

PHYTOPLANKTON FROM SOME LAKES ON MT WILHELM, EAST NEW GUINEA *

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INTRODUCTION

Although the Indonesian Archipelago is phycologically rather well-known, information about the freshwater algae in New Guinea is very scanty. There are only a few papers, e.g. by Bernard (1910) and Cholnoky (1963), but these give only a glimpse of the phycocoenoses of the New Guinea lakes, especially those of the high mountains. Many of these lakes have been mentioned in travel books, and some seem to be promising localities for freshwater algae.

The biogeographical relations between Malesian and Australian regions have been much discussed. A number of biogeographers have attempted to unravel the complex of transition in this part of the world. Phytogeographers often accept the Torres Strait as a boundary between the Malesian and the Australian floras. This is only true in a general statistical way; the flora of the dry savannahs of the southern lowland shows a great similarity to that of northern Australia, while the high-mountain flora shows distinct affinities with both the northern temperate Asiatic flora and the temperate South Pacific flora. Zoogeographers, however, include New Guinea mostly in the Australian region because of the existence of a land-bridge between Australia and New Guinea during past geological epochs (see fig. 11—5, in Knight, 1965). In this connection the character and relations of the freshwater algal flora of New Guinea is of some interest. It has been shown by Scott & Prescott (1958) that the freshwater algal flora of northern Australia is closely related to that of the Indo-Malayan region.

In order to obtain some information on the phytoplankton of the New Guinea lakes I asked Mr. M. M. J. van Balgooy to make collections for me during his expedition to New Guinea in 1965. He collected only at high-altitude stations and the algal flora found is of course of a temperate nature. It remains desirable to collect in future samples from the lowland lakes which will obviously show other affinities.

The collections which were most kindly placed at my disposal originate from Mt Wilhelm, located in the Bismarck Range ($5^{\circ}43' \text{ S}$, $144^{\circ}58' \text{ E}$), Eastern Highlands District, Australian New Guinea. All the lakes sampled by Mr. van Balgooy are in the vicinity of the Australian National University field-station, which is situated near Lake Aunde at an approximate altitude of 3560 m on the eastern slope of Mt Wilhelm (see fig. 1 and 6). The samplings were made between April 19 and June 25, thus during the rainy season which is practically continuous from October to June. A total of 17 samples from 5 lakes were collected. Collections were made by repeatedly throwing a 25 μ -net into the water from the shore, or by dragging it slowly behind an air-matress which

* Dedicated to the memory of Prof. G. Einar Du Rietz 25/4 1895—7/3 1967.

SAMPLING STATIONS

Lake Pinde (Piunde). Altitude 3650 m, size about 500 by 300 m, one of the largest lakes on the mountain. On the north side of the lake there is a rocky slope, too steep to support much vegetation; the other slopes are covered with alpine meadows and shrubberies. Maximum depth as sounded by Rapson is 54 m (Brass 1964); van Balgooy (1965) reports a depth of 50 m in the centre of the lake. The water of this lake is clear, slightly greenish, the bottom muddy. The surface temperature of the water was 12° C on April 19 and 10° C at the end of June. In all 5 samples were collected in April and June, in different parts of the lake. The content of these samples is almost identical, so I have not given a separate list for each sample. The composition of the prevailing plankton community is shown in table 1, column 1.

Lake Aunde. The altitude is 3560 m. This lake is slightly smaller than the previous one, about 300 by 400 m. It is surrounded by alpine shrubberies which are best developed on the northern and southern slopes; an alpine grassland, sometimes of boggy type, occurs between the shrubberies. The greatest depth is 33 m, according to the soundings by Rapson; van Balgooy reports a depth of 20 m in the centre of the lake. The water is very clear. Patches of submerged *Callitriche* and *Scirpus* occur over all the shallower parts of the lake. The recorded water temperatures were between 10.5° C and 12° C. The only pH measurement gave 6.5. Between April 19 and June 17, seven plankton samples were collected from different parts of the lake. As for the previous lake, the composition of plankton in different samples was quite uniform; column 2 in table 1 is, therefore, a summary list.

Brass's Tarn.¹⁾ Located at an altitude of 3920 m, west of Lake Pinde in a depression on a ridge. A small body of water, about 20 by 40 m. It is surrounded by a 10 m wide quaking bog. The maximum depth of this pond is about 3 m. The water has a greenish colour. The bottom is covered with a thick growth of submerged *Scirpus*, *Callitriche*, and *Spirogyra*. The water temperature was 10–10.5° C during the sampling on June 21.

Lake Guraguragukl. Located at an altitude of 3750 m in an often clouded valley, it is a small lake, about 200 by 200 m. The northern shore of the lake is a very steep rocky slope. The other shores are covered with grass and scattered shrubs; near the outflow there is a small shrubbery. The maximum depth is about 20 m. The water is clear, slightly greenish. The bottom is rocky with a thin layer of silt, here and there are patches of a thick growth of submerged *Scirpus* and *Callitriche*. The temperature of the surface water was 9.5° C during the sampling on June 25.

Lake Tekeh Pangwa. Altitude 3800 m, size about 100 by 200 m. The lake is surrounded by steep rocky slopes, except at the outflow. The shores are covered by grasses and herbs with scattered low shrubs. The maximum depth is about 10 m. The temperature of the water was 10° C during the sampling on June 23.

GENERAL CONSIDERATIONS

All these lakes on Mt Wilhelm (see map, fig. 1 and 6) are of Pleistocene glacial origin, possibly about 20,000 years old. They all have a small drainage area and are, as far as one can judge from the composition of the plankton, poor in nutrients. The net plankton is quantitatively as well as qualitatively very limited. All these lakes are obviously

¹⁾ Brass's Tarn is the name given by van Balgooy to this hitherto nameless pond first mentioned in literature by Brass in 1964.

oligotrophic. It would be more appropriate to designate them as ultraoligotrophic. It is interesting to note that there are practically no differences between the different water bodies as to the composition of plankton, as far as the most abundant plankton species are concerned. The composition of the prevailing phytoplankton communities is summarized in table 1. Since the zooplankton is being studied by Dr. W. Vervoort (Leyden), I will only emphasize here the abundant occurrence of the rotifer *Keratella serrulata curvicornis* in all samples.

