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# ALGAE

## COLLECTED BY ERIC HULTÉN ON THE SWEDISH KAMTCHATKA EXPEDITION 1920–22, ESPECIALLY FROM HOT SPRINGS

BY

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# INTRODUCTION

The material for this work was collected by ERIC HULTÉN during the Swedish Kamtchatka expedition 1920—22. Information about the expedition and its route can be gathered from HULTÉN (1928), and in the same work there is a map giving all the localities mentioned. Particulars of the individual groups of springs are given in HULTÉN (1923, p. 340).

Of special interest are the analyses which SCHMIDT (1885) caused to be made of the water in several of the groups of springs. In the list below of the samples examined I have stated what the springs or groups of springs concerned are called in SCHMIDT's publication.

Only a few works are available on the fresh water flora of Kamtchatka. GUTWINSKI (1891) enumerates 19 species of Diatoms and one species of Cyanophyceae which he found in a sample from the outflow from the hot spring Banna. ELENKIN (1914 I), on the other hand, has made a comprehensive investigation of the algal floras in many kinds of waters in the peninsula, also in numerous hot springs. In the systematic part of the present work those species have been marked with an * which have not been mentioned by these authors. In the literature some few species may be found which are referred to as native to Kamtchatka, e. g. in AD. SCHMIDT's Atlas der Diatomaceenkunde (*Didymosphenia sibirica* (Grun.) M. SCHMIDT Taf. 214, fig. 1—3) or in CLEVE's Synopsis I, p. 166 (*Cymbella cuspidata* Kütz.)

# List of the Samples Examined.

**1.** Akhomten Bay, fresh water stream $^{18}/_{9}$ 1920.

1417. Only contained Diatoms.

**2.** Hot springs near Paratunka $^{13}/_{2}$ 1921 (Hultén 1923, p. 341). Called by Schmidt (1885, p. 3) the Sierebrannikow springs.

1507. 25° C. *Chara Braunii*, numerous Diatoms.

1512. 45° C. Dried sample; contained *Vaucheria hamata*, and numerous Diatoms.

1513. 37° C. *Oscillatoria anguina, O. Okenii, O. proboscidea* var. *Westii, O. tenuis* var. *tergestina*, and numerous Diatoms.

1514. 32° C. in formalin and dried. *Rhizoclonium hieroglyphicum* with epiphytes: *Chamaesiphon incrustans, Lyngbya Kützingii, Xenococcus chroococcoides* and Diatoms.

1515. 44°—45° C. *Phormidium laminosum, P. Valderiae.*

1516. 25° C. *Nitella* sp., Diatoms.

1521. 32° C. *Merismopedia glauca, Oscillatoria proboscidea* var. *Westii, O. splendida, O. terebriformis*, Diatoms.

1525. 32° C. Diatoms.

1526. Cold influx 10° C. Diatoms.

**3.** Hot springs near the Savan river $^{31}/_{7}$ 1921. Hultén 1923, p. 343. Not mentioned by Schmidt.

2527. 52° C. Taken with a plankton net. *Spirogyra* sp., *Cosmarium Meneghinii*, Diatoms.

2528. 50° C. *Oscillatoria terebriformis, Phormidium laminosum, P. fragile, Cosmarium* sp., *Scenedesmus denticulatus*, Diatoms.

2530. 73° C. *Phormidium laminosum* (predominantly), Diatoms.

2533. 63° C. *Phormidium laminosum, Scenedesmus quadricauda*, few Diatoms.

**4.** Lower Bolschaja rjeka (undoubtedly newly formed marsh) $^{26}/_{8}$ 1921.

2974. Dried sample. *Vaucheria* sp. with numerous Diatoms.

**5.** Hot springs by the Siku river $^{5}/_{9}$ 1921. Hultén 1923, p. 342 = Apatcha springs (Schmidt 1885, p. 7).

3037. 42° C. *Phormidium laminosum*, Diatoms.

3039. 46° C. *Mastigocladus laminosus, Phormidium laminosum, P. tenue.*

3060. 67° C. *Mastigocladus laminosus, Phormidium laminosum, Aphanocapsa thermalis, Cosmarium sexnotatum* var. *tristriatum.* There were also a number of valves of Diatoms; but it was not possible to find any with a cell content.

6. Hot springs near Karymchina $^{10}/_{9}$ 1921. HULTÉN 1923, pag. 342.

3108. 30° C. *Mastigocladus laminosus, Phormidium laminosum.*

3113. 38° C. *Chroococcus membraninus, Mastigocladus laminosus, Oscillatoria proboscidea* var. *Westii.*

3116. 37° C. Dried sample of a crust. Only effervesces slightly with hydrochloric acid; so probably consists predominantly of $SiO_2$. *Mastigocladus laminosus.*

3117. 37° C. *Mastigocladus laminosus, Phormidium Treleasei,* Diatoms.

3118. 14° C. *Rhizoclonium hieroglyphicum,* Diatoms.

7. The hot spring "Malenki klutchik" (Bannaja) $^{12}/_{7}$ 1921. HULTÉN 1923, p. 342.

3136. 70° C. *Oscillatoria terebriformis, Phormidium tenue,* many Diatoms, nearly all with well preserved cell contents.

3137. 77° C. *Mastigocladus laminosus,* Diatoms in great numbers. Not a few of the Diatoms with well preserved cell contents; a number of empty valves.

3138. 66° C. (Temperature sometimes variable). Numerous Diatoms; a number of empty valves, but many with well preserved cell contents.

3139. 66° C. *Mastigocladus laminosus, Phormidium laminosum,* numerous Diatoms, but valves quite predominantly empty.

3140. 29° C. Botton mud. Diatoms.

3141. 29° C. ("Plankton"). *Rhizoclonium hieroglyphicum, Chamaesiphon incrustans,* Diatoms.

3142. 29° C. *Rhizoclonium hieroglyphicum, Chamaesiphon incrustans,* Diatoms.

3143. 29° C. Dried sample. *Pleurocapsa minor.*

3144. 60° C. *Oscillatoria amoena,* Diatoms; a number of dead valves were present, but also many with a well preserved cell content.

**8.** Hot springs near Bannaja $^{12}/_{9}$ 1921. HULTÉN 1923, p. 342. Referred to in SCHMIDT (p. 8) as Bannaja or Merlin springs.

3170. Temperature? Few Diatoms, only empty valves.

3176. Temperature? *Lyngbya perelegans, Stigonema panniforme, Cosmarium* sp. (only one specimen seen). Diatoms.

3180. 46° C. Bottom mud. Diatoms.

3181. 46° C. *Mastigocladus laminosus, Phormidium Valderiae* and *P. V.* var. *tenue.*

3182. At the outflow of the hot stream. *Chamaesiphon curvatus, C. minutus, Mastigocladus laminosus, Phormidium laminosum, Rhizoclonium hieroglyphicum,* Diatoms.

3183. 46° C. Running water. *Mastigocladus laminosus, Phormidium purpurascens.*

3184. 46° C. Diatoms.

3187. 35° C. *Aphanocapsa thermalis, Chroococcus minutus, Spirogyra* sp., Diatoms.

3189. Mud from "dead" spring. No algae found.

3232. 46° C. *Mastigocladus laminosus, Phormidium laminosum,* Diatoms.

**9.** Hot springs near Natchika, $^{14}/_{9}$ 1921. HULTÉN 1923, p. 341. Natchiki springs in SCHMIDT (1885, p. 6). These springs are evidently the same that ELENKIN (1914 I, p. 183, in note) calls "Naczikin skije kliuczi" and which are depicted in the upper picture of the plate p. 96.

3234. 27° C. *Calothrix parietina, Chroococcus turgidus, Dichothrix gypsophila, Gomphosphaeria aponina, Merismopedia glauca, Nostoc Riabuschinskyi, Scytonema mirabile,* Diatoms.

3235. 27° C. *Mastigocladus laminosus, Phormidium laminosum.*

3236. 38° C. *Dichothrix Orsiniana,* Diatoms.

3237. 40° C. *Oscillatoria angusta, O. tenuis* var. *tergestina,* Diatoms.

3239. 42° C. *Mastigocladus laminosus, Phormidium laminosum, P. Valderiae,* Diatoms, but no cell contents seen.

**10.** Hot springs near the upper Paratunka river, on the slope of the mountain "Garaschie Gara" $^{10}/_{3}$ 1922. See HULTÉN 1923, p. 341. Called by SCHMIDT (1885, p. 6) the Wimut spring.

3701. Temperature? *Hapalosiphon intricatus, Scytonema mirabile, Cosmarium amoenum, Cylindrocystis Brebissonii,* Diatoms.

3702. 12°—13° C. *Mastigocladus laminosus, Symploca thermalis, Cosmarium* sp., *Cylindrocystis Brebissonii,* Diatoms.

3703. 16° C. (the air 13°). Diatoms.

**11.** The hot spring by the middle reach of the Paratunka river, situated between the two branches of the river. See HULTÉN 1923, p. 341. Called by SCHMIDT (1885, p. 6) the Podprugin spring.

3712. 58° C. *Mastigocladus laminosus,* Diatoms, but only empty valves have been seen.

3716. 10° C. *Ulothrix* sp., Diatoms.

3719. 35° C. *Chamaesiphon cylindricus, C. incrustans, Lyngbya Kützingii, Chara Braunii,* Diatoms.

3720. 21° C. *Mougeotia* sp., Diatoms.

**12.** The Shalsan pass 700 m. above the sea. $^2/_7$ 1922 (red snow).

3834. *Chlamydomonas nivalis.*

**13.** Hot spring at the upper Opala river $^2/_8$ 1922. Plankton. HULTÉN 1923, p. 342.

4132. Predominantly detritus; loose trichomes of *Oscillatoria* sp.? and *Mastigocladus* sp.?

**14.** Hot springs near Unkanakchek $^{20}/_8$ 1922. HULTÉN 1923, p. 343.

4328. Temperature? Bottom mud. *Phormidium* sp.; Diatoms. It was not possible to see specimens with cell contents in this sample.

4329. 12° C. Dried sample. *Enteromorpha intestinalis,* Diatoms.

**15.** Unnumbered (marked U. N.) samples.

"Gorelaja" $^{15}/_7$ 1922, the Gorelaja volcano at the upper Opala river; red snow. *Chlamydomonas nivalis*; *Eunotia* sp., *Pinnularia* sp., *Pinnularia borealis,* empty valves.

Hot spring near Schadutka $^{12}/_8$ 1922 (bottom mud) c. 40° C. HULTÉN 1923, p. 343. Purely inorganic material, only a few empty Diatom valves.

Cold stream near camp 4, $^{15}/_7$ 1921, near the upper Abschan river. *Prasiola* sp. (in the *Hormidium* form), *Chamaesiphon incrustans,* Diatoms.

Hot spring near Paratunka $^{17}/_{6}$ 1921, 29° C.
*Merismopedia punctata, Oscillatoria proboscidea* var. *Westii, Scenedesmus quadricauda,* Diatoms.

Hot spring near Paratunka $^{17}/_{6}$ 1921, 44° C.
*Mastigocladus laminosus, Oscillatoria anguina, O. proboscidea* var. *Westii, O. tenuis* var. *tergestina, Phormidium laminosum, P. Valderiae.* Only some few empty valves of Diatoms.

Hot spring near Paratunka $^{17}/_{6}$ 1921, 25° C.
*Chamaesiphon incrustans, Lyngbya distincta, L. Kützingii, Rhizoclonium hieroglyphicum, Spirogyra* sp., Diatoms.

Hot spring near Paratunka, the bathing spring 41° C. $^{16}/_{5}$ 1921. Taken with the plankton net. *Oscillatoria princeps, O. proboscidea* var. *Westii, O. terebriformis,* Diatoms.

Hot spring near the Savan river $^{31}/_{7}$ 1921, dried sample. *Microspora* sp.

I Kamtchatka, without further data.
*Mastigocladus laminosus, Phormidium Treleasei, Oedogonium* sp. Diatoms.

II Kamtchatka, without further data.
*Oedogonium* sp., *Scenedesmus* sp., *Schizochlamys gelatinosa,* Diatoms.

III Kamtchatka, without further data.
*Mastigocladus laminosus.*

I have tried to utilise the material for ecological studies. This must necessarily cause considerable difficulties, since it was not collected with this special purpose in view. The results must therefore on some points remain uncertain; but I am in hopes that the present work may contribute to the solution of various problems concerning the hot spring flora.

