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FRESHWATER COMMUNITIES ON THE KRAKATAU ISLANDS

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CONTENTS

Three small ponds, one on Sertung and two on Panjang, are the only known permanent freshwater bodies on the Krakatau Islands. Their macroinvertebrates were investigated in 1986. The three ponds differ substantially, each being dominated by different invertebrate groups. Trichoptera and Ephemeroptera are recorded for the Krakatau Islands for the first time.

1. Introduction

Biotic diversity on the Krakatau Islands is limited by the general lack of large or permanent bodies of freshwater. None are present on Rakata or on Anak Krakatau, but early accounts (summarized by Dammerman (1948)) note the existence of large brackish lagoons on the spit of Sertung. These have long since been eroded away by the easterly movement of the mobile spit (Thornton & Rosengren 1988). So far as is known, the only relatively permanent water bodies on the Islands at present are three, small, concrete-lined ponds, one on Sertung and two close together near the observation bunker constructed on northern Panjang in the late 1920s to monitor the emergence of Anak Krakatau. These ponds are the only possible permanent breeding sites for freshwater invertebrates on the Krakataus. Their macro-invertebrates were investigated in September 1986, as part of the faunal documentation of these islands. It is possible that a few tree holes or other natural cavities could provide for small temporary water bodies on the islands, but none were noted during our surveys.

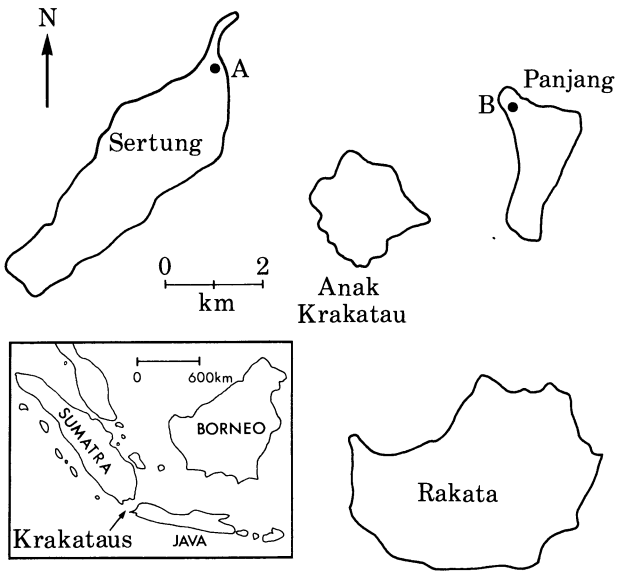

FIGURE 1. The Krakatau Islands, showing the position of the artificial ponds on Sertung (A) and Panjang (B).

The ponds (figure 1) have not been examined on previous expeditions, and no literature on their contents and history has been traced. The Sertung pool was examined on 18 September 1986, and the Panjang ponds two days later.

The freshwater habitats

(*a*) *Sertung*

The water body is about 500 m south of the main ecotone between the spit and higher regions of the island, near the east coast (figure 1, A). A gully leads inland for about 200 m, climbing to about 30 m. Most of the gully was dry at the time of our visit, near the end of the 'dry season', and the substratum consists of gravel and larger rocks. It ends at a cliff some 20 m high, down which water trickles, the cliff surface apparently remaining wet throughout the year. A small plunge-pool at the base of the cliff has been edged with concrete and thereby dammed to provide a permanent reservoir, which overflows down the gully. A water trickle, up to about 3 cm deep and 20 cm wide extended about 100 m down the gully at the time of our visit and it seems likely that during the wet season a relatively fast-flowing stream would extend to the beach.

The pool is used frequently for ablutions and as a water supply by visiting fishermen and others. It was surrounded by much debris, including plastic, paper, wooden planks, and bottles, and the gully is clearly used as a regular track from the beach.

During our visit, a pipeline was constructed to take water from the pool to the beach, to function as accessible water for the recently constructed national park (P.H.P.A.) building some 250 m to the north. The pool may be less intensively used in the future, as water is now more easily accessible to casual visitors without their having to clamber along the gully. It may, therefore, come to support a less-disturbed community, though seems inevitably to be continuously flushed during periods of heavy rainfall.

The Sertung pool is 2 m long and averages about 1.25 m wide. Midline depths, at quarter

lengths from the cliff are 15, 32 and 35 cm, and the water overlies some 40 cm of the litter and mud. The water body is clear, pH 7.5–7.7, and there is no macro-vegetation. The concrete is covered with loose green filamentous algae, and traces of this are present also on a few large submerged stones. The substrate comprises dead foliage overlying black anaerobic mud. The vertical cliff face supports a more elaborate mat of filamentous algae and mosses.