The thermal conditions of high mountain lakes, especially those in the tropics, are of great interest for lake metabolism (cf. Löffler, 1964). However, only tentative suggestions as to the possible occurrence of polymictic ¹⁾ lakes can be made from surface water temperatures. The five lakes studied on Mt Wilhelm are all sheltered by ridges, have a restricted area, and are relatively deep, Brass's Tarn excepted. The daily air temperatures during the period April—June varied as follows: minimum 3—6.5° C and maximum 7—18° C, measured at the field-station (3560 m a.s.l.). Considering the available information about lake morphometry and the air and water temperatures, the occurrence of polymixis in at least four of these five lakes does not seem very plausible. The small and shallow Brass's Tarn, however, might possibly be a polymictic body of water. In this connection it ought to be mentioned that regular occurrence of frosty nights has been recorded by Mr. van Balgooy at altitudes of 3750 and 4050 m, and that the ground temperatures on exposed grass-covered soil recorded on June 10—21 were as follows: minima + 3° — 2.5° C and maxima 17°—33° C. Thus the thermal conditions are more favourable for life in the water than on the land (cf. Thomasson, 1956, p. 120).

When one has only a limited number of samples at hand there is always the question about the value of studies based on such random samples. The matter has been illustrated e.g. by Spodniewska (1964). Even in the case of a large number of samples, however, it is often practically impossible for one person to work carefully through all groups of algae within a reasonable time, especially if the samples are quantitatively as well as qualitatively rich. One has to restrict oneself to a limited number of samples, and even in such a case the stress is as a rule laid upon one's speciality (cf. Davis, 1966, p. 3). However, it is always desirable that at least some information is included as to the organisms which can be identified without special studies, although in fact beyond one's speciality. This gives us some idea about the composition of the biocoenoses. It should be noted, however, according to Behre (1966) that: "wenn eine Arbeit in einer längeren Artenliste nur Formen enthält, die schon vor mehreren Jahrzehnten in der Süßwasserflora beschrieben sind, so erweckt das kein Vertrauen". Many of the algae collected are not recognized for what they are, but are squeezed conveniently into existing categories. One must keep in mind that the logarithmic increase in research during the past two decades has produced a vast amount of information to be found in discouragingly scattered papers. To keep account of all that information is one of the major problems in the identification of many algae. As proper naming is fundamental in ecology, the correlations of ecological features can, therefore, in many cases only be made in very broad generalizations, or are of questionable value because specific determinations of algae have not been made (cf. Cholnoky, 1966, p. 170). Anyway, there is no chance to cover the whole biocoenosis; that would demand a large, international team of taxonomists. What we can deal with, however, are the different kinds of taxocenes, i.e. associations of particular systematic groups (Chodorowski, 1959, p. 53).

¹⁾ A term used for a water body without persistent thermal stratification. See Hutchinson, A treatise on Limnology, 1 (1957) 467.

TABLE 1.
(bold type means dominant)

	Pinde	Aunde	Brass's Tern	Guraguregukl	Tekoh Pangwa	
<i>Anabaena</i> sp.	+	+	.	.	+	
<i>Aphanocapsa elachista</i>	+	
<i>A. elachista</i> var. <i>planctonica</i>	+	+	.	.	.	
<i>Aphanothece clathrata</i> var. <i>brevis</i>	+	
<i>A. stagnina</i>	.	+	.	.	.	
<i>Chroococcus turgidus</i>	.	.	+	.	.	
<i>Gloeocapsa</i> sp.	+	
<i>Gomphosphaeria lacustris</i>	+	+	+	+	+	
<i>Microcystis elabens</i>	.	+	.	.	.	
<i>Nostoc coeruleum</i>	+	
<i>Petalomonas</i> cf. <i>pragnans</i>	.	+	.	.	.	
<i>Peridinium pusillum</i>	+	+	+	+	+	24 μ long
<i>P. volzii</i>	.	.	+	+	.	
<i>Peridinium</i> sp.	+	
<i>Dinobryon calyciforme</i>	+	.	+	.	.	on detritus
<i>Epipyxis eurystoma</i>	.	.	+	.	.	
<i>E. pulchra</i>	.	.	+	.	.	
<i>E. tubulosa</i>	.	.	+	.	.	
<i>Epipyxis</i> sp.	+	
<i>Peroniella planctonica</i>	.	+	.	.	.	
<i>Stichogloea delicatula</i>	+	+	+	.	.	det. H. Skuja
<i>Melosira distans</i>	+	
<i>M. italica</i> var. <i>valida</i>	+	+	+	.	.	
<i>M. roseana</i>	+	
<i>M. roseana</i> var. <i>epidendron</i>	+	fig. 4:1; diam. 14 μ
<i>Diatoma hiemale</i> var. <i>mesodon</i>	.	.	.	+	.	
<i>Eunotia robusta</i>	.	.	+	.	.	
<i>Rhizosolenia eriensis</i> var. <i>morsa</i>	+	+	+	.	.	
<i>Ophiocytium maius</i>	.	.	+	.	.	
<i>Haematococcus pluvialis</i>	.	+	.	.	.	
<i>Trachelomonas globularis</i> var. <i>punctata</i>	.	.	+	.	.	
<i>Gloeococcus schroeteri</i>	+	+	.	+	+	
<i>Tetraspora lacustris</i>	+	+	+	.	.	
<i>Ankistrodesmus falcatus</i>	.	+	.	+	+	
<i>A. falcatus</i> var. <i>spiralis</i>	+	+	.	.	.	
<i>Botryococcus braunii</i>	+	+	+	+	+	
<i>Coelastrum cambricum</i> var. <i>intermedium</i>	+	+	.	.	.	
<i>C. microporum</i>	.	+	.	.	.	