## Brackish Water Diatoms in Hot Springs.

Brues (1924, 1928) found that there is a great similarity between the fauna of brackish water and that of hot springs in America. Sprenger (1930) found in accordance herewith that in the hot springs around Karlsbad there are numerous halophilous and mesohalobous species among the Diatoms;

however, halophobous forms also occur, though very sporadically, and finally a great number of indifferent species. Adopting a method of estimation in which the species are given points from 1—6 according to their frequency, he sets up a spectrum for these springs which has the following appearance:

| | Number of forms | % |
|---|---|---|
| Halophobous ......... .. | 3 | 4.41 |
| Indifferent ............. | 50 | 73.53 |
| Halophilous ........... | 9 | 13.24 |
| Mesohalobous.......... | 4 | 5.88 |
| ? ..................... | 2 | 2.94 |
| | 68 | 100.00 |

This spectrum is only with great reserve comparable with the spectra set up by me (Boye Petersen 1943); but as Sprenger (l. c.) finds 609—632 mg. Cl′/L in the Karlsbad springs, there is, as far as one can judge, no bad agreement with my spectrum from Flyndersø (Boye Petersen l. c. p. 31).

Schwabe (1936) (from determinations made by Krasske 1938) gives a list of brackish water Diatoms in the Icelandic hot springs and points out that the thermal and brackish water floras have certain features in common. He thinks the cause of this is (1) that the thermal water often has a larger electrolyte content than ordinary fresh water (though as a rule of quite a different composition to brackish water); (2) that in many cases both types of water show more or less marked fluctuations of biologically active factors (thermal water: temperature; brackish water: salt content). He is of opinion, therefore, that the biological affinity between thermal and brackish water must for the present be characterised by the fact that they must both be inhabited by species of a relatively wide ecological amplitude. Unfortunately we have no analyses of the water in the Icelandic hot springs examined by Schwabe.

At the outset Schwabe's considerations seemed to me doubtful as I could not easily conceive that the high temperature in the hot springs could be the cause of the presence of the Halobia. Further, it is not correct to say that the temperature fluctuates particularly in water of a thermal nature, on the contrary (Elenkin 1914 II, pp. 99 and 108), more correctly the water of hot springs is characterised by its constant temperature throughout the year, a temperature which need not be at all high, in contrast with that of other waters, whose temperature may fluctuate from less than 0° to 30° C.

The presence of the halophilous and mesohalobous forms is more probably due to the fact that the thermal water contains a comparatively large amount of chloride. As already stated, this is known to be the case at Karlsbad, whereas we have no information of the chloride content of the springs examined by Schwabe.

Schmidt (1885, pp. 18—19) gives analyses of the water of some hot springs in Kamtchatka, namely of springs near the village of Paratunka, near the river Bannaja, and near the town of Natchika. As will appear from the appended Table 1 after Schmidt, none of these springs contains chloride in any large amounts, as they have from 112.37—194.16 mg. Cl′/L, and it is not to be expected, therefore, that these springs should harbour halophilous and mesohalobous Diatoms to any great extent.

Table 1.

Analyses of the water in some hot springs after Schmidt 1885, pp. 18—19.

| | Paratunka | Bannaja | Natchika | Sea water |
|---|---|---|---|---|
| Mineral substances mg. pr. L. ...... | 1449.69 | 1310.49 | 942.83 | 32924.2 |
| Cl′, — ...... | 194.16 | 112.37 | 145.25 | 18218.7 |
| Na′, — ...... | 297.49 | 309.97 | 261.92 | 10128.7 |
| $SO_3''$, — ...... | 580.30 | 438.15 | 310.56 | 2148.1 |
| Fe‴, — ...... | 0.39 | 0.36 | 0.06 | 1.5 |
| Ca″, — ...... | 136.37 | 16.87 | 19.87 | 376.4 |
| $SiO_2''$, — ...... | 49.48 | 174.15 | 72.18 | 8.0 |

I have now set up Halobion spectra according to the same method that I have previously used (Boye Petersen 1943), both of the samples from these groups of springs and of those from the rest of the springs, and further, for comparison, from a couple of streams whose water is not of a thermal nature. In some few cases I have taken counts in more than 25 visual fields, namely in certain preparations in which there were not very many Diatoms. The frequency percentages for the individual forms are given under each form in the systematic part. If no percentage is given for a particular sample for which a spectrum has been made, it means that the species was so sparsely represented in the sample that it received no points in the count. In Table 2 the results have been condensed to spectra and in Table 3, finally, the average spectra for each of the groups of springs have been calculated.

## Notes on the individual Halobion Spectra.

(see Table 2)

Cold stream near camp 4. The water is not of thermal origin. The spectrum is an ordinary fresh water spectrum with predominantly indifferent forms (96.8 p. c.) and only a very small number of Halophobes. The dominant species is *Fragilaria construens* in various forms. This species is distributed in fresh water of all kinds.

1417. Akhomten Bay, fresh water rivulet.
The spectrum is peculiar by the fact that it contains 86.3 % of *Diatoma hiemale* which is generally regarded as halophobous. It is a northern-alpine species, common in cold springs, brooks and water holes.

1526. Could afflux to a hot spring near Paratunka (10° C.). The spectrum is remarkable for its abundance of forms (75), which are predominantly indifferent. Among the forms constituting the 23.5 % whose place in the Halobion system is uncertain are *Fragilaria bicapitata* (6.1 %) and *Melosira cataractarum* (14.4 %). These species are perhaps both halophobous. In addition there occurred small numbers of halophilous and some few mesohalobous species. It seems most like an ordinary fresh water spectrum.

## Hot Springs near Paratunka.

1507. 25° C. The spectrum shows 99.2 % of indifferent forms, predominantly *Cocconeis placentula* (57.5 %). The 0.8 %

Table 2.
Halobion spectra of the individual samples.

| No. | Locality | Temp. | Oligohalobous | | | Mesohalobous | ? | Number of forms | Individuals counted |
|---|---|---|---|---|---|---|---|---|---|
| | | | halophobous | indifferent | halophilous | | | | |
| — | Cold stream, camp 4....... | cold | 2.6 | 97.0 | 0.0 | 0.0 | 0.4 | 29 | 470 |
| 1417 | Akhomten Bay, fresh water stream.................... | cold | 86.3 | 13.7 | 0.0 | 0.0 | 0.0 | 5 | 182 |
| 1526 | Paratunka, cold afflux...... | cold | 2.0 | 71.0 | 3.1 | 0.4 | 23.5 | 75 | 444 |
| 1507 | — , hot spring...... | 25° | 0.0 | 99.2 | 0.0 | 0.0 | 0.8 | 20 | 120 |
| 1512 | — , — — ...... | 45° | 0.0 | 89.3 | 2.2 | 0.0 | 8.5 | 13 | 191 |
| 1513 | — , — — ...... | 37° | 0.0 | 97.8 | 0.0 | 0.0 | 2.2 | 17 | 457 |
| 1514 | — , — — ...... | 32° | 0.0 | 99.0 | 0.0 | 0.0 | 1.0 | 16 | 486 |
| 1516 | — , — — ...... | 25° | 0.8 | 85.3 | 0.8 | 0.0 | 13.1 | 18 | 130 |
| 1521 | — , — — ...... | 32° | 0.4 | 96.3 | 2.9 | 0.0 | 0.4 | 29 | 284 |
| U. N. | — , — — ...... | 25° | 0.0 | 99.6 | 0.0 | 0.0 | 0.4 | 15 | 233 |
| - - | — , — — ...... | 29° | 2.6 | 89.2 | 0.0 | 0.0 | 8.2 | 43 | 313 |
| - - | — , the bathing spring | 41° | 1.3 | 98.3 | 0.0 | 0.0 | 0.4 | 34 | 477 |
| 2527 | Savan river, hot spring..... | 52° | 19.8 | 79.2 | 0 0 | 0.0 | 1.0 | 36 | 196 |
| 2528 | — — , — — ..... | 50° | 66.6 | 24.0 | 0.0 | 0.0 | 9.4 | 40 | 148 |
| 2530 | — — , — — ..... | 73° | 54.6 | 37.5 | 0.0 | 0.0 | 7.9 | 15 | 64 |
| 2533 | — — , — — ..... | 63° | 22.1 | 41.1 | 0.0 | 0.0 | 36.8 | 35 | 89 |
| 3037 | Siku river, — — ..... | 42° | 6.3 | 69.4 | 0.0 | 0.0 | 24.3 | 19 | 128 |
| 3117 | Karymchina,— — ..... | 37° | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 3 | 223 |
| 3118 | — ,— — ..... | 14° | 1.2 | 98.3 | 0.0 | 0.0 | 0.5 | 20 | 581 |
| 3136 | "Malenki klutchik"......... | 70° | 9.9 | 85.4 | 3.0 | 0.0 | 1.7 | 20 | 532 |
| 3137 | — — ......... | 77° | 9.1 | 88.5 | 2.4 | 0.0 | 0.0 | 39 | 375 |
| 3138 | — — ......... | 66° | 10.3 | 80.7 | 1.3 | 0.0 | 7.7 | 37 | 154 |
| 3139 | — — ......... | 66° | 17.6 | 80.5 | 0.2 | 0.0 | 1.7 | 59 | 398 |
| 3140 | — — ......... | 29° | 16.2 | 80.4 | 2.9 | 0.0 | 0.5 | 46 | 203 |
| 3141 | — — ......... | 29° | 10.2 | 86.6 | 0.4 | 0.0 | 2.8 | 46 | 218 |
| 3142 | — — ......... | 29° | 36.1 | 63.9 | 0.0 | 0.0 | 0.0 | 18 | 158 |
| 3144 | — — ......... | 60° | 11.9 | 86.6 | 0.8 | 0.0 | 0.7 | 51 | 258 |
| 3180 | Bannaja, hot spring........ | 46° | 2.1 | 96.4 | 0.4 | 0.0 | 1.1 | 25 | 438 |
| 3184 | — , — — ........ | 46° | 2.3 | 97.2 | 0.5 | 0.0 | 0.0 | 46 | 400 |
| 3187 | — , — — ........ | 35° | 6.8 | 93.7 | 0.5 | 0.0 | 0.0 | 10 | 206 |
| 3232 | — , — — ........ | 46° | 7.4 | 73.7 | 4.2 | 2.1 | 12.6 | 45 | 95 |
| 3234 | Natchika, — — ........ | 27° | 0.0 | 97.9 | 0.0 | 0.7 | 1.4 | 15 | 156 |
| 3236 | — ,— — ........ | 38° | 1.6 | 98.4 | 0.0 | 0.0 | 0.0 | 12 | 61 |

Table 2 (continued).

| No. | Locality | Temp. | Oligohalobous | | | Mesohalobous | ? | Number of forms | Individuals counted |
|---|---|---|---|---|---|---|---|---|---|
| | | | halophobous | indifferent | halophilous | | | | |
| 3237 | Natchika, hot spring ....... | 40° | 8.9 | 72.3 | 18.8 | 0.0 | 0.0 | 52 | 90 |
| 3701 | Hot spring on Garaschie Gara | ? | 83.2 | 13.9 | 0.0 | 0.0 | 2.9 | 7 | 272 |
| 3702 | — — - — — | 12–13° | 7.8 | 3.2 | 0.0 | 0 0 | 89.0 | 8 | 64 |
| 3703 | — — - — — | 16° | 6.3 | 89.7 | 2.3 | 0.0 | 1.7 | 43 | 176 |
| 3716 | — — by the middle reach of the Paratunka river.... | 10° | 4.5 | 62.1 | 29.2 | 0.0 | 4.2 | 49 | 840 |
| 3719 | — — by the middle reach of the Paratunka river.... | 35° | 0.3 | 98.2 | 0.4 | 0.0 | 1.1 | 18 | 304 |
| 3720 | — — by the middle reach of the Paratunka river.... | 21° | 1.5 | 95.8 | 2.6 | 0.0 | 0.1 | 41 | 637 |
| 4328 | Unkanakchek, hot spring ... | ? | 3.8 | 96.2 | 0.0 | 0.0 | 0.0 | 27 | 53 |
| 4239 | — , — — ... | 12° | 10.0 | 71.8 | 5.5 | 2.7 | 10.0 | 29 | 110 |

of forms with an uncertain position consists of *Caloneis Hultenii*, which is possibly halophobous.

1512. 45° C. Here are 89.3 % of indifferent forms; the dominant being *Navicula minima* (48.2 %). The 2.2 % of halophilous species are constituted by *Rhopalodia gibberula*, which is often regarded as indifferent. The counting of this spectrum was difficult owing to the very small Navicula forms.

1513. 37° C. The spectrum shows 97.8 % of indifferent forms; the dominant is *Achnanthes exigua* (96.1 %).

1514. 32° C. The sample contained *Rhizoclonium*, and the Diatoms are essentially epiphytes on this. Here are 99 % of indifferent species, the most frequent being *Nitzschia amphibia* (76.7 %) and *Cocconeis placentula* (19.9 %).