(*b*) *Panjang*

The concrete storage ponds are sited on the northern ridge of Panjang (figure 1, B), one each side of the abandoned bunker. They are similar in size, and separated by about 35 m, pond 1 being about 20 m north and pond 2 about 15 m south of the bunker. Both are about 1.3 m^2 with a total depth of about 96 cm near the northwest and 125 cm near the southeast end. They are largely filled with mud, so that the water depths are only 22–28 cm (pond 1) and 25–35 cm (pond 2). They differed slightly in pH (6.5–7.0 in pond 1 compared with 7.5 in pond 2) and both are essentially stagnant, depending on precipitation for filling and without a defined overflow. They contained no macro-vegetation but the sides were coated with filamentous algae. The ponds are in secondary forest, with adjacent trees and overhanging foliage.

2. Methods

Samples of the larger fauna were taken by sweeping the water body with a pond net, visual observation of the surface film and selective netting of animals seen, netting samples of mud from the substrate and irrigating them for sorting in white trays, and scraping samples of algae from pond sides, larger rocks and (Sertung) the cliff face and preserving for later microscopic sorting.

Care was taken to avoid oversampling from these very restricted habitats. Only 10–15 % of water volumes and substratum areas, for examples, were examined. Some rarer taxa present may thus have been overlooked, but the samples are sufficient for both documentation of the individual ponds, and assessing similarities and differences between their communities.

All samples were preserved in 70–80 % ethanol.

3. Results

3.1. *Sertung pool*

The most conspicuous and abundant animal found was the aquatic thiarid snail *Melanoides tuberculata* (Müller), the only mollusc encountered. It occurred in the water, on and under rocks, on the concrete rim above water level, and on the cliff-face, and was responsible for the numerous well-marked grazing trails on all substrata. Most individuals were small (shell length 3–5 mm), but a few reached 10–12 mm in length.

Sweeping yielded one dytiscid beetle and a very few ostracods, apparently of only one species. No insect larvae were collected by this method. The bottom fauna was also sparse: one dragonfly larva (Libellulidae), and a few larvae of Trichoptera (Hydropsychidae) and Diptera (Chironomidae), seemingly only one species of each of the last two orders. Ostracods were more numerous within a few centimetres of the bottom, and a single, small oligochaete was found in mud at the cliff base. There was no surface-film fauna.

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The algal mat on the cliff contained substantial numbers of small trichopteran larvae, each in a slender case of algal filaments.

3.2. *Panjang ponds*

No molluscs were found, and samples from the mud substrata yielded no arthropods. No Coleoptera, Trichoptera or Odonata larvae were found in either pond.

A. Pond 1. The surface film supported a large population of apterous adults and immature stages of a veliid hemipteran (*Microvelia* sp.). The water mass and substrate surface supported a few small larvae of Ephemeroptera: Baetidae, and Diptera (Chironomidae, 1 sp.; Ephydridae, 1 sp.).

B. Pond 2. Veliidae and Ephemeroptera were absent, but a very large population of culicine mosquito larvae and pupae was present. A very few chironomid and ephydrid larvae (the same species as in pond 1) were also present.

The major taxa are enumerated in table 1.

Table 1. The macroinvertebrates of three artificial ponds on the Krakatau Islands, September 1986

(×, Absent.)

taxon	Sertung	Panjang A	Panjang B
Mollusca			
Melanoides tuberculata (Müller)	abundant	×	×
Annelida			
Oligochaeta	rare	×	×
Arthropoda			
Ostracoda	abundant	×	×
Insecta			
Odonata: Libellulidae	rare	×	×
Ephemeroptera: Baetidae	×	rare	×
Hemiptera: Veliidae	×	abundant	×
Microvelia			
Coleoptera: Dytiscidae	rare	×	×
Trichoptera: Hydropsychidae	rare	×	×
Psychomyiidae	abundant	×	×
Diptera: Chironomidae	rare	rare	rare
Ephydridae	×	rare	rare
Culicidae	×	×	abundant

4. Discussion

The three ponds differed substantially from each other. Each was dominated by a different taxon that was either absent from or scarce in the other two. The Sertung pool is shallower and better aerated, through continuous water flow, than those on Panjang. The Panjang ponds are similar in character. The macro-invertebrate communities of all the ponds were simple, and clearly not as diverse as the larger freshwater and brackish habitats formerly present on Sertung, in which a wide range of aquatic invertebrates was present (Dammerman 1948). The main lake on Sertung harboured many aquatic insects in 1919–22 and 1932–34, including species that may now not be resident on the islands. Most species of Odonata now present on the Krakataus, for example, are likely to be nomadic (Yukawa & Yamane 1985), an inference

supported by our observations on the order: adult Libellulidae and Agrionidae were observed flying strongly on Anak Krakatau in 1984, 1985 and 1986. The single well-grown libellulid larva found can in no way adequately reflect the four species of this family (and one agrionid) found on Sertung by Yukawa and Yumane. Even if other species are breeding in the ponds, populations are clearly very low. No exuviae were found on nearby vegetation. It is not clear to what extent other taxa found in this work may have been present in the former Sertung sites. *Melanoides* was taken in the Sertung Lake in 1933, and is likely to have been continuously present on the island since then. The snail is widespread and known from Java, Sumatra and Sebesi, further north in the Sunda Strait. Some of the aquatic Diptera may also have survived since the 1930s but, as with the dytiscid beetle, it has not been possible to confirm the specific identity of our material.