<i>Crucigenia rectangularis</i>	+	+	+	+	.	
<i>Kirchneriella irregularis</i>	.	+	.	.	+	
<i>Nephrocytium lunatum</i>	+	+	.	.	.	
<i>Oocystis solitaria</i>	.	+	.	+	+	
<i>Oonephrys obesa</i>	+	.	+	.	+	
<i>Pediastrum araneosum</i>	+	+	.	+	+	
<i>P. boryanum</i>	.	+	.	.	.	
<i>Quadrigula closteroides</i>	.	.	+	+	.	
<i>Microspora membranacea</i>	.	.	+	.	.	a short piece
<i>Ulothrix amphigranulata</i>	.	.	.	.	+
<i>Spirotaenia condensata</i>	.	.	.	+	.	
<i>Cylindrocystis brebissonii</i>	.	.	+	.	.	
<i>Gonatozygon monotaenium</i>	.	.	+	+	.	
<i>G. kinahani</i>	+	.	.	.	.
<i>Closterium cynthia</i>	.	+	.	.	.	
<i>C. cynthia</i> var. <i>curvatissimum</i>	+	.	.	.	.	fig.3:1; 154 μ long
<i>C. diana</i>	.	.	+	.	.	
<i>C. kuetzingii</i>	.	.	+	.	.	
<i>C. pseudodiana</i>	.	.	+	.	.	
<i>C. rostratum</i>	+	.	+	.	.	
<i>C. rostratum</i> var. <i>brevirostratum</i>	+	.	.	.	.	fig.4:6; 286 μ long
<i>C. striolatum</i>	.	.	+	.	.	fig.4:5 & 7; 256-348 μ long
<i>Penium cylindrus</i>	.	.	+	.	.	
<i>Pleurotaenium ehrenbergii</i>	.	.	+	+	.	
<i>Euastrum bidentatum</i> var. <i>speciosum</i>	+	+	+	+	+	
<i>E. brasiliense</i> forma Borge 1924	+	.	.	.	.	fig.3:2; 106 by 54 μ
<i>E. denticulatum</i> var. <i>quadridarium</i>	.	+	.	.	.	
<i>E. didelta</i>	.	.	+	+	.	fig.3:4 & 4:3; 158 by 72 μ
<i>E. dubium</i> forma	.	+	.	.	.	
<i>E. dubium</i> var. <i>ornatum</i>	.	+	.	.	.	
<i>E. oblongum</i>	+	+	+	.	.	fig.3:3
<i>Micrasterias crux-melitensis</i>	.	+	.	.	.	
<i>M. crux-melitensis</i> f. <i>simplex</i>	+	+	.	+	.	fig.2:1-3 & 3:9-10
<i>M. quadridentata</i> var. <i>indonesiensis</i> f.	.	.	+	.	.	fig.4:2; 258 by 220 μ
<i>Cosmarium amoenum</i> var. <i>mediolaeve</i>	.	.	+	.	.	fig.5:19; 60 by 38 μ
<i>C. amplum</i> forma	.	.	+	.	.	fig.3:5-8; 116-120 by 76-78 μ
<i>C. bioculatum</i> var. <i>excavatum</i>	+	+	+	.	.	
<i>C. caelatum</i>	.	+	.	.	.	
<i>C. contractum</i>	.	+	+	.	.	
<i>C. contractum</i> var. <i>ellipsoideum</i>	.	.	+	.	.	
<i>C. cyclicum</i> var. <i>arcticum</i>	.	.	+	.	.	fig.5:22; 60 by 60 μ
<i>C. denotarisii</i>	.	+	.	.	.	84 μ long
<i>C. dorsitruncatum</i> forma	.	.	+	.	.	fig.5:21; 48 by 52 μ

<i>C. hammeri</i>	.	.	.	.	+
<i>C. nasutum</i> f. <i>granulata</i>	.	+	.	.	.	50 μ long
<i>C. quadratum</i>	+	+	.	.	.	
<i>C. quadratum</i> forma	.	.	.	+	+	Förster 1965; fig.11:16
<i>C. quadrifarum</i> f. <i>octasticha</i>	+	+	.	.	.	
<i>C. spirale</i>	+	.	+	.	+	fig.5:20; 72 μ long
<i>C. subspeciosum</i> var. <i>validius</i>	.	+	+	.	+	fig.3; 54 μ long
<i>C. tetraophthalmum</i>	.	+	.	.	.	102 μ long
<i>Xanthidium antilopaeum</i>	+	+	+	+	+	fig.5:26
<i>Staurodesmus brevispinus</i>	+	+	+	.	+	
<i>S. clepsydra</i>	.	.	+	.	.	
<i>S. clepsydra</i> f. <i>reducta</i>	+	.	.	.	.	32 by 30 μ
<i>S. dejectus</i>	+	.	+	.	.	Smith 1924 fig.68:22
<i>S. dickiei</i>	+	+	.	.	.	
<i>S. dickiei</i> var. <i>maximus</i>	+	+	+	+	.	fig.5:1-3; 44-50 by 44-48(60-64) μ
<i>S. extensus</i>	.	.	+	+	.	fig.5:4; 26(48) by 52 μ
<i>S. mamillatus</i>	.	.	.	+	.	fig.5:5; 44 by 48 μ
<i>S. megacanthus</i>	.	+	.	.	.	
<i>Staurostrum aculeatum</i>	.	+	.	.	.	
<i>S. alternans</i>	.	+	.	.	.	
<i>S. armigerum</i> var. <i>furcigerum</i>	+	+	.	+	+	2- & 3-radiate
<i>S. armigerum</i> var. <i>gracillimum</i>	+	.	.	.	.
<i>S. avicula</i> var. <i>subarcuatum</i>	+	+	+	+	.	fig.5:15-16; 32 by 48 μ
<i>S. biordinatum</i> forma	.	.	+	+	+	fig.4:4 & 5:17; 28-29 by 34-37 μ
<i>S. capitulum</i> var. <i>amoenum</i>	.	.	.	+	.	36 μ long; Nordstedt 1872, fig.7:25
<i>S. dilatatum</i>	+	.	.	.	.
<i>S. eboracense</i>	.	.	.	+	.	
<i>S. erasum</i>	+	.	+	.	+	fig.5:10-11
<i>S. hexacerum</i>	.	.	+	.	.	fig.5:18; 32 by 32 μ
<i>S. lapponicum</i>	.	.	+	.	.	fig.5:9
<i>S. pachyrhynchum</i> (?)	+	.	+	+	+	fig.5:6-8; 40-48 by 40-48 μ
<i>S. petsamoense</i> var. <i>minus</i> forma	+	+	+	+	.	28 μ long
<i>S. polymorphum</i>	.	.	.	+	.	
<i>S. pseudosebaldi</i>	.	.	+	.	.	fig.5:14; 44 μ long
<i>S. punctulatum</i>	.	+	.	.	.	
<i>S. punctulatum</i> var. <i>subfusiforme</i>	+	.	.	.	.
<i>S. sebaldi</i> var. <i>altum</i> f. <i>pusilla</i>	.	.	+	.	.	fig.5:23; 40 by 40 μ
<i>S. sebaldi</i> var. <i>ornatum</i>	+	+	+	.	.	fig.2:4-5 & 5:24-25; 82 by 88 μ
<i>S. spongiosum</i> var. <i>griffithsianum</i>	.	.	+	.	+	
<i>S. teliferum</i>	.	.	+	.	.	fig.5:13; 44(52) by 38(48) μ
<i>Spondylosium panduriforme</i>	+	+	.	.	.	
<i>Hyalotheca dissiliens</i>	+	+	+	+	.	