1516. 25° C. The sample consisted of a *Nitella* sp. in the dried condition. Here were 85.3 % of indifferent forms, predominantly *Cocconeis placentula* (33.8 %) and *Fragilaria construens* forms (34.6 %).

1521. 32° C. Mostly indifferent forms (96.3 %); the dominants were small forms of *Fragilaria construens* (49.3 %); in addition the sample contained numerous specimens of *Achnanthes exigua* (28.3 %) and *Nitzschia amphibia* (10.9 %). The 2.9 % of halophilous species are *Navicula cryptocephala* v. *veneta* and *Rhopalodia gibberula*, which are both dubiously halophilous.

Unnumbered. 25° C. The sample contained *Rhizoclonium* and the Diatoms are in the main epiphytes from this and nearly all indifferent (99.6 %). The dominant form is *Nitzschia amphibia* (69.5 %).

Unnumbered. 29° C. The spectrum shows 89.2 % of indifferent forms and also 9 halophobous forms which, however, only represent 2.6 % in all.

Unnumbered. 41° C. The indifferent forms represent 98.3 % and of these *Achnanthes exigua* constitutes 87.6 %. In addition there are 1.3 % of halophobous species.

Hot Springs near the Savan River.

2527. 52° C. This sample contained *Spirogyra* sp. and *Cosmarium Meneghinii.* A striking feature is 19.8 % of halophobes (14 forms in all), among which must especially be noted *Eunotia exigua* (8.2 %) and *Pinnularia subcapitata* var. *Hilseana* (6.1 %), which both belong to high moors (sphagnophilous). The indifferent species constitute 79.2 %.

2528. 50° C. This sample contains still more halophobes than the preceding one (66.6 %) while the indifferent species only constitute 24.0 %. Among the halophobous species *Eunotia exigua* dominates (58.8 %). This spectrum comes very near to that of a spring moor (Vældmose) (Boye Petersen 1943, p. 45).

2530. 73° C. The sample only contained 15 species with but a small number of individuals. But it must be noted that of 6 species specimens with endochrome were seen. 6 of the species must be regarded as halophobous, and they constitute 54.6 % of all the individuals. Of indifferent species there were 37.5 %.

2533. 63° C. In this spectrum too there is a large element of halophobous forms (22.1 %), while the indifferent forms constitute 41.1 %; the sample did not contain many specimens, and forms whose place in the Halobion system is unknown constituted 36.8 %, which gives rise to some uncertainty. Among these forms may be mentioned *Pinnularia divergentissima* (11.2 %), *Melosira cataractarum* (6.7 %) and *Fragilaria* sp. (16.7 %).

Hot Spring near the Siku River.

3037. 42° C. The spectrum shows a considerable contingent of halophobous forms (6.3 %) while, however, the indifferent species are dominant (69.4 %). *Achnanthes exigua* is the most frequent species (28.9 %). Some valve fragments of *Melosira granulata* are not included. The 24.3 % of uncertain position are mostly made up of a *Navicula* sp. (16.4 %).

Hot Spring near Karymchina.

3117. 37° C. The sample only contained 3 species of which *Nitzschia amphibia* was markedly dominant (99.1 %).

3118. 14° C. The Diatoms are in the main epiphytic upon *Rhizoclonium*. The forms are predominantly indifferent (98.3 %), *Amphora veneta* being the most frequent (93.5 %).

Hot Spring "Malenki klutchik" near Bannaja.

3136. 70° C. The spectrum shows predominantly indifferent forms (85.4 %), but in addition not a small number of halophobous species are present (9.9 %), especially *Diatoma hiemale* (9.6 %). The 3.0 % of halophilous forms are exclusively constituted by *Navicula viridula* var. *rostellata*, which is only with some doubt referred to this category. It should be noted that 7 of the 20 species found here were observed to contain endochrome.

3137. 77° C. The spectrum is highly reminiscent of the preceding one. It contains 9.1 % of halophobes, of which *Diatoma hiemale* constitutes 5.6 %. Of the indifferent 88.5 % the commonest are *Fragilaria construens* var. *venter* (46.8 %), and *Fragilaria Vaucheriae* (15.5 %). Of the 38 forms 7 were found to contain endochrome.

3138. 66° C. A somewhat higher percentage of halophobes than in the two preceding samples (10.3 %) predominantly represented by *Diatoma hiemale* (9.7 %), which was found to contain endochrome. The dubiously halophilous *Navicula viridula* var. *rostellata* constituted the halophilous 1.3 %. The rest (80.7 %) were indifferent, *Fragilaria construens* forms being the most frequent (31.8 %).

3139. 66° C. The spectrum shows 17.6 % of halophobous forms of which *Diatoma hiemale* (7.8 %) and *Meridion circulare* (5.3 %) are the most important; both were found with cell contents. Among the indifferent species (80.5 %) the most numerous are *Fragilaria construens* var. *venter* (27.4 %) and *Fragilaria pinnata* (10.8 %).

3140. 29° C. Bottom mud. The spectrum shows 16.2 % of halophobous forms, *Diatoma hiemale* being the most frequent (10.8 %). Among the indifferent (80.4 %) *Fragilaria construens* var. *venter* is the most abundant (39.9 %). In this sample only *Melosira varians* was found with cell contents.

3141. 29° C. "Plankton"; *Rhizoclonium* with epiphytes. Of the 45 forms 9 were found with cell contents. Of the 10.2 % of halophobous forms *Diatoma hiemale* constituted 6.0 %. Among the indifferent ones the most important were *Nitzschia amphibia* (29.8 %) and small forms of *Fragilaria construens* (22.5 %).

3142. 29° C. *Rhizoclonium* with epiphytes. The floristic composition of the Diatom flora differs somewhat from that of the preceding samples. There are 36.1 % of halophobes, chiefly represented by *Eunotia pectinalis* (35.5 %), while the most numerous among the indifferent forms are *Nitzschia amphibia* (25.9 %) and *Amphora veneta* (18.4 %).

3144. 60° C. Of the 51 forms 7 were found to contain endochrome. Among the halophobous species (11.9 %) the most numerous were *Diatoma hiemale* (5.8 %) and *Meridion circulare* (2.3 %). Among the indifferent *Fragilaria construens* var. *venter* was dominant (50.8 %).

Hot Springs near the Bannaja River.

3180. 46° C. Bottom mud. The spectrum shows quite predominantly indifferent forms (96.4 %), among which *Achnanthes exigua* (39,0 %), *Fragilaria construens* var. *venter* (15.2 %), and *Nitzschia amphibia* (13.5 %) are the commonest.

3187. 35° C. Predominantly indifferent forms (92.7 %), *Achnanthes exigua* being dominant (68.9 %). *Eunotia monodon* alone constitutes the 6.8 % of halophobes.

3232. 46° C. In this sample I have not seen Diatoms with cell contents. It was fairly rich in forms (45) which were predominantly indifferent (73.7 %). However, there were not a few halophobes (7.4 %), the most frequent being *Amphora Normanii* (6.3 %). Of halophilous forms 4.2 % were noted, distributed over several species. *Diploneis pseudovalis*, which is supposed to be mesohalobous, was represented by 2.1 %. A large number of fragments of valves were present in the preparation so that the counting was rather difficult and cannot be regarded as very exact.

### Hot Springs near Natchika.

3234. 27° C. The spectrum shows a predominance of indifferent forms (97.9 %) among which *Anomoeoneis exilis* is the dominant (83.9 %). *Diploneis pseudovalis* constitutes the 0.7 % of mesohalobous forms.

3236. 38° C. Predominantly indifferent forms (98.4 %), the dominant being *Anomoeoneis exilis* (82.0 %). *Amphora Normanii* constitutes the 1.6 % of halophobes.

3237. 40° C. The sample was considerably richer in species than the preceding ones and is especially remarkable by the fact that the spectrum exhibits 18.8 % of halophilous forms; these, however, consist in the main of *Rhopalodia gibberula* var. *producta* (14.4 %), which is a doubtful halophilous species. The 8.9 % of halophobes comprise amongst others *Amphora Normanii* (5.6 %).

### Hot Springs near the Upper Course of the Paratunka River on the Northern Slope of the Mountain "Garaschie Gara".

3701. Temperature ? The spectrum is especially remarkable by the marked dominance of halophobous forms (83.2 %), especially 2 species: *Frustulia vitrea* (45.6 %) and *Navicula fossalis* (34.6 %). On the whole the sample is poor in species (7 forms).

3702. 12--13° C. The spectrum shows very little, forms with an uncertain place in the Halobion system constituting 89.0 °/₀ in all. This is especially due to *Caloneis Hulténii* (82.8 °/₀), but there is much to indicate that this species is in reality halophobous. If it is included among the halophobous forms, the spectrum will resemble the preceding one. The presence in the sample of *Cylindrocystis Brebissonii* and *Cosmarium* sp. would seem to point in the same direction.

3703. 16° C. The spectrum exhibits a predominance of indifferent forms (89.7 °/₀) the most frequent being *Achnanthes lanceolata* (17.6 °/₀), *Melosira varians* (11.9 °/₀), and *Fragilaria Vaucheriae* (11.4 °/₀). The most frequent of the halophobes (6.3 °/₀) is *Diatoma hiemale* (2.9 °/₀).

Hot Spring near the Middle Course of the Paratunka River.

3716. 10° C. The spectrum is remarkable in that it shows 29.2 °/₀ of halophilous forms. This is due to a vigorous development of *Diatoma elongatum*. This apart, the spectrum is an ordinary fresh water spectrum with a predominance of indifferent forms (62.1 °/₀), *Fragilaria construens* var. *venter* being particularly frequent (50.9 °/₀).

3719. 35° C. The Diatoms are in the main epiphytes on *Chara Braunii*. Indifferent forms are by far the most predominant (98.2 °/₀), the most abundantly represented being *Nitzschia amphibia* (47.0 °/₀) and *Cocconeis placentula* (26.0 °/₀). The spectrum is a pure fresh water spectrum.

3720. 21° C. The spectrum is quite like the preceding one with 95.8 °/₀ of indifferent forms; but here *Fragilaria construens* var. *venter* is the dominant (77.2 °/₀).

Hot Spring near Unkanakchek.

4328. Temperature? Bottom mud. In this sample no Diatoms with cell contents were seen, and many fragments of valves were present. The spectrum shows a predominance of indifferent forms (96.2 °/₀), the most frequent species being *Achnanthes exigua* (35.9 °/₀), and a small percentage of halophobes (3.8 °/₀).

4329. 12° C. The spectrum exhibits a predominance of indifferent forms, the most numerous being *Fragilaria Vaucheriae* (22.7 $^0/_0$) and *Cymbella ventricosa* (18.2 $^0/_0$), but in addition there are 10 $^0/_0$ of halophobes, viz. *Ceratoneis arcus* (6.4 $^0/_0$), and *Diatoma hiemale* (3.6 $^0/_0$). On the other hand, the halophilous *Navicula gregaria* (1.8 $^0/_0$) and the mesohalobous *Navicula salinarum* (2.7 $^0/_0$) are also present.

## Comprehensive Remarks on the Halobion Spectra.

Of the Halobion spectra here set up there are only two in which we see a distinct manifestation of halophilous forms, namely 3716 from the hot spring near the middle course of the Paratunka river and 3237 from the hot spring near Natchika. In all the others the percentage of halophilous forms is very small and is as a rule due to species which can only with doubt be regarded as halophilous. In many of the spectra, on the other hand, a very distinct element of halophobous forms is observable; altogether the spectra show that we can hardly be concerned with any brackish water flora in the Kamtchatka springs investigated.

In most cases the spectra from the same spring and group of springs exhibit a fairly close mutual agreement and I have therefore tried to gain a better idea of the conditions for each spring or group of springs by calculating the average of all the spectra from them. The result appears in Table 3, where I have arranged the springs according to increasing salt content and added the amount of chloride found by Schmidt in some of them. It must then be supposed that the water of the springs near the Savan river and on Garaschie Gara is very poor in minerals and especially in chloride, and it agrees with this that I have in fact found Desmidiaceae in these springs. The springs at Bannaja and Natchika must be assumed to contain almost normal fresh water; according to Schmidt's analyses the amount of chloride in these springs is only slightly over 100 mg. Cl′/L, which according to my investigations in Denmark (1943) should be the border value for the amount of chloride usually manifested in the Diatom flora. Only in the springs by the middle course of the Paratunka there seems to be so much chloride in the water that it appears in the spectrum.