Ours are the first records of Ephemeroptera and Trichoptera from the Krakatau Islands. The mayfly, a species of *Cloëon* (Baetidae), represents a family well known as colonizers of small oceanic islands. The family includes some unusually long-lived mayflies: up to 14 days has been recorded for some ovoviviparous species (Brittain 1982). A female adult of the same genus was captured by us in a light trap on Anak Krakatau in September 1984, and specimens of *Cloëon* were taken in eastern Sumatra and western Java at that time. Edmunds (1972) suggested that, as dying females of some mayflies usually extrude their eggs, even dead wind-blown females could conceivably be effective propagules. The characteristically short life of adult mayflies in most other families mitigates against them being successful colonists, and the chances of colonization of small ponds on the Krakataus by non-baetid Ephemeroptera, which tend to be less vagile, appear to be small. Some Baetidae are associated with brackish water.

Although no adult Trichoptera have been found on the Krakataus, populations of two species, representing different families, are well-established on Sertung, apparently absent from Panjang. The larger larvae, and the only ones found in the pool, are of a species of Hydropsychidae, and it is not yet possible to identify them beyond this level. A few such larvae also occurred on the cliff, but the more abundant species there was a species of *Tinodes* (Psychomyiidae). Three species of *Tinodes* have been described from Sumatra or Java or both, but other undescribed Indonesian species are known (A. Neboiss, personal communication). Specific identification of the *Tinodes* larva is at present impracticable.

Scarcity of major predators such as Odonata and larger Coleoptera probably reflects the scarcity of potential prey. Larger Dytiscidae, like some other water beetles, can fly strongly and are renowned colonizers of static water bodies. Dammerman (1948) noted two species from the water-butt of the former resident of Rakata, Mr Händl, in 1920. Both were widely distributed species of *Hydaticus*, which the present adult strongly resembles.

The Veliidae, surface-film dwellers and predators, is a family not previously recorded from the Krakataus. All individuals captured were apterous, and adults and nymphs were present together. Alary polymorphism is well known in *Microvelia*, species of which occur as far into the Pacific as Samoa. These bugs typically occur in ponds, and relatively few Microveliinae occur in open water (McCafferty 1981). Three other aquatic Hemiptera were recorded by Dammerman (1948), and at least two were active colonizers in 1920–21, one being noted as 'flying aboard the ship', and the other from Mr Händl's water-butt. Aquatic bugs were also captured in water traps on bare lava on Anak Krakatau (Thornton *et al.* 1988), and it seems that, like other weakly flying insects, they may arrive by wind.

It is remarkable that representatives of two of the three orders of aquatic insects not hitherto

recorded from the Krakataus have become established in such small and inconspicuous ponds. The Panjang ponds are both under forest canopy, and the relatively small population of *Cloëon*, limited to one pond, could represent recent colonization from a single founder female. The Sertung Trichoptera appear to be more securely established.

Progressive mixing of these three currently rather different communities may now occur, together with the advent of further taxa. We intend to reassess the complexity and similarity of the three ponds, which may be expected to be subjected to less intense human interference in the future, on further expeditions to the Krakataus. The data presented here will provide the necessary baseline for such monitoring.

We acknowledge permission to work on the Krakatau Islands granted by the Indonesian Academy of Sciences, the National Institute of Biology, and the National Parks Authority, and thank our colleagues on the 1986 Expedition for their companionship and help. Dr A. Neboiss identified the Trichoptera.

References

Brittain, J. E. 1982 Biology of mayflies. *A. Rev. Ent.* **27**, 119–147.

Dammerman, K. W. 1948 The fauna of Krakatau 1883–1933. *Verh. K. ned. Akad. Wet.* (tweede sectie) **44**, 1–594.

Edmunds, G. F. 1972 Biogeography and evolution of Ephemeroptera. *A. Rev. Ent.* **17**, 21–42.

McCafferty, W. P. 1981 *Aquatic entomology*. Boston, Massachusetts: Jones and Bartlett.

Thornton, I. W. B., New, T. R., McLaren, D. A., Sudarman, H. K. & Vaughan, P. J. 1988 Air-borne arthropod fall-out on Anak Krakatau and a possible pre-vegetation pioneer community. *Phil. Trans. R. Soc. Lond.* B **322**, 471–479. (This volume.)

Thornton, I. W. B. & Rosengren, N. J. 1988 Zoological expeditions to the Krakatau Islands, 1984 and 1985: general introduction. *Phil. Trans. R. Soc. Lond.* B **322**, 273–316. (This volume.)

Yukawa, J. & Yamane, S. 1985 Odonata and Hemiptera collected from the Krakatau and surrounding islands, Indonesia. *Kontyû* **53**, 690–698.

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