In the present case we have to do with seventeen random samples. They are from five different waters, but their contents, when compared with each other are so similar that I am inclined to consider them quite representative for the sampling period. Naturally, the tabulation above is by no means a total list. Originally I was interested only in the desmids in these waters. Although I have looked especially for them, one ought to keep in mind the illustrative example given by Hutchinson (1964, p. 336) that it is possible that in a lake rare species are not likely to be observed in small samples. For trustworthy complete inventories time-consuming studies of large samples are required, the more so because for a reliable determination, as a rule, numerous specimens ought to be studied. The problem has been studied and analyzed by many planktologists, e.g. by Mrs Hillbricht-Ilkowska (1965) who worked with 20 liter samples. However, one just wonders if her results of every 14 days sampling as compared with every 3—5 days sampling are comparable. In the latter the total quantity of the water filtered was about 3—4 times as large as in every 14 days sampling. For a proper comparison the values from every 14 days sampling should have been based on 100 liter samples.

In spite of the shortcomings discussed above I believe that the list on net plankton gives a fairly good idea of the character of these lakes. The length of life or generation time of individual organisms as related to length of the period of environmental changes makes the long-lived organisms which have a low rate of reproduction, like those listed above, more suitable for characterization of biocoenoses than the short-lived organisms with a high rate of reproduction. The latter ones are often useful for the characterization of different aspects of the biocoenosis, and for tracing short-term environmental fluctuations; see e.g. Panknin (1941, p. 162). This is strikingly evident when a plankton sample has been left standing unpreserved. Then the quantitative composition of the protozoa, flagellates as well as ciliates, changes completely within a short time.

TAXONOMICAL NOTES

A plain enumeration of algae without any taxonomical comments and/or illustrations is often considered a rather suspicious information of only restricted scientific value. Therefore, a few taxonomical notes to the above reproduced table are added here.

Closterium striolatum Ehrenb. — Fig. 4: 7, length 256 μ . Compare *C. striolatum* in Prescott & Scott 1952, fig. 1: 5.

Euastrum brasiliense Borge forma — Fig. 3: 2, length 106 μ , width 54 μ . Compare *E. ansatum* var. *dideltiforme* f. *australianum* Prescott & Scott 1952, fig. 2: 5, and *E. brasiliense* Borge forma in Fritsch & Rich 1924, p. 330, fig. 8F. Furthermore, see *E. brasiliense* var. *convergens* Krieger, and also *E. brasiliense* Borge in Förster 1963, p. 52, figs. 2: 7—8. There is also resemblance to some forms of *E. obesum*, *E. didelta*, and also *E. ansatum*, e.g. its var. *dideltiforme*. Moreover, compare *E. quadriceps* var. *minor* Fritsch & Rich 1937, figs. 7d—g which also has some resemblance to the specimens under consideration.

Micrasterias crux-melitensis f. **simplex** (Borge) Thom. n. comb. — Figs. 2: 1—3 & 3: 9—10. Basionym: *M. crux-melitensis* var. *simplex* Borge (1894) Bih. Svenska Vetensk.-Akad. Handl., 19. I am in doubt about the taxonomic value of this and some closely related taxa, like var. *lapponica* Roll and var. *rabenhorstii* (Kirchner) Krieger. They are very likely merely teratological forms. Curiously enough there are no records of *M. crux-melitensis* or its varieties and forms in Krieger (1932) and Scott & Prescott (1958 & 1961). Behre (1956), however, reports *M. crux-melitensis* from Java and Celebes.