Table 3.
Average spectra for the groups of springs examined.

| | Oligohalobous | | | Mesohalobous | ? | Chloride-content of the water after SCHMIDT (1885), mg. Cl.'/L. |
|---|---|---|---|---|---|---|
| | halophobous | indifferent | halophilous | | | |
| Springs near the Savan-river | 40.8 | 45.4 | 0.0 | 0.0 | 13.8 | — |
| — on Garaschie Gara.. | 32.4 | 35.6 | 0.8 | 0.0 | 31.2 | — |
| "Malenki klutchik"......... | 15.1 | 81.6 | 1.4 | 0.0 | 1.9 | — |
| Springs near the Siku-river.. | 6.3 | 69.3 | 0.0 | 0.0 | 24.3 | 120.64 |
| — — Unkanakchek.. | 6.9 | 84.0 | 2.7 | 1.4 | 5.0 | — |
| — — Bannaja....... | 4.7 | 90.0 | 1.4 | 0.5 | 3.4 | 112.4 |
| — — Natchika...... | 3.5 | 89.6 | 6.3 | 0.2 | 0.4 | 145.25 |
| — — Karymchina... | 0.6 | 99.1 | 0.0 | 0.0 | 0.3 | — |
| — — Paratunka village..................... | 0.6 | 94.9 | 0.6 | 0.0 | 3.9 | 194.16 |
| Springs near the middle course of the Paratunka river .................... | 2.1 | 85.4 | 10.7 | 0.0 | 1.8 | — |

To arrive at an expression of the total content of brackish water Diatoms in the Kamtchatka springs the average spectra may be calculated for all the samples examined. If we first count how many forms have been found of each of the categories of the Halobion system we arrive at the following result:

| | | total of forms | % of the total amount |
|---|---|---|---|
| Oligohalobous | halophobous..... | 45 | 20.3 |
| | indifferent....... | 117 | 53.0 |
| | halophilous ..... | 14 | 6.3 |
| Mesohalobous..................... | | 5 | 2.3 |
| ? ................................ | | 40 | 18.1 |
| | | 221 | 100.0 |

Already here it will be seen that the halophobous and indifferent forms are predominant, while the halophilous and the mesohalobous are less frequently represented. If, however, we also consider the frequency of the individual forms and set up a spectrum giving the average of those shown in Table 3 we shall arrive at a kind of normal spectrum for the Kamtchatka springs as a whole. This spectrum is as follows:

| | | % of individuals |
|---|---|---|
| Oligohalobous | halophobous | 11.3 |
| | indifferent | 77.5 |
| | halophilous | 2.4 |
| Mesohalobous | | 0.2 |
| ? | | 8.6 |
| | | 100.0 |

As will appear from this, the spectrum must be regarded as a fresh water spectrum, which, if anything, has an unusually large amount of halophobous forms, while the halophilous and mesohalobous are very poorly represented.

I think it possible therefore to draw the following conclusions:

1. The hot springs investigated in Kamtchatka all contain water with a small chloride content.
2. The finding of many halophilous and mesohalobous forms in certain hot springs in other parts of the world is due to the fact that the water contains larger amounts of chloride and is not, as assumed by SCHWABE, caused by the temperature conditions.
3. By means of the Halobion spectra it is possible to arrange the springs according to increasing Cl′ content.
4. The groups of springs, as to the chemistry of which data are available, are distributed in the series in accordance with the Cl′ content.

## Algae and the Temperature of Hot Springs.

### The highest Temperature Limit in General.

From the old days it has been matter for surprise that living organisms, more especially algae, will grow in very hot water in hot springs at temperatures which are absolutely fatal to most organisms. (The literature dealing with this subject is quoted by EMOTO (1933)). There is no doubt, however, that the earlier authors have not been critical enough but simply presumed that the algae grew at the temperature stated by the collector for the water of the spring. This has been pointed out several times. Later on a great number of investigations have been published, which attempt to establish the upper temperature limits for the growth of algae. I may mention Bohlin (1901), who was one of the first to advance a serious criticism of the available statements of temperatures at which algae would thrive. On the Azores he found Chlorophyceae up to a maximum of 40° C. and blue-green algae up to at most 53.5° C. Setchell (1903) also assumes a very critical attitude and on the basis of investigations in the Yellowstone district he lays down a number of more general rules. As genuine thermal water he regards water with a temperature of over 43—45° C., and he finds that there are no animals in such water, nor any living Diatoms. Only Schizophyceae, that is to say blue green algae and Bacteria thrive there. Blue green algae are found at temperatures of up to 65—68° C. and in some cases, but sparsely, up to 75—77° C. Bacteria are abundantly developed at 70—71° C. and may still be found at 82—89° C. This latter temperature is the highest at which he has found any living organism. Further, he arrives at the very interesting result that the chemical composition of the water is of significance for the maximum temperature tolerated by the organisms. The limit of life in waters containing silica is between 75° and 77° for coloured, 89° for colourless Schizophyta, while the limit in calciferous waters is 60°—63° C. for coloured, 70°—71° for colourless Schizophyta. The reaction of the water is likewise of significance for the organisms. Amongst other things he has not found living beings in any springs with a highly acid reaction.

Elenkin's investigations (1914 I) of hot springs will be discussed presently. He finds a maximum temperature of 75.7° C. for Cyanophyceae.

Molisch too (1926), who has examined a very large number of springs in Japan, criticises the earlier statements and comes to the conclusion that blue green algae (especially *Mastigocladus laminosus* and *Phormidium laminosum*) will thrive at a temperature of up to 69° C. and bacteria at up to 77.5°. Incidentally, it is to be regretted that his large material has not been more systematically worked up; the available determinations have a temporary character, nor have any chemical analyses been made of the water in the hot springs examined.

Famin (1931) has examined several groups of springs in France and amongst other things attempted to establish a maximal temperature for the living organisms. He arrives at the result that no higher plants tolerate higher temperatures than 30° C.; few green algae thrive at over 30° C.; *Cosmarium Meneghinii*, however, at up to 37° C. He has not found living organisms at over 65° C. The book does not say what organisms he found at these temperatures.

Schwabe (1936) has devoted much care to establishing the upper temperature limits for a series of species in Icelandic hot springs. He arrives at the result that growths of Bacteria may thrive at 87.5° C., while blue green algae at most reach 60.2° C. Concerning his results for the individual species see Table 4. Finally Vouk (1937) has tried to collect what has so far appeared of temperature indications and his final result is that the maximum at which algae are able to grow is 69—72° C., while bacteria can exist at somewhat higher temperatures (77.5° C.).

For the hot springs of the Yellowstone district Copeland (1936) has given the highest temperatures at which algae occur; his final results are as follows:

| | |
|---|---|
| Myxophyceae | 85.2° C. |
| Chroococcales | 84.0° - |
| Chamaesiphonales | 80.0° - |
| Oscillatoriales | 85.5° - |
| Bacteria | 89.0° - |
| Chrysophyceae | 40.2° - |
| Cryptophyceae | 39.9° - |
| Bacillarieae | 50.7° - |
| Heterokontae | 32.5° - |
| Chlorophyceae | 50.5° - |
| Isokontae | 48.5° - |
| Conjugatae | 50.5° - |
| Phycomycetes | 37.2° - |
| Charophyceae | 37.1° - |

Thus there is still a rather considerable difference between the maximal temperatures stated by the various authors. They all agree, however, that the Chlorophyceae and Diatoms tolerate much less heat than Cyanophyceae and bacteria. According to the various authors the upper limit for the first two groups lies between 40° (BOHLIN) and 60° (ELENKIN). For the last two groups the differences are still greater; for the Cyanophyceae they vary between 60.2° (SCHWABE) and 85.2° (COPELAND). The observations were made on different springs, probably with water of a rather different composition, and this will perhaps explain the divergencies.

The Temperature Limits for the Algae of Kamtchatka.

As regards the temperature indications accompanying the samples in HULTÉN's collection it should be noted that according to the statements of the collector the temperatures were taken at the sources of the springs so as to establish the temperature at the place where the hot water comes up to the light of day. Often the algae did not grow there, especially in the case of very hot springs, but in the basin into which the springs usually debouch, and where the temperature will be lower. As already mentioned, there can be no doubt that, if we want to gain accurate information as to the temperature at which a growth of algae has developed, very special precautions must be taken, which it is difficult to do on a troublesome expedition. This kind of investigations must therefore especially be carried out by investigators who are able to stay for some length of time near the hot springs.

The temperatures stated in this publication are therefore given with all reserve.

## *Cyanophyceae.*

In order to compare the temperatures given here with those found in the literature I have entered in Table 4 the Cyanophyceae found in Kamtchatka with the temperatures indicated and, for comparison, the maximal temperatures stated by some other investigators. It will be seen that apart from the very high temperatures ranging around 60°—77°, HULTÉN's values agree very well with what has been found by the other authors, with

Table 4.

| | Kamtchatka Boye Petersen | Kamtchatka Elenkin 1914 I | Schwabe 1936 Iceland | Boye Petersen 1923 Iceland | Molisch 1926 |
|---|---|---|---|---|---|
| Mastigocladus laminosus | 77° | 55–60° | 60.2° | 55° | 65° |
| Phormidium laminosum | 73° | 75.7° | 58° | 42° | 65° |
| Oscillatoria terebriformis | 70° | .. | .. | .. | 35° |
| Phormidium tenue | 70° | 60° | .. | 50° | 46° |
| Aphanocapsa thermalis | 67° | 53° | .. | .. | .. |
| Oscillatoria amoena | 60° | .. | .. | .. | .. |
| Phormidium Valderiæ | 46° | 31.5° | 48° | .. | .. |
| — Valderiæ v. tenuis | 46° | .. | .. | .. | .. |
| — purpurascens | 46° | .. | .. | .. | .. |
| Oscillatoria tenuis v. tergestina | 44° | 24° | 44.0° | .. | 44° |
| — proboscidea v. Westii | 44° | .. | 41.5° | 40° | 45° |
| — anguina | 44° | .. | .. | .. | .. |
| — angusta | 40° | .. | .. | .. | .. |
| Dichothrix Orsiniana | 38° | .. | .. | .. | .. |
| Chroococcus membraninus | 38° | .. | .. | .. | .. |
| Phormidium Treleasei | 37° | .. | .. | 40° | .. |
| Oscillatoria Okenii | 37° | .. | .. | .. | .. |
| Chamæsiphon cylindricus | 35° | .. | .. | .. | .. |
| — incrustans | 35° | 35–40° | .. | .. | .. |
| Chroococcus minutus | 35° | .. | .. | .. | 42° |
| Lyngbya Kützingii | 35° | ? | .. | .. | .. |
| Xenococcus chroococcoides | 32° | .. | .. | .. | .. |
| Oscillatoria splendida | 32° | .. | .. | .. | 36.5° |
| Merismopedia glauca | 32° | ? | .. | .. | .. |
| Pleurocapsa minor | 29° | .. | .. | .. | .. |
| Merismopedia punctata | 29° | .. | .. | .. | .. |
| Nostoc Riabuschinskii | 27° | 28–32° | .. | .. | .. |
| Gomphosphæria aponina | 27° | .. | .. | .. | .. |
| Dichothrix gypsophila | 27° | ? | .. | .. | .. |
| Chroococcus turgidus | 27° | 30° | .. | .. | .. |
| Calothrix parietina | 27° | .. | .. | 30° | .. |
| Symploca thermalis | 12–13° | 75.7° | .. | 33° | 45° |

the exception of Elenkin's indication of 75.7° for *Phormidium laminosum* and especially for *Symploca thermalis*. These figures must be considered extremely doubtful (Vouk 1937, p. 60).

## *Chlorophyceae.*

All authors are agreed that Chlorophyceae will not grow at nearly as high temperatures as blue green algae and bacteria. Thus the following authors have given the temperatures stated below:

| | |
|---|---|
| Bohlin (1901) .......... | 40° C. |
| Elenkin (1914) ........ | 60° C. |
| Molisch (1926) ........ | 40° C. |
| Vouk (1937) ........... | 59° C. |
| Copeland (1936) ....... | 50.5° C. |

Altogether the authors are fairly well agreed that the limit for the growth of the Chlorophyceae lies at about 50° C. This indeed accords in the main with the statements from Kamtchatka, as will be seen from Table 5. Essentially above this limit we only encounter *Scenedesmus rostrato-spinosus*, which was found

Table 5.

| | Kamtchatka Boye Petersen | Kamtchatka Elenkin 1914 |
|---|---|---|
| Scenedesmus rostrato-spinosus ........ | 63° | .. |
| Cosmarium Meneghinii ............... | 52° | — |
| Spirogyra sp. ....................... | 52° | .. |
| Scenedesmus denticulatus ............. | 50° | .. |
| Vaucheria hamata .................... | 45° | .. |
| Rhizoclonium hieroglyphicum........ .... | 32° | 45° |
| Scenedesmus quadricauda ............ | 29° | 53° |
| Chara Braunii ....................... | 35° | .. |
| Nitella sp. ........................... | 25° | .. |
| Mougeotia sp. ....................... | 21° | .. |
| Cylindrocystis Brebissonii............ | 12–13° | .. |
| Enteromorpha intestinalis ............. | 12° | .. |
| Ulothrix sp. .......................... | 10° | .. |

in few specimens among *Phormidium laminosum* at 63° C. It must be regarded as improbable that it has lived at this high temperature. The information in various authors as to the species found is as a rule very imperfect. Their interest has centred entirely round the Cyanophyceae. Hence in Table 5 I have refrained from giving material for comparison from other authors.

