nos 53 - 56).

Loc. **Bawean** Island, Java Sea, south coast.

Soil: old laterite.

Vegetation: mixed forest, secondary growth, many shrubs, mould very scarce
(Nos 57 - 60).

Data: 7 - 9 V 1928 (Nos 57 - 60).

Loc. **Kambera**, N.E. **Sumba**.

Soil: a calcareous soil.

Vegetation: mixed forest (Nos 61 - 63); grass, mould very scarce (Nos 64
and 65).

Data: 20 III 1925 (Nos 61 and 62); 29 III 1925 (Nos 63 - 65).

Loc. **Laora**, West **Sumba**, alt. 100 m.

Soil: probably marly or calcareous.

Vegetation: mixed forest (Nos 66 and 67); grass, scarcely any mould (Nos
68 and 69).

Data: 9 IV 1925 (Nos 66 and 67); 14 IV 1925 (Nos 68 and 69).

Loc. **Mao Marroe**, East **Sumba**, alt. 450 m.

Soil: unknown.

Vegetation: mixed forest (Nos 70 and 71); grass, scarcely any mould (Nos 72
and 73).

Data: 6 - 8 V 1925 (Nos 70 - 73).

Loc. **Kananggar**, East **Sumba**, alt. 700 - 850 m.

Soil: a dark sandy quartz soil.

Vegetation: mixed forest (Nos 74 - 76); grass, no mould (Nos 77 and 78).

Data: 18 V 1925 (Nos 75 and 76); 20 V 1925 (74, 77 and 78).