Cosmarium amplum Nordst. forma — Figs. 3: 5—8, length 116—120 μ , breadth

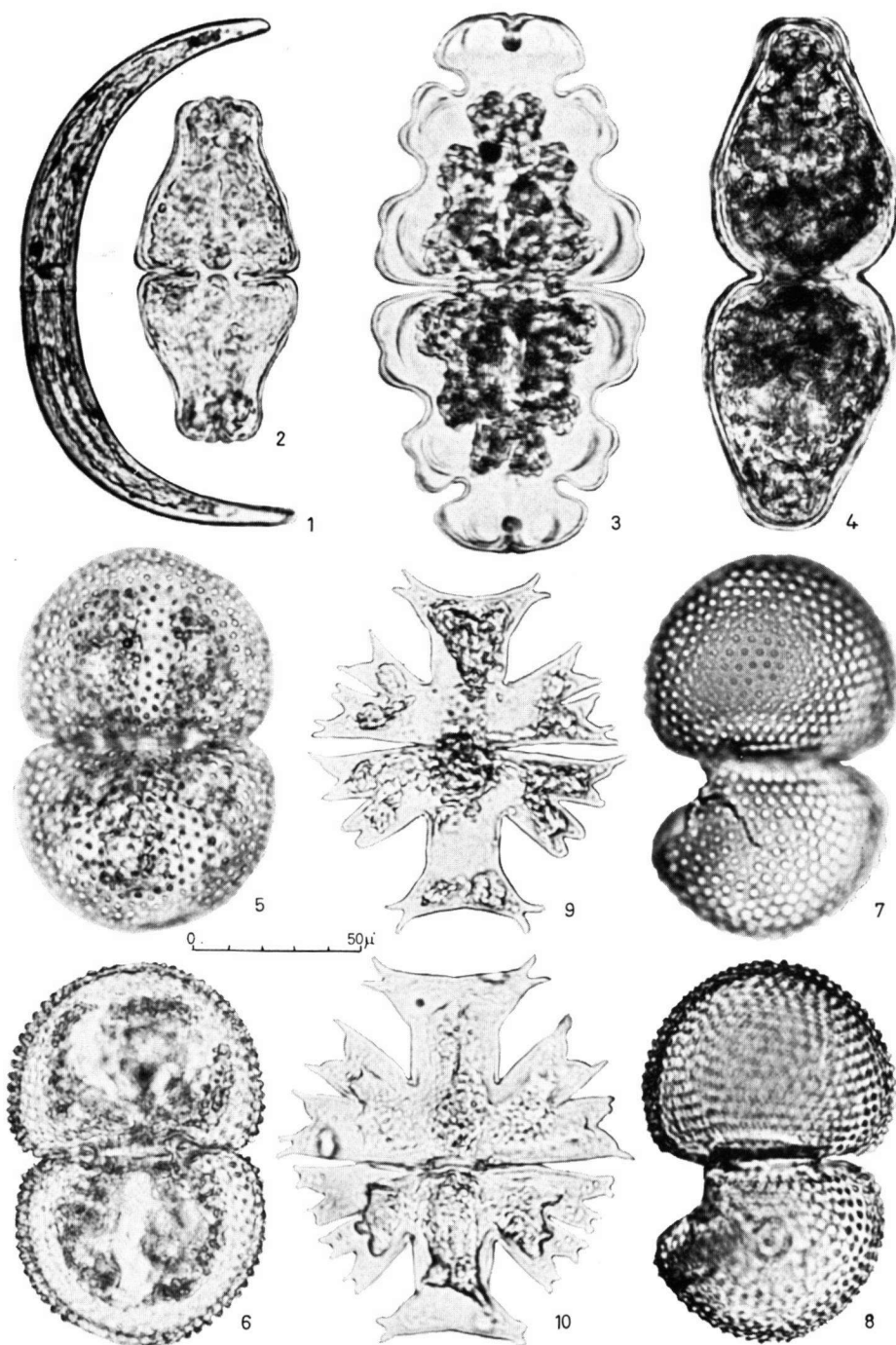


Fig. 3: 1. *Closterium cynthia* v. *curvatissimum* W. & W. — 2. *Euastrum brasiliense* Borge forma. — 3. *E. oblongum* (Grev.) Ralfs. — 4. *E. didelta* Ralfs. — 5—8. *Cosmarium amplum* Nordst. forma. — 9—10. *Micrasterias crux-melitensis* f. *simplex* (Borge) Thom.