## *Diatomaceae.*

It applies to the Diatoms even more than to the other groups that the statements concerning their occurrence in hot springs in the earlier literature are as a rule not very valuable, because the earlier investigators took it for granted that, when they found Diatom valves in the samples, Diatoms had lived in the springs from which the samples were derived and at the temperature indicated. That this need by no means be the case has been pointed out by several authors (MOLISCH 1926, KOLBE 1932, SCHWABE 1936, HUSTEDT 1938). On the contrary, it is necessary to convince oneself that the Diatoms really were alive in the locality, and it is best to do so by a microscopical examination on the spot. This has indeed been done by SCHWABE (1936, p. 306) in Icelandic hot springs, and he comes to the conclusion that numerous Diatoms certainly tolerate 40° C. while he thinks that they will probably withstand higher temperatures. HUSTEDT also (1938, p. 125) made accurate investigations on Diatoms in the hot springs of Java, Bali, and Sumatra. He states that the collector (RUTTNER) convinced himself on the spot that there were living Diatoms in the samples. On the basis of these samples HUSTEDT then arrives at the conclusion that Diatoms in these countries can only live at a maximum temperature of 45°. At temperatures between 40° and 45° RUTTNER only found dead cells. COPELAND (1936) states from the Yellowstone district that 50.7° is the maximal temperature at which he has found living Diatoms.

In all the samples from hot springs in Kamtchatka from which I have made counts for the purpose of drawing up Halobion spectra, which will be seen in Table 2, I have found a greater or less number of cells with contents. Occasionally nearly all the Diatoms had a distinct cell content, in other cases only a few cells showed such. The same will prove to be the case upon examination of ordinary cold water samples. If for instance you examine scrapings from stones or plant stems on the bank of a lake or a stream, most of the Diatoms will have cell contents; if, on the other hand, you examine a mud sample from the bottom, most of the Diatoms will only occur as empty valves; usually, however, no one will doubt that these species have grown in the lake or stream concerned and must be included in their flora even if most of them have not grown on the bottom. The same applies to the hot springs; any large amount of valves of Diatoms will be considered to belong to the locality of the spring; but it is not certain that they occur in the place in the spring where they have lived, and thus amongst other things it is not certain that they have lived at the temperature stated for the locality. Investigations on the spot must then decide how the presence of the Diatoms should be interpreted.

The examination of the samples from Kamtchatka was carried out as follows. For each sample I first examined a styrax preparation and determined the forms of Diatoms occurring in it. While these were still present I examined a preparation in water of the untreated material, and I could then, except in the case of doubtful forms, identify the species present and see whether or not they had cell contents. The results may be seen under the individual species in the systematic part.

For most of the samples examined the temperature is noted as being below that stated by the above-mentioned investigators as the maximal temperature for Diatoms. But from two of the springs, viz. that near the Savan river and "Malenki klutchik" there are samples for which much higher temperatures are stated, and nevertheless I have found Diatoms with cell contents in them, in some of them even a great many. According to other available particulars of the occurrence of Diatoms in hot springs it must be concluded, in agreement with what was said on p. 24, that the algae in these samples have not grown at the temperature stated, though within the locality of the spring, and at a lower temperature.

## Is there a Special Community of Thermal Diatoms?

That numerous Diatoms are met with in hot springs has been known from the old days. As far as the earlier literature is concerned it will suffice to refer to the reports in Emoto (1933). This earlier literature in the main comprises dry lists of species without more detailed information of an ecological kind (e. g. Quint 1905, 06, Lacsny 1912), but one fact may already be gathered from it, viz. that no species occur in hot springs which may not also be found in cold water, and to this day no form is known which is only found in hot springs, with the exception perhaps of some recently described species at present only recorded from a single locality. It may therefore be established that forms entirely limited to hot springs do not exist.

It is another question whether the hot springs, for instance in Kamtchatka or Iceland, countries with a cold climate, may perhaps be the resorts of thermophilous species which could not otherwise grow in these countries. Elenkin has tried to solve this problem (1914 I) for Kamtchatka and Schwabe (1936) for Iceland.

Elenkin (l. c. p. 588) attempts to clear up the question in the following way. Of euthermophilous species (i. e. species found at 30°—80°) he has found 17; of these only 7 have not also been found among the mesothermophilous (i. e. species found at 15°—30°). Among these 7, 4 species have not been encountered in cold water in Kamtchatka, but 3 of these are common cold water species. Only *Nitzschia thermalis*, Elenkin thinks, is a genuine thermophilous species. The grounds he gives for this do not, however, seem very good, when we are told that he has found it in small number, and only empty valves, at 60° C. I have myself found this species in 20 % of the samples from Kamtchatka and here it was fairly frequent, constituting on the average 6.2 % of the Diatoms present, while I too have not seen it in any of the few samples from cold water I have had for examination. Any collective view of the occurrence of this species will hardly be found in the literature; but much would seem to indicate that it is widespread in fresh water and consequently not especially characteristic of hot springs.

Schwabe (1936) has tried something similar for Iceland. On p. 286 he gives a list of Diatoms which have only been found in hot springs in Iceland. He mentions 9 species; but he has overlooked the fact that 4 of these have been found in the island by Boye Petersen (1928) in aerial localities, and 2 of them by Østrup (1916) at the coasts of Iceland, while 2 have been found by Krasske (1938) in cold water in the island. There only remains *Nitzschia filiformis*, which in Europe is

Table 6.

| Østrup 1918 Iceland | Constancy (⁰/₀ of samples) | Hustedt 1938 Java, Bali, Sumatra | Constancy (⁰/₀ of samples) |
|---|---|---|---|
| Diploneis elliptica | 60 | Nitzschia amphibia | 72 |
| Nitzschia amphibia | 57 | Achnanthes exigua v. heterovalv. | 68 |
| Pinnularia borealis | 57 | Rhopalodia gibberula | 65 |
| Epithemia zebra | 50 | Diploneis subovalis | 55 |
| Rhopalodia gibberula | 43 | Navicula Ruttneri | 55 |
| Meridion circulare | 40 | Cymbella Mülleri v. javanica | 49 |
| Rhopalodia gibba | 37 | Amphora fontinalis | 45 |
| Synedra ulna | 37 | Synedra ulna | 40 |
| Caloneis silicula | 33 | Navicula Lagerheimii | 34 |
| Diatoma hiemale | 33 | Pinnularia interrupta | 34 |
| Frustulia vulgaris | 33 | Achnanthes lanceolata v. rostrata | 32 |
| Pinnularia viridis | 33 | Epithemia zebra v. saxonica | 32 |
| Tabellaria flocculosa | 33 | Navicula cryptocephala | 30 |
| Achnanthes lanceolata | 30 | Melosira Roeseana | 28 |
| Cymbella parva | 30 | Achnanthes inflata | 25 |
| Hantzschia amphioxys | 30 | Cymbella turgida | 25 |
| Rhoicosphenia curvata | 30 | Nitzschia palea | 25 |
| Rhopalodia ventricosa | 30 | Pinnularia leptosoma | 25 |
| Ceratoneis arcus | 27 | Eunotia Tschirchiana | 23 |
| Navicula radiosa | 27 | Navicula confervacea | 23 |
| Cocconeis placentula | 23 | Nitzschia microcephala | 23 |
| Diatomella Balfouriana | 23 | Caloneis bacillum | 21 |
| Navicula dicephala | 23 | Navicula brekkaensis | 21 |
| Synedra ulna v. danica | 23 | Cymbella pusilla | 19 |
| Amphora ovalis | 20 | Nitzschia vitrea | 19 |
| Pinn. viridis v. commutata | 20 | Achnanthes minutissima | |
| Rhopalodia gibba v. rupestris | 20 | v. cryptocephala | 17 |
| Caloneis silicula v. alpestris | 17 | Frustulia rhomboides v. saxonica | 17 |
| Cymbella ventricosa | 17 | Navicula pupula v. rostrata | 17 |
| Diploneis ovalis v. oblongella | 17 | Nitzschia debilis | 17 |
| Eunotia prærupta v. curta | 17 | Pinnularia leptosoma v. gracilis | 17 |
| Gomphonema parvulum | 17 | Achnanthes minutissima | 15 |
| Mastogloia elliptica v. Dansei | 17 | Caloneis bacillum v. fontinalis | 15 |
| Navicula pusilla | 17 | Cymbella sumatrensis | 15 |
| Neidium affine v. amphirhyncus | 17 | Navicula cryptocephaloides | 15 |
| Pinn. interrupta v. stauroneiformis | 17 | — Grimmei v. rostellata | 15 |
| — mesolepta v. stauroneiformis | 17 | — mediocris | 15 |
| Rhopalodia parallela | 17 | Achnanthes lanceolata | 13 |

| Krasske 1938 Iceland | Constancy (%of samples) | Frequency (estimated) | Kamtchatka | Constancy (% of samples) | Frequency (%) |
|---|---|---|---|---|---|
| Rhopalodia gibberula ..... | 94 | 4.9 | Gomphonema parvulum .. | 82 | 2.6 |
| Diploneis ovalis .......... | 91 | 3.6 | Nitzschia amphibia ....... | 79 | 16.2 |
| Pinnularia viridis ......... | 91 | 3.3 | Achnanthes exigua ........ | 72 | 19.2 |
| Achnanthes lanceolata .... | 88 | 3.4 | — lanceolata .... | 72 | 2.1 |
| Nitzschia amphibia ....... | 88 | 4.5 | Cymbella ventricosa ...... | 62 | 2.3 |
| Diploneis elliptica ........ | 85 | 3.0 | Fragilaria Vaucheriæ ..... | 59 | 5.3 |
| Gomphonema gracile ..... | 85 | 3.7 | Melosira varians .......... | 59 | 1.7 |
| Rhopalodia gibba ........ | 85 | 4.6 | Navicula minima ......... | 59 | 4.8 |
| Caloneis bacillum ........ | 82 | 2.5 | Fragilaria construens coll. | 59 | 23.3 |
| Navicula cryptocephala | | | Cocconeis placentula ..... | 54 | 7.2 |
| v. veneta ................ | 82 | 3.9 | Fragilaria pinnata ........ | 54 | 3.4 |
| Caloneis silicula v. alpina. | 79 | 2.8 | Rhopalodia gibberula ..... | 54 | 1.0 |
| Pinnularia borealis ....... | 79 | 2.5 | Diatoma hiemale ......... | 46 | 3.7 |
| — gracillima ..... | 77 | 2.8 | Fragilaria brevistriata .... | 46 | 1.3 |
| Fragilaria pinnata ........ | 74 | 4.0 | Meridion circulare ....... | 46 | 1.1 |
| Navicula contenta ........ | 74 | 2.6 | Caloneis bacillum ........ | 41 | 2.7 |
| Amphora Normannii ...... | 74 | 3.9 | Synedra ulna ............. | 41 | 0.7 |
| Epithemia zebra .......... | 74 | 4.0 | Amphora ovalis ........... | 38 | 0.1 |
| Synedra ulna ............. | 71 | 4.2 | Gomphonema angustatum | | |
| Diatomella Balfouriana ... | 71 | 3.4 | v. productum ........... | 38 | 1.4 |
| Frustulia vulgaris ........ | 71 | 2.6 | Achnanthes lanceolata | | |
| Navicula variostriata ..... | 71 | 3.7 | v. capitata .............. | 36 | 0.9 |
| Pinnularia leptosoma ..... | 71 | 2.3 | Navicula gregaria ......... | 36 | 0.6 |
| Amphora ovalis .......... | 71 | 2.3 | Amphora ovalis v. pedicul. | 33 | 1.3 |
| Nitzschia frustulum ....... | 71 | 3.4 | Ceratoneis arcus ......... | 33 | 0.7 |
| Eunotia prærupta ........ | 68 | 1.7 | Pinnularia borealis ....... | 33 | 0.1 |
| Achnanthes exigua heterov. | 68 | 4.4 | Amphora Normannii ...... | 31 | 1.3 |
| Pinnularia Lagerstedtii ... | 68 | 2.0 | Fragilaria leptostauron ... | 31 | 0.3 |
| Nitzschia linearis ......... | 68 | 3.7 | Frag. Vaucheriæ v. kamtch. | 31 | 2.2 |
| Fragilaria virescens | | | Caloneis Hultenii ......... | 28 | 8.1 |
| v. subsalsa ............... | 65 | 3.5 | Fragilaria capitellata ..... | 28 | 5.9 |
| Fragilaria brevistriata .... | 65 | 4.5 | Melosira italica ........... | 28 | 1.5 |
| Navicula mutica .......... | 65 | 1.9 | Nitzschia Clausii ......... | 28 | 2.5 |
| Pinnularia fasciata ........ | 65 | 3.3 | Rhoicosphenia curvata .... | 28 | 1.0 |
| Navicula perpusilla ....... | 62 | 2.2 | Eunotia lunaris .......... | 26 | 1.0 |
| Pinnularia stomatophora .. | 62 | 2.7 | Navicula rotaeana ........ | 26 | 0.4 |
| Hantzschia amphioxys .... | 62 | 2.3 | — viridula v. rostell. | 26 | 0.8 |
| Cocconeis placentula ..... | 59 | 2.9 | Nitzschia dissipata ........ | 26 | 0.8 |

(to continue)

Table 6

| Østrup 1918 Iceland | Constancy (°/o of Samples) | Hustedt 1938 Java, Bali, Sumatra | Constancy (°/o of Samples) |
|---|---|---|---|
| Surirella ovata | 17 | Amphora ovalis | 13 |
| Epithemia argus | 13 | Eunotia exigua | 13 |
| — zebra v. proboscidea | 13 | Melosira Ruttneri | 13 |
| Gomphonema gracile v. aurit. | 13 | Surirella tenera v. nervosa | 13 |
| — subclavatum | 13 | Achnanthes exigua v. elliptica | 11 |
| Melosira varians | 13 | Anomoeoneis sphærophora | 11 |
| Navicula nivalis | 13 | Cymbella cymbiformis | 11 |
| Nitzschia denticula | 13 | Eunotia similis | 11 |
| — sinuata | 13 | Fragilaria construens | 11 |
| Pinnularia lata | 13 | — pinnata | 11 |
| — major | 13 | Hantzschia amphioxys | 11 |
| | | Hydrosera triquetra | 11 |
| | | Navicula mutica f. Cohnii | 11 |
| | | — pupula | 11 |
| | | — Schroeteri | 11 |
| | | Pinnularia acrosphæria | 11 |
| | | — appendiculata | 11 |
| | | — borealis | 11 |
| | | — subcapitata v. Hilseana | 11 |

(continued)

| Krasske 1938 Iceland | Constancy (% of Samples) | Frequency (estimated) | Kamtchatka | Constancy (% of Samples) | Frequency % |
|---|---|---|---|---|---|
| Navicula fragilarioides | 59 | 2.0 | Cymbella sinuata | 23 | 0.1 |
| Nitzschia debilis | 59 | 2.0 | Diatoma anceps | 23 | 0.1 |
| Navicula tenelloides | 56 | 3.3 | Eunotia pectinalis v. minor. | 23 | 2.0 |
| — radiosa | 56 | 2.5 | Pinnularia viridis | 23 | 0.9 |
| — pusilla | 56 | 2.2 | Achnanthes minutissima | 20 | 2.3 |
| Cymbella ventricosa | 56 | 2.4 | Frustulia rhomboides | | |
| Gomphonema angustatum | 56 | 2.7 | v. saxonica | 20 | 3.3 |
| Pinnularia major | 53 | 1.9 | Melosira cataractarum | 20 | 3.8 |
| Gomphonema longiceps | | | Nitzschia thermalis | | |
| v. subclavatum | 53 | 2.7 | v. minor | 20 | 6.2 |
| Eunotia pectinalis | 50 | 1.7 | Surirella robusta | | |
| Navicula minima | 50 | 3.4 | v. splendida | 20 | 0.0 |
| — dicephala | 50 | 2.4 | Achnanthes lanceolata | | |
| Rhopalodia parallela | 50 | 3.5 | v. rostrata | 18 | 1.4 |
| Anomoeoneis exilis | 47 | 2.4 | Frustulia vitrea | 18 | 7.7 |
| Cymbella æqualis | 47 | 2.0 | Pinnularia gibba | 18 | 0.1 |
| Eunotia tenella | 44 | 2.0 | Synedra acus | 18 | 2.7 |
| Navicula minuscula | 44 | 2.2 | Cymbella cistula | 15 | 0.1 |
| — cocconeiformis | 44 | 1.7 | Diatoma hiemalis v. meso- | | |
| Epithemia argus | 44 | 4.3 | don. | 15 | 1.4 |
| Tabellaria flocculosa | 41 | 3.1 | Diploneis pseudovalis | 15 | 0.5 |
| Pinnularia subcapitata | 41 | 2.6 | Eunotia monodon | 15 | 1.7 |
| — obscura | 41 | 1.5 | Fragilaria capucina v. acuta | 15 | 0.7 |
| Synedra Vaucheriæ | 38 | 2.9 | Gomphonema acuminatum | 15 | 0.1 |
| Meridion circulare | 38 | 2.8 | Navicula cryptocephala | 15 | 1.2 |
| Eunotia lunaris | 38 | 1.9 | Nitzschia palea | 15 | 2.4 |
| Achnanthes minutissima | 38 | 2.6 | Anomoeoneis exilis | 13 | 37.2 |
| Pinnularia Balfouriana | 38 | 2.4 | Cymbella perpusilla | 13 | 0.1 |
| | | | Eunotia exigua | 13 | 16.6 |
| | | | — pectinalis | 13 | 7.4 |
| | | | Fragilaria construens | | |
| | | | v. binodis | 13 | 0.2 |

widespread in brackish water and probably rather common. It is not recorded that it in any way prefers waters with a high temperature.

It would seem then that for Iceland too it is not possible to establish that certain species are exclusively met with in hot springs.

Nevertheless it might be supposed that there existed a community of Diatoms which constantly occurred in the hot springs and proved to be characteristically different in composition from the Diatom community of cold waters. To ascertain this it would be necessary to have at hand investigations on the constancy and frequency of the individual species in the hot springs (cf. Kolbe 1932, p. 239). Of this we know very little; still, something may be gathered from the literature. The first who attempted to provide some information of the constancy of the individual Diatom species in the thermal community was Østrup (1918). In his work there are no indications of the temperature; but he has made out a list of all the forms (178 in all) which he has found in 30 samples from Icelandic hot springs. The list (l. c., p. 83) states in how many samples each form was found, and thus we have here a primitive measure of the constancy of the individual species in the community. On the basis of Østrup's list I have made out the first column of Table 6, where the commonest 49 forms are entered according to their frequency, and which states in how many per cent of all the samples each of them has been found. Of the frequency Østrup gives no information.

Similarly I have in Table 6 given a list from the East Indies after Hustedt (1938, Allg. Teil p. 127, Table 97), who examined a total of 49 samples and found 146 forms. Further I have given a list from Iceland after Krasske (1938), who examined 34 samples and there found 281 forms, and finally a list from the hot springs of Kamtchatka based on my own investigations. In this I have included the samples from which I have made counts for the setting up of Halobion spectra, 39 samples in all, in which I found 214 species.

It then turns out that certain species appear in all the lists among those showing the greatest constancy. Here we must especially mention *Nitzschia amphibia,* which in all 4 lists is among the most constant. The same applies to *Rhopalodia gibberula* and *Synedra ulna.* In the East Indian Islands and in Kamtchatka forms of *Achnanthes exigua* are among the most constant; in Iceland, according to KRASSKE, it is only present in 70 %, and according to ØSTRUP only in 3 % of the samples.

As far as the other species are concerned, it is difficult to establish any general rule for their constancy. On the other hand, the flora in the two lists from Iceland show great agreement. Besides the above-mentioned species we here find *Diploneis elliptica, Pinnularia borealis, Epithemia zebra,* and *Rhopalodia gibba* among the most constant. For these 4 species I have made out a separate table, Table 7, in which the constancy of the species in all 4 localities is stated. It appears from this that *Diploneis elliptica* is common in the hot springs of Iceland both according to KRASSKE and ØSTRUP, while it has not been found at all either in the Sunda Islands or in Kamtchatka. *Pinnularia borealis* has been found in all 4 localities with varying constancy; of this species it is well known that it occurs in nearly all fresh water samples but in small numbers; it is extremely common in aerial localities from which it is washed down into the fresh waters. *Epithemia zebra* is fairly constant also in the East Indies, while in the hot springs of Kamtchatka I have seen very little of it. *Rhopalodia gibba* is common in Iceland but very rare in the East Indies and does not occur at all in Kamtchatka. None of these species can therefore be regarded as generally constant members of the thermal community.

Table 7.

| Constancy in % | ØSTRUP 1918 | HUSTEDT 1938 | KRASSKE 1938 | Kamtchatka |
|---|---|---|---|---|
| Diploneis elliptica | 60 | 0 | 88 | 0 |
| Pinnularia borealis | 57 | 11 | 82 | 33 |
| Epithemia zebra | 50 | 32 | 76 | 3 |
| Rhopalodia gibba | 37 | 4 | 88 | 0 |

HUSTEDT'S list from the East Indian Islands contains numerous species which do not appear in any of the other lists; we have here evidently to do with special tropical forms, such as

*Diploneis subovalis, Navicula Ruttneri, Cymbella Mülleri* var. *javanica*, and *Eunotia Tschirchiana*, which are all very widely diffused in Java and Sumatra and partly only known from the Sunda Islands.

My list from Kamtchatka is more like the two Icelandic lists in conformity with the cold climate in the two regions, though it also shows rather marked differences.

Something therefore would seem to indicate that in its composition the thermal flora depends on the other flora of the country, so that of this such species have been selected which will tolerate the particular conditions of the hot springs; thus Kolbe's view is confirmed (1932, p. 239).

As to the frequency of the individual species in the hot springs we know still less, and for the elucidation of the power of these forms to adapt themselves to the thermal life conditions an investigation of their frequency would be of decisive importance. As a matter of fact, Schwabe (1936) attaches special weight to this and mentions (l. c. p. 317) 8 species which in Iceland often develop very abundantly in hot springs. Schwabe's material is dealt with in more detail by Krasske (1938) who in a table states in what samples the individual forms occur and in addition estimates their frequency in the samples, denoting it by letters. I have attempted to convert these letters into numerical values as follows:

$$m = 6,\ h = 5,\ zh = 4,\ z = 3,\ zs = 2,\ s = 1.$$

The designations in Krasske's table are replaced by the numerical values; these are added up and divided by the number of samples in which the species occurred. In this way we get a certain measure of the average frequency of the species in the samples and a supplement to the constancy value. The frequency values are given in Table 6. It turns out that certain species with a high constancy have a low frequency and the reverse. If now we examine the frequency value for the 8 species selected by Schwabe, it is seen that they all belong to that with the highest frequency, with values exceeding 4, except *Gomphonema gracile* which has only the frequency value 3.7. Exceeding this in frequency we have *Epithemia argus* with the value 4.3, *Epithemia zebra* which has a frequency of 4.0, and

*Navicula cryptocephala* var. *veneta* and *Amphora Normannii* with the value 3.9.

For my material from Kamtchatka I have likewise given frequency values of the individual species; but these figures are calculated in quite another way and are therefore only mutually comparable, but cannot be compared with the Icelandic values. My figures are based on counts from the individual samples, and denote the average of the percentages in which each species was found in the samples in which it occurred. These values undoubtedly give a much truer picture of the frequency of the species than those I have calculated from Krasske, and show with still greater distinctness that species with a high constancy have sometimes a low frequency and the reverse. A species with a high constancy and a low frequency is *Gomphonema parvulum*, while *Anomoeoneis exilis* is an example of the opposite. It is possible that *Gomphonema parvulum* is common in Kamtchatka and therefore will often be included in the samples from the hot springs; it militates against this, however, that Elenkin (1914 I) does not mention it at all. It is also strange that Hustedt (1938, p. 434) has found the species exceedingly common on Java and Sumatra but never observed it in any of the hot springs. This species therefore cannot very well be counted as a typical example of a thermal form.

Otherwise with *Anomoeoneis exilis*. It only occurs in 13 % of the samples from Kamtchatka; but in the individual samples it is present in great numbers and in several of the samples it was seen with a well preserved cell content. This species has also been found diffused in certain parts of Java and Sumatra by Hustedt (1938, p. 218), while it was entirely absent in other parts, and he did not see it in any hot spring. It is likely, then, that it is not the thermal conditions as such which have caused its abundant development in some of the hot springs in Kamtchatka, but that it is some specific circumstance that favours its growth, e. g. some peculiarity in the composition of the water.