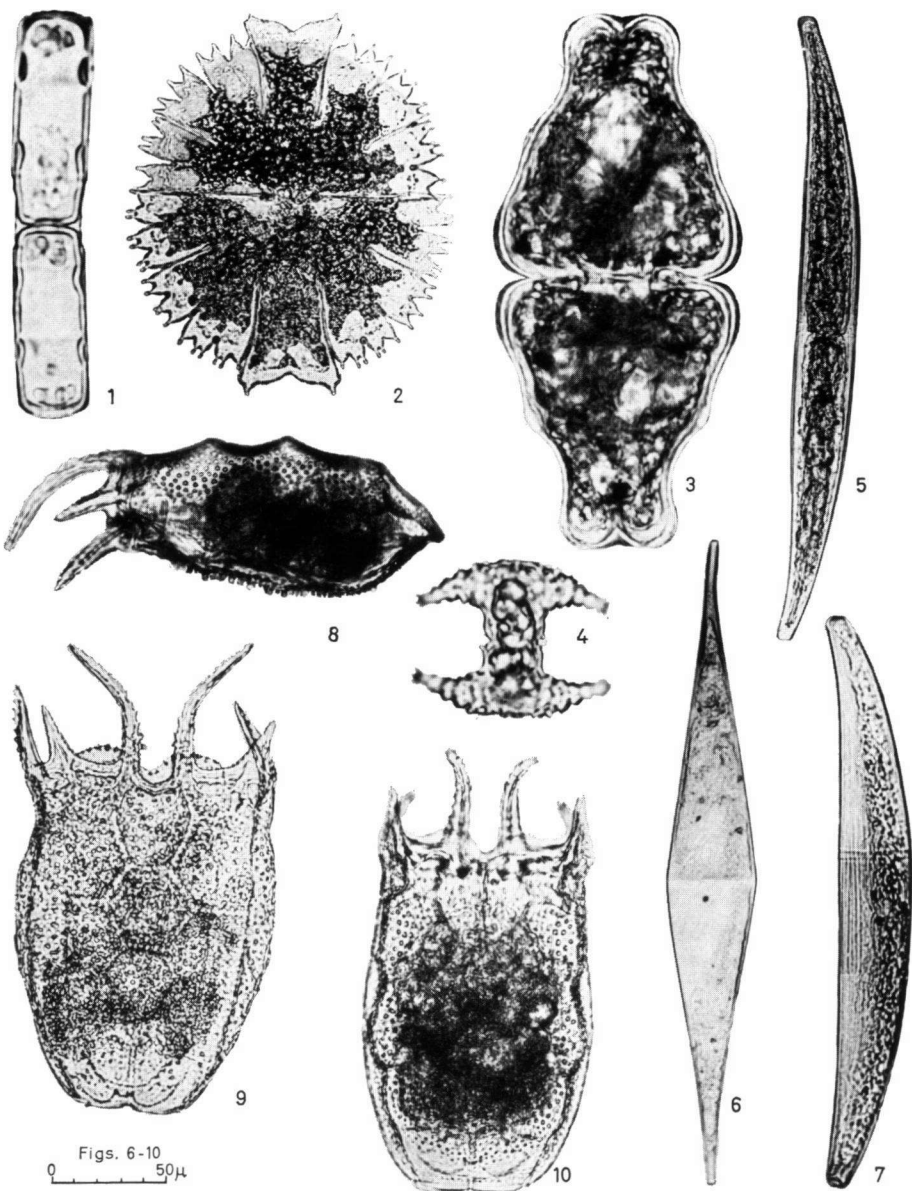


Fig. 4: 1. *Melosira roseana* v. *epidendron* Grun. — 2. *Microasterias quadridentata* v. *indonesiensis* Scott & Prescott forma. — 3. *Euastrum didelta* Ralfs. — 4. *Staurastrum biordinatum* W. & W. forma. — 5 & 7. *Closterium striolatum* Ehrenb. — 6. *Closterium rostratum* v. *brevirostratum* W. West. — 8—10. *Keratella serrulata curvicornis* Rylov.

Fig. 5: 1—3. *Staurodesmus dickiei* v. *maximus* (W. & W.) Thom. — 4. *S. extensus* (Borge) Teiling. — 5. *S. mamillatus* (Nordst.) Teiling. — 6—8. *Staurastrum pachyrhynchum* Nordst. (?) — 9. *S. lapponicum* (Schmidle) Grönblad. — 10—11. *S. erasum* Bréb. — 12. *S. spongiosum* v. *griffithsianum* (Näg.) Lagerh. — 13. *S. teliferum* Ralfs. — 14. *S. pseudosebaldi* Wille. — 15—16. *S. avicula* v. *subarcuatum* (Wolle) W. & W. — 17. *S. biordinatum* W. & W. forma. — 18. *S. hexacerum* (Ehrenb.) Wittr. — 19. *Cosmarium amoenum* v. *mediolaeae* Nordst. — 20. *C. spirale* (Playf.) Krieger & Gerloff. — 21. *C. dorsitruncatum* (Nordst.) G. S. West forma. — 22. *C. cyclicum* v. *arcticum* Nordst. — 23. *Staurastrum seabaldi* v. *altum* f. *pusilla* Playf. — 24—25. *S. seabaldi* v. *ornatum* Nordst. — 26. *Xanthidium antilopaeum* (Bréb.) Kütz.

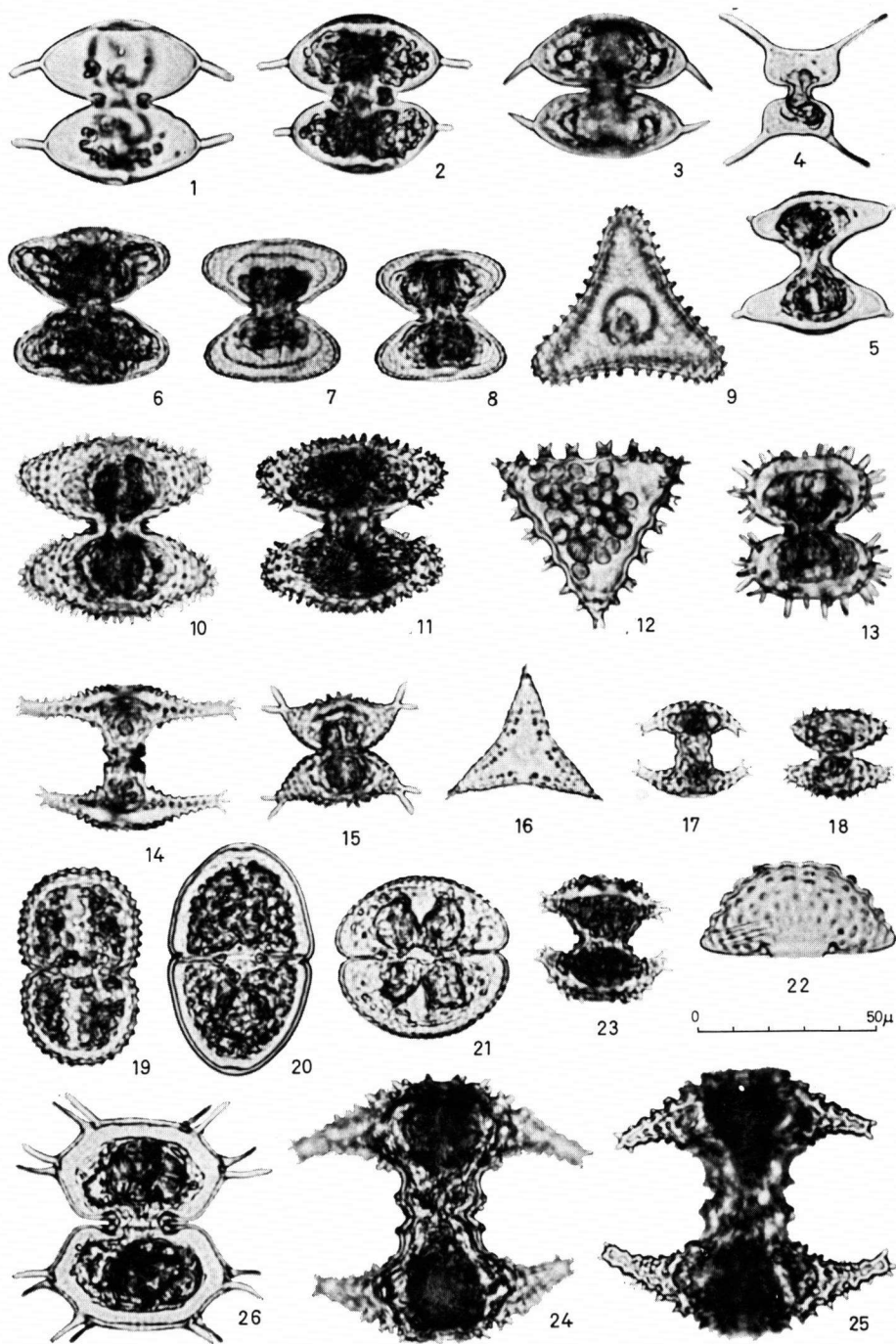




Fig. 6. Above: Pindunde Valley on Mt Wilhelm; from left to right Lake Aunde, Lake Pinde, and Brass's Tarn. The biological station is indicated by an arrow above the middle of Lake Aunde.