Among species with a high frequency we must point out *Nitzschia amphibia* and *Achnanthes exigua*, which also belong to the most constant.

Another species with a very high frequency is *Fragilaria construens* coll. On the basis of Krasske I have calculated the frequency of this species at 2.4, i. e. a relatively low frequency, while *Fragilaria brevistriata* according to Krasske has a very high frequency (4.5). As I have pointed out elsewhere, it is very difficult to recognise these species when they are seen in girdle view, and that will usually be the case with most specimens in a preparation. It is possible therefore that among my *Fr. construens* there may lurk some *F. brevistriata.*

*Rhopalodia gibberula,* which according to Krasske has the highest frequency, exhibits a very low frequency in Kamtchatka, even though its constancy is comparatively high; and *Rhopalodia gibba,* for which Krasske gives the frequency 4.6, I have not seen at all in the hot springs of Kamtchatka. Elenkin, however, states that it has been found in a hot spring there.

The species which are most characteristic of the thermal community thus seem to be *Nitzschia amphibia* and *Achnanthes exigua* which both show great constancy in all 4 lists, and when we know anything about it, likewise a high frequency. Both species, however, are by no means restricted to living in thermal water; on the contrary, both of them are common in cold water and cannot consequently be regarded as thermal species (cf. Hustedt 1938, pp. 197 and 475). They must more probably be regarded as eurythermal species, and the same thing evidently applies to the other species found in hot springs. We then arrive at the conclusion that special thermal Diatoms do not exist, but that the thermal flora is composed of eurythermal species from the cold water flora of the country in question, as has previously been conjectured by Elenkin (1914 I, p. 588), Boye Petersen (1928 I, p. 367), Kolbe (1932, p. 239), Krasske (1938, p. 508), and Hustedt (1938, p. 125).

# LIST OF THE SPECIES

## *Cyanophyceae.*

## Chroococcales.

### Chroococcaceae.

**Aphanocapsa thermalis** Brügg.

Geitler 1932, p. 139; Elenkin 1914 I, p. 149.

Diameter of cells measured at 3.3 μ and 3.8 μ. Found in hot springs at the Siku river (3060) at 67° and at Bannaja (3187) in water 37° warm. Determination somewhat doubtful.

***Chroococcus membraninus** (Menegh.) Näg.

Geitler 1932, p. 238, fig. 116a. Fig. 1.

Found in abundance among *Oscillatoria proboscidea* var. *Westii* in a hot spring near Karymchina (3113—38°). Showed close agreement with the diagnosis cited, though a faint strati-

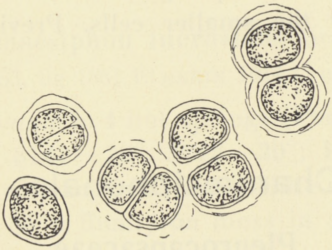

Fig. 1. *Chroococcus membraninus* (Menegh.) Näg. × 1200.

fication was sometimes seen in the sheaths which were often very deliquescent. The diameter of the cells without sheaths was 6—8 μ, with sheaths 8.5—9.6 μ.

* species not formerly found in Kamtchatka.

***Chroococcus minutus** (Kütz.) Näg.

Geitler 1932, p. 232, fig. 112.

In hot spring near Bannaja (3187 — 35°).

***Chroococcus turgidus** (Kütz.) Näg.

Geitler 1932, p. 228, fig. 109, 110; Elenkin 1914 I, p. 148.

In hot spring near Natchika (3234 — 27°).

***Gomphosphæria aponina** Kütz.

Geitler 1932, p. 245, fig. 118 b.

In hot spring near Natchika (3234 — 27°) as a subordinate component of the vegetation.

**Merismopedia glauca** (Ehrb.) Näg.

Geitler 1932, p. 264, fig. 129 d; Elenkin 1914 I, p. 153.

Observed in two samples from hot springs near Paratunka (1521 — 32°) and Natchika (3234 — 27°).

***Merismopedia punctata** Meyen

Geitler 1932, p. 263, fig. 129 c.

Only observed in hot spring near Paratunka (29°). Differs from *M. glauca* by the smaller cells. Previously observed in hot springs.

## Chamæsiphonales.

### Pleurocapsaceae.

***Pleurocapsa minor** Hansg. emend. Geitler

Geitler 1925, p. 129, fig. 160–163; Geitler 1932, p. 348, fig. 182–185.

Found in a dried sample where it formed an almost black crust. On soaking the layer assumed a dark purple colour. Under the microscope the various parts of the growth differed somewhat in colour, the cell contents being sometimes violet, sometimes more olive brown.

In the hot spring "Malenki klutchik" (Bannaja) (3143—29°).

### *Xenococcus chroococcoides F. E. Fritsch

GEITLER 1932, p. 329, fig. 162.

Found on *Rhizoclonium* in hot spring near Paratunka (1314—32°).

## Chamaesiphonaceae.

### *Chamaesiphon curvatus Nordst.

GEITLER 1932, p. 426.

Bannaja at the outfall of the warm stream, on *Rhizoclonium* (3182—temp.?).

### *Chamaesiphon cylindricus Boye P.

BOYE PETERSEN 1923, p. 272, fig. 2.

This species, so far only known from Iceland, was found in a hot spring by the middle course of the Paratunka river (3719—35°). The specimens were a little thicker than those from Iceland (3.0—3.3 $\mu$).

### Chamaesiphon incrustans Grun.

GEITLER 1925, p. 153, fig. 186; ELENKIN 1914 I, p. 135.

Grew on *Rhizoclonium* in 4 hot springs (Paratunka 1514—32°; "Malenki klutchik" 3141—29°, 3142—29°; Paratunka 25°); on *Chara Braunii* in the spring near the middle course of the Paratunka river (3719—35°); finally on moss in a cold stream near camp 4.

### Chamaesiphon minutus (Rostf.) Lemm.

GEITLER 1932, p. 429, fig. 248; ELENKIN 1914 I, p. 155.

On *Rhizoclonium* in a hot stream from the spring near Bannaja (3182—temp. ?).

# Hormogonales.

## Stigonemataceae.

### *Hapalosiphon intricatus W. et G. S. West

Geitler 1932, p. 533, fig. 330.

In a hot spring by the upper Paratunka river (Garaschie Gara) (3701 — temp.?). In small quantity among moss and other algae.

### Stigonema panniforme (Ag.) Born. et Flah.

Geitler 1932, p. 503, fig. 304; Elenkin 1914 I, p. 199.

Only observed in hot spring near Bannaja (3176 — temp.?).

## Mastigocladaceae.

### Mastigocladus laminosus Cohn

Geitler 1932, p. 558; *Hapalosiphon laminosus* Hansg. 1885; Boye Petersen 1923, p. 307, fig. 15; Elenkin 1914 I, p. 196.

This genuine thermal alga I have previously decribed at length (l. c.), especially the various growth forms in which it may appear; in the samples from Kamtchatka it seems much more uniform than in Iceland, seeing that I have here mainly found f. *typica*, while f. *anabaenoides* and f. *phormidioides* were not observed to be distinctly developed.

Found in virtually all the groups of springs investigated and at temperatures between 12° and 77°. For the 10 samples the temperature is stated to be between 30° and 50°. A temperature above 50° is recorded for 4 samples, below 30° for 1 sample. In Iceland I have never found this species at temperatures exceeding 58° C., but there are many records of occurrences at higher temperatures in other parts of the world. See the general part (p. 25).

3039, 3060, 3108, 3113, 3116, 3117, 3137, 3139, 3181, 3182, 3183, 3232, 3239, 3702, 3712, Paratunka 44°, unnumbered I, III.

## Rivulariaceae.

***Calothrix parietina** Thuret

Geitler 1932, p. 604.

In the hot spring near Natchika where it grew somewhat submerged in thalli of *Nostoc Riabuschinskyi* at a temperature of 27° (3234). Hardly identical with var. *thermalis* G. S. West.

***Dichothrix Orsiniana** Born. et Flah.

Geitler 1932, p. 588, fig. 370.

In a hot spring near Natchika (3236 — 38°). The sample was somewhat rotten and the determination therefore rather doubtful; the dimensions and ramification of the filaments are typical, but the hairs were lacking, so that it bears a certain resemblance to *D. fusca* Fritsch, a species that Geitler (l. c. p. 593) regards as identical with *D. Orsiniana*.

**Dichothrix gypsophila** (Kütz.) Born. et Flah.

Geitler 1932, p. 590, fig. 372; Elenkin 1914 I, p. 205.

In a hot spring near Natchika (3234 — 27°) in small quantity.

## Scytonemataceae.

**Scytonema mirabile** (Dillw.) Born.

Geitler 1932, p. 775; Elenkin 1914 I, p. 193.

Only observed in one sample from a hot spring (Garashie Gara) near the upper Paratunka river (3701 — temp. ?). It grew here in company with *Cylindrocystis Brebissonii*, *Cosmarium amoenum* and other species which will hardly tolerate any high temperature; the temperature of the locality must therefore be presumed to have been in accordance herewith.

## Nostocaceae.

**Nostoc Riabuschinskyi** Elenk.

Elenkin 1914 I, p. 181, fig. 3–5.

According to Elenkin, this characteristic species has once or twice been collected in hot springs "Naczikin skije kliuczi", presumably the same locality that HULTÉN calls Natchika. HULTÉN records the temperature at 27° while ELENKIN gives 28°—32° C. A photo of the spring itself is shown on the plate (ELENKIN l. c. p. 96) at top. 3234 —27°.

## Oscillatoriaceae.

### **Lyngbya Kützingii** Schmidle

GEITLER 1925, p. 402, 1932, p. 1035; ELENKIN 1914 I, p. 173.

Occurred as an epiphyte on *Rhizoclonium* in hot springs near the Paratunka (1514 — 32°, U. N. — 25°), as well as on *Chara Braunii* in the hot spring near the middle course of the Paratunka river (3719 — 35°).

### ***Lyngbya perelegans** Lemm.

LEMMERMANN 1905, p. 153, Tab. 11, figs. 13, 14.

Found in the hot spring near Bannaja (3176 — temp?). Thickness of filaments 2.0 μ, thickness of trichomes 1.4 μ, length of cells 4.7 μ.

### ***Oscillatoria amoena** Gom.

GEITLER 1932, p. 969, figs. 603a, 611k.

Found typically developed in the hot spring "Malenki klutchik" near Bannaja (3144 — 60°). The species seems to be eurythermal.

### ***Oscillatoria anguina** (Bory) Gom.

GEITLER 1925, p. 359, fig. 424.

In two samples from hot springs near Paratunka (1513 — 37°, U. N. — 44°). Previously observed in hot springs, but also in other localities.

### ***Oscillatoria angusta** Kappe

GEITLER 1932, p. 965.

In a hot spring near Natchika (3237 — 40°) an *Oscillatoria* was found which, according to the somewhat brief description in GEITLER, might very well be *O. angusta*. The determination is, however, very doubtful. Thickness of trichomes 1.3 μ, length of cells 8.5 μ.

### *Oscillatoria Okenii (Ag.) Gom.

Geitler 1925, p. 372, fig. 463.

In a hot spring near Paratunka (1513 — 37°).

### *Oscillatoria proboscidea Gom. var. Westii A. Forti

A. Forti in De-Toni Syll. Alg. 5. p. 152; *O. proboscidea* var. West 1902, p. 245, figs. 28—30.

Occurred in 4 samples from hot springs near Paratunka (1513 — 37°, 1521 — 32°, U. N. — 44° and 29°) and in a sample from Karymchina (3113 — 38°). Recorded amongst other localities from hot springs in Iceland, where it was found at temperatures of 15°—40°.

### *Oscillatoria splendida Grev.

Geitler 1932, p. 972, fig. 620 d—f.

In hot spring near Paratunka (1521 — 32°).

### *Oscillatoria tenuis Ag. var. tergestina Rabh.

Geitler 1932, p. 959.

Found among other *Oscillatoria* in springs near Paratunka (1513 — 37°, U.N. — 44°), and Natchika (3237 — 40°).

Thickness of trichomes c. 5 μ.

### *Oscillatoria terebriformis Ag.

Geitler 1932, p. 954, fig. 607 d.

In hot springs near Paratunka (1521 — 32°), near the Savan river (2528 — 50°), and in "Malenki klutchik" (Bannaja) (3136 — 70°); in the last-mentioned sample especially it was very common. The species is in the main only known from hot springs.

### Phormidium laminosum Gom.

Geitler 1932, p. 1005, fig. 642 c; Elenkin 1914 I, p. 168.

The species, as is usual in hot springs, is very widely distributed in the area here in question. Found in 13 samples at temperatures between 30° and 73°, most commonly at 40°—50°.

Paratunka (1515 — 44°-45°, U.N. 44°), near the Savan river (2528 — 50°, 2530 — 73°, 2533 — 63°), near the Siku river (3037 — 42°, 3039 — 46°, 3060 — 67°), Karymchina (3108 — 30°), "Malenki klutchik" (3139 — 66°), Bannaja (3182 — temp. ?, 3232 — 46°, 3239 — 42°).

### *Phormidium purpurascens (Kütz.) Gom.

GEITLER 1932, p. 1009, fig. 644 c.

Occurred in a hot spring near Bannaja (3183 — 46°) in running water. Here it formed a ramified thallus, which may be supposed to be connected with the occurrence here. Previously observed in hot springs.

### Phormidium tenue (Menegh.) Gom.

GEITLER 1932, p. 1004, fig. 642 d, e; ELENKIN 1914 I, p. 167.

Observed in two hot springs, namely at the Siku river (3039 — 46°), and in "Malenki klutchik" (3136 — 70°).

### Phormidium Treleasei Gom.

GEITLER 1932, p. 1006.

In the spring near Karymchina (3117 — 37°) there occurred a Phormidium which agreed in character with this species. A similar form was seen in a sample without any exact designation (U.N. I). Possibly = *P. angustissimum* W. et G. S. WEST (ELENKIN 1914 I, p. 166).

### Phormidium Valderiae (Delp.) Gom.

*P. valderianum* Gom. Monogr. II, p. 167, pl. 4, fig. 20.
— — ELENKIN 1914 I, p. 167.

In springs near Paratunka (1515 — 44°-45°, U.N. — 44°), Bannaja (3181 — 46°) and Natchika (3239 — 42°).

### *Phormidium Valderiae (Delp.) Gom. var. tenuis Woronich.

GEITLER 1932, p. 1011.

In a hot spring near Bannaja (3181 — 46°) in company with the species.

**Symploca thermalis** (Kütz.) Gom.

Geitler 1932, p. 1127; Elenkin 1914 I, p. 174.

In a hot spring (on Garashie Gara) at the upper Paratunka river (3702 — 12°-13°). The species has often been found at much higher temperatures, for instance at 30°-35° (Boye Petersen 1923, p. 288).

## *Diatomaceae.*

### Centricae.

**Cyclotella Meneghiniana** Kütz.

Hustedt 1930, p. 100, fig. 67; Elenkin 1914 I, p. 339.

Elenkin (l. c.) observed this species in various samples from the peninsula, but not from any hot spring.

I have found it in 4 samples in all, but only in one with cell contents (a hot spring by the middle course of the Paratunka river (3716 — 10°)).

3712, 3716 (0.4 %), 3719, 3720.

According to Boye Petersen 1943, p. 63 .... halophilous.

***Melosira cataractarum** Hustedt

Hustedt 1938, p. 142, Taf. IX, figs. 6,7; Fig. nostra 2.

The specimens found showed close agreement with Hustedt's description. I observed the following dimensions, breadth 3.3 $\mu$ — 6.7 $\mu$, height of the whole cell 5 — 8.4 $\mu$ Striae c. 18 in 10 $\mu$, distinctly dotted.

The species was not uncommon in the samples from Kamtchatka. It was observed in 10 samples in all, in the main from springs; but cells with cell contents were nowhere to be found.

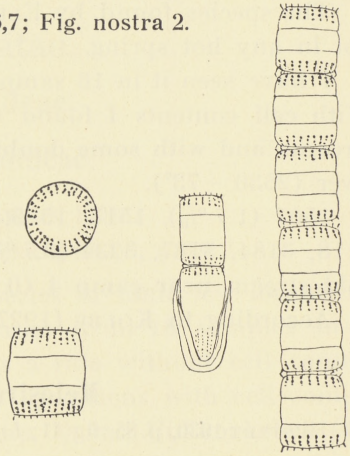

Fig. 2. *Melosira cataractarum* Hustedt × 1700.

1516 (12.3 %), 1526 (14.4 %), 2533 (6.7 %), 3118 (0.5 %), 3141 (0.5 %), 3232 (3.2 %), 3716 (1.7 %), U. N. II, Paratunka 29° (5.4 %), 25° (0.4 %).

Position in the Halobion system ..................... ?

### **Melosira distans** (Ehrb.) Kütz.

HUSTEDT 1930, p. 92, fig. 53; ELENKIN 1914 I, p. 335.

ELENKIN (l. c.) observed this species in a single locality. I have found the species in 2 samples in small numbers:

1526 (0.5 %), 3239.

Position in the Halobion system ..................... ?

### **Melosira granulata** (Ehrb.) Ralfs

HUSTEDT 1930, p. 87, fig. 44; ELENKIN 1914 I, p. 336.

The species has been mentioned by ELENKIN (l. c.) from a number of localities in the peninsula. I have only observed empty valves of it in two samples:

3232 (1.1 %), 3237.

According to KOLBE (1927).................. indifferent.

### **Melosira italica** (Ehrb.) Kütz.

HUSTEDT 1930, p. 91, fig. 50; *M. crenulata* ELENKIN 1914 I, p. 336.

The species found by ELENKIN (l. c.) in many localities, but not in any hot spring.

I have seen it in 16 samples in all, mainly from hot springs. With cell contents I found specimens in 2 samples from cold streams and with some doubt in the hot spring near the Savan river (2530 — 73°).

1507 (1.7 %), 1513, 1525, 1526 (7.4 %), 2530 (4.7 %), 2974, 3118, 3184, 3187, 3234 (0.7 %), 3236, 3237, 3239, 4328 (9.4 %), cold stream near camp 4 (0.4 %), Paratunka 41° (0.4 %).

According to KOLBE (1927) and SCHULZ (1928) ........ indifferent.

### **Melosira varians** Ag.

HUSTEDT 1930, p. 85, fig. 41; *Lysigonium varians* ELENKIN 1914 I, p. 333.

ELENKIN (l. c.) found this species very common in the peninsula but it only occurred in one instance in a hot spring (17°

— 19°). I have found it in 25 samples in all, but in most of them in small numbers, mainly from hot springs. In 16 samples from hot springs there were specimens with cell contents at temperatures from 10° — 70° C. The springs from which these specimens are derived are: Paratunka (1507 — 23° (1.7 $^0/_0$), 1514 — 32°, U. N. — 29° (0.3 $^0/_0$) and 25° (7.7 $^0/_0$)), Karymchina (3118 — 14°), "Malenki klutchik" (3136 — 70° (0.9 $^0/_0$), 3138 — 66°, 3139 — 66° (1.5 $^0/_0$), 3140 — 29°, 3144 — 60° (0.8 $^0/_0$)), Bannaja (3180 — 46° (4.3 $^0/_0$), 3182 — temp. ?, 3184 — 46° (0.3 $^0/_0$)), Garaschie Gara (3703 — 16° (11.9 $^0/_0$)), spring by the middle course of the Paratunka river (3716 — 10° (0.1 $^0/_0$), 3720 — 21° (6.1 $^0/_0$)). Without cell contents in 1513, 1526 (4.7 $^0/_0$), 3137 (2.2 $^0/_0$), 3141, 3142, 3187 (1.0 $^0/_0$), 3719, 4328, cold stream near camp 4, Paratunka 41°.

According to Boye Petersen 1943, p. 77 ..... indifferent.

***Stephanodiscus astraea** (Ehrb.) Grun.

Hustedt 1930, p. 110, fig. 85.

Found in small numbers and without cell contents in one sample.

2528.

According to Boye Petersen 1943, p. 90 ..... indifferent.

# Pennatae.

## Araphideae.

### Fragilarioideae.

**Ceratoneis arcus** Kütz.

Hustedt 1930, p. 134, fig. 122; Elenkin 1914 I, p. 332.

Elenkin (l. c.) found the species in some few localities in the peninsula. I have come across it in 18 samples in all, mainly from hot springs and as a rule without cell contents. Only in two samples were there specimens with cell contents, namely from Bannaja (3182 — temp. ?) and Unkanakchek (4329 — 12° (6.4 $^0/_0$)).

1526, 2527 (0.5 $^0/_0$), 2528 (0.6 $^0/_0$) 2974, 3118, 3136 (0.3 $^0/_0$), 3137 (0.8 %), 3139, 3140, 3141, 3144 (0.4 %), 3184, cold stream near camp 4, Paratunka 29°, 41°, cold afflux (0.2 %).

According to HUSTEDT (1938) the species is oligohalobous and principally a form found in brooks. SCHULZ (1928) likewise records it as oligohalobous. According to the occurrence of the species in running water I should suppose that it is in reality: halophobous.

***Ceratoneis arcus** Kütz. var. **amphioxys** (Rabh.) De-Toni

HUSTEDT 1930, p. 135, fig. 123.

Of this variety I have only seen empty valves in 2 samples from hot springs.

1513, 3182.

Presumably like the species................ halophobous.

***Diatoma anceps** (Ehrb.) Grun.

HUSTEDT 1930, p. 130, fig. 117.

Found in small numbers, and never with cell contents, in 13 samples from cold water as well as from hot springs:

1525, 1526 (0.7 %), 2533, 2974, 3137 (0.8 %), 3138, 3139 (0.7 %), 3140 (0.5 %), 3141, 3144 (0.7 %), 3182, 3703 (0.6 %), Paratunka 41°.

HUSTEDT (1930 and in Rabh. Kryptog. Fl.) reports its habitat to be: running water, especially in the mountains. It must therefore presumably be regarded as.............. halophobous.

**Diatoma elongatum** Ag.

HUSTEDT 1930, p. 127, fig. 111; ELENKIN 1914 I, p. 300.

ELENKIN (l. c.) found several remarkable forms of this species in Kamtchatka, but I have observed none of these in the present material. I have only come across the species in 2 samples, and only found cells with cell contents in one of them, namely in a hot spring by the middle reach of the Paratunka river (3716—10° (28.8 %)).

3712.

According to BOYE PETERSEN 1943, p. 66.... halophilous.

### Diatoma hiemale (Lyngb.) Heib.

HUSTEDT 1930, p. 129, fig. 115—116; ELENKIN 1914 I, p. 305.

ELENKIN (l. c.) found this species very common in Kamtchatka, both in cold water and in water of a thermal nature. In hot springs he observed it at 17°—55° C.

In the present material I have seen the species in 25 samples in all, both from cold streams and from hot springs.

MOLISCH (1926, p. 103) records this species as a pronounced cold water species, and he has experimented with it and shown that its cells are injured already at 20°—25° C, and at 29° they died in the course of 24 hours, whereas they remained alive for several days at 14° C. Under natural conditions too he asserts that the species disappears when the temperature rises above 20° in the month of May. This is in the most absolute contrast to what my samples show.

The samples from hot springs in which specimens with cell contents were found are: "Malenki Klutchik" (3136 — 70° (9.6 %), 3137 — 77° (5.4 %), 3138 — 66° (9.7 %), 3139 — 66° (7.8 %), 3141 — 29° (6.0 %), 3144 — 60° (5.8 %)), from Bannaja (3182 — temp. ?), from the spring on Garaschie Gara (3703 — 16° (2.9 %)), from the spring at the middle course of the Paratunka (3716 — 10°) and Unkanakchek (4329 — 12° (3.6 %)). It likewise occurred in large numbers and with cell contents in a couple of cold streams (1417 (86.3 %)) and in a cold stream near camp 4 (1.0 %). According to the data it seems to be an extremely eurythermal species.

Further it was found without cell contents in the following samples: 2528 (0.6 %), 2533, 2974, 3118 (0.5 %), 3140 (10.8 %), 3142 (0.6 %), 3184, 3712, 3720, 4328 (1.9 %), U. N. I, II, Paratunka 41° (0.9 %).

According to BOYE PETERSEN (1930) and SCHULZ (1928) halophobous.

### *Diatoma hiemale (Lyngb.) Heib. var. mesodon (Ehrb.) Grun.

HUSTEDT 1930, p. 129, fig. 116.

This short form of the species, which is not mentioned by ELENKIN (1914), was found by me in 12 samples in all, as a rule in company with the species, but in three of the samples alone. With cell contents it was only seen in a cold stream in Akhomten Bay (1417 (2.2 ‰)), and in a hot spring near Bannaja (3184 — 46° (1.5 ‰)).

1507, 1526 (0.5 ‰), 2527 (1.5 ‰), 2528 (0.6 ‰), 3139 (4.0 ‰), 3140 (1.0 ‰), 3182, 3712, a cold stream near camp 4 (0.4 ‰), U. N. I.

Hustedt (Rabh. Kr. Fl., p. 