Below: Mr. Van Balgooy using an air-mattress as a raft on Lake Pinde for collecting plankton.

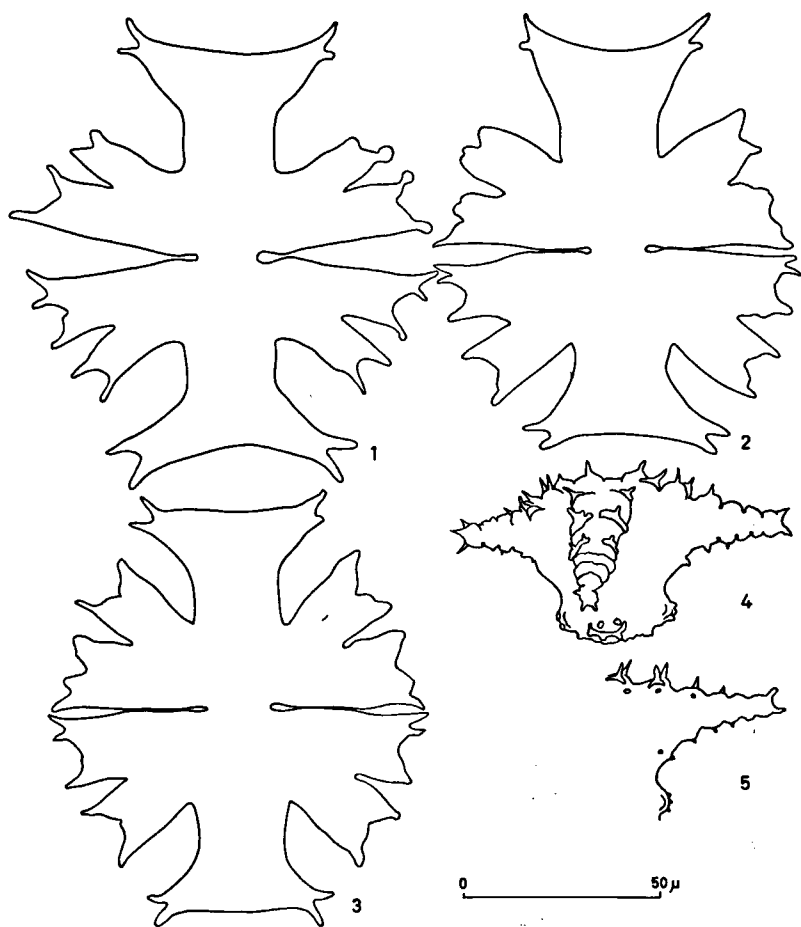


Fig. 2: 1—3. *Micrasterias crux-melitensis* f. *simplex* (Borge) Thom. — 4—5. *Staurastrum sebaldi* v. *ornatum* Nordst.

76—78 μ . Compare *C. amplum* Nordstedt 1888, p. 63, fig. 6: 20, and *C. amplum* in Bernard 1908, fig. 6: 137. The last one is somewhat smaller than the New Guinea specimens.

***Cosmarium dorsitruncatum* (Nordst.) G. S. West forma** — Fig. 5: 21, length 48 μ , width 52 μ . Another difficult case. Note the structure of the cell-wall. There are two pyrenoids in each semicell, like in *C. dorsitruncatum*. The apex is, however, rounded and not truncate as in typical *C. dorsitruncatum*. There are some similar specimens figured in literature, e.g. *C. depressum* in Scott & Prescott 1961, fig. 26: 6, *C. cyclicum* var. *sinense* in Jao 1949, fig. 2: 22, *C. lundellii* var. *ellipticum* in Hinode 1961, figs. 2: 44, 45, and also *C. lundellii* var. *corruptum* in Dick 1923, fig. 1: 12. Furthermore, see also the rather compressed form of *C. stigmatosum* (?) in Croasdale 1956, figs. 5: 1, 2.

***Staurastrum avicula* var. *subarcuatum* (Wolle) W. & W.** — Figs. 5: 15—16, length 32 μ , width 48 μ . This is a common taxon belonging to those grouped around

S. avicula. It is a quite complicated group. Especially the distinction between *S. avicula* var. *subarcuatum* and *S. subcruciatum* is often difficult, see also West's Monograph V, pp. 40—43. But also the nature of *S. avicula* itself is not fully clear, especially when the original drawing by Brébisson is considered and compared with many later figures. Note that the figure reproduced in Ralfs has also rather prominent spines at the extremity of the processes like the plants drawn by Brébisson and those figured in the present paper. The plants under discussion should be compared with *S. avicula* var. *subarcuatum* in Dick 1926, figs. 21: 22—24, and in Skuja 1956, figs. 37: 7—8. The New Guinea specimens also resemble some forms of *S. arcuatum*, especially because sometimes there are stout spines, at times bifurcate, on the apex. See also *S. furcatum*, e.g. in Villeret 1951, figs. 1—5. However, the angles of the semicell are in New Guinea plants, like in many plants adhered to *S. avicula* var. *subcruciatum*, produced to form short cylindrical processes which are tipped by two stout spines. The drawing of *S. subcruciatum* by Cooke and Wills shows a specimen with short terminal spines on processes, and a shape reminding of the specimens often included in the *polymorphum*-*affine*-*proboscidium* group. A taxonomical study of all forms belonging to the *avicula* group is urgently needed. In absence of this every identification should be followed by either a drawing or a reference to an already published identical figure.

Staurostrum biordinatum W. & W. forma — Figs. 4: 4 & 5: 17, length 24—29 μ , width 28—37 μ . Compare *S. biordinatum* in West & West 1902, fig. 21: 36, which is of about the same magnitude and shape as the plants figured here. The apical ornamentation, however, is much heavier in the plants described by West & West. Compare also *S. cystocera* in Donat 1926, fig. 3: 5, and *S. paulense* var. *brasiliense* in Förster 1963, fig. 6: 10, which is not closely related to *S. paulense*. Furthermore, see also *S. crenulatum* forma in Scott & Prescott 1961, fig. 59: 10, and some forms of *S. proboscidium*. Actually the New Guinea specimens could equally well be connected to *S. proboscidium* as a variety or forma if one likes lumping.

Staurostrum lapponicum (Schmidle) Grönbl. — Fig. 5: 9. This plant which is characterised by prominent granulation of the cell-wall has with some doubt been assigned to *S. lapponicum*. Similar forms can be found also in the *dilatatum*-*punctulatum* group.

Staurostrum pachyrhynchum Nordst. (?) — Figs. 5: 6—8, length 40—48 μ , width 40—48 μ . The semicells are triangular in vertical view and their cell-wall is distinctly punctate. In spite of the familiar appearance it is difficult to establish the taxonomical position of these specimens. After much consideration I have finally decided to arrange them with doubt to belong to *S. pachyrhynchum*. Compare Croasdale 1965, figs. 7: 12—15. My hesitation depends partly on the regular arrangement of the punctulation of the cell-wall. There is also some resemblance to some forms grouped with *S. dilatatum*. However, the interpretation of *S. dilatatum* must remain unsettled because the figures forming the starting point for *S. dilatatum* are of poor quality. They very likely represent *S. alternans*. Similar to the New Guinea plants are also some forms of *S. punctulatum* var. *kjellmanii*. It is obvious that in citing any of the taxa mentioned above one should always provide either a drawing or a reference to an identical figure in the literature, because otherwise the information about their occurrence is of little value.

Staurostrum sebaldi var. *altum* f. *pusilla* Playfair — Fig. 5: 23, length 40 μ , width 40 μ . Compare *S. sebaldi* var. *altum* f. *pusilla* in Playfair, 1908, fig. 13: 13. Of course the relation of this taxon to *S. sebaldi* is disputable. The New Guinea plant should also be compared with some forms of *S. aculeatum* and with *S. borgeanum* in Förster 1965, fig. 9: 1.

Staurastrum sebaldi var. *ornatum* Nordst. — Figs. 2: 4—5 & 5: 24—25, length 81—94.5 μ , width 81—88 μ . Compare *S. sebaldi* var. *ornatum* f. *novizelandica* in Nordstedt, 1888, p. 36, fig. 4: 3; this forma scarcely deserves distinction and can better be included within the range of variability of *S. sebaldi* var. *ornatum*. See also *S. mansfeldtii* forma in Messikommer, 1938, fig. 10: 11, and *S. kwangsiense* in Thomasson, 1965, figs. 12: 1—2; both are smaller than the New Guinea specimens.

PLANTGEOGRAPHICAL NOTES

As has already been mentioned, there are many plankton species in these lakes which have their main distribution in temperate regions and have been reported seldom or not at all from the adjacent Malesian and Australian regions. For example, *Euastrum oblongum* has its main distribution in arctic and temperate regions of the northern hemisphere. There are also some records of it from high altitudes in Africa and South America. It is not listed for Indonesia and Australia by Krieger (1932), Behre (1956), and Scott & Prescott (1958 & 1961). Another member of the northern flora in the New Guinea samples is the plant designated as *Micrasterias crux-melitensis* f. *simplex*. Among other taxa occurring in New Guinea high altitude samples is *Staurastrum spongiosum*. On the whole this is a northern temperate species; it is common in subarctic regions and I have also observed it in high-altitude samples from Africa (Thomasson 1965). From the same African samples the arctic-alpine *Cosmarium nasutum* Nordst. was recorded; in the Mt Wilhelm samples *C. nasutum* var. *granulatum* Nordst. occurred (*C. nasutum* var. *subnasutum* (Racib.) Nordst. reported from New Zealand and Australia is likely a species of its own). *Cosmarium caelatum* Ralfs listed above has also its main distribution in northern temperate regions, and has been characterized as an upland species. *Staurastrum capitulum* Bréb., incl. var. *spetsbergense* (Nordst.) Cooke, is another plant of northern temperate and arctic regions. The specimen from Lake Guraguragukl is similar to the one figured by Nordstedt (1872, fig. 7: 25); the length of the specimen was 36 μ . To the noted algae which are known to have their main distribution in northern temperate and arctic regions belongs also *Cosmarium cyclicum* var. *arcticum* Nordst., but not *Staurastrum lapponicum* (Schmidle) Grönb. which in spite of its suggestive name has a wide distribution. *Keratella serrulata curvicornis* Rylov is also a northern temperate species, reported from Russia, Germany, Roumania, Canada, and the U.S.A. It is evident from these examples that there is a distinct touch of northern arctic-alpine character in the New Guinea high altitude phycocoenoses. Naturally, there are also some connections with the Australian flora, but they are scarce, e.g. *Cosmarium spirale* (Playf.) Krieger & Gerloff, an otherwise Australian species. The majority of the algae listed above is cosmopolitan.

It should be admitted here that remote plant-geographical relations have only a very tentative value, as our information about the algal flora of New Zealand and Tasmania, and also of Australia, is scanty. Northward of New Guinea we lack data from the mountain lakes and waters in the Moluccas, Celebes, the Philippines, and Taiwan.

Noteworthy is the occurrence of a triradiate facies of *Cosmarium subspeciosum* var. *validius* Nordst. Triradiate facies of usually biradiate taxa are often met with in high altitude waters. This may partly be due to the increased ultraviolet radiation (Thomasson 1956, p. 125). Similar conditions prevail in subarctic areas, e.g. at Abisko in Sweden (Thomasson 1962, p. 450). Division of cells can be arrested or impeded and mutations brought about by irreversible alterations in nucleic acids imposed by exposure to this type of radiation. On the other hand also the influence of low temperature ought to be considered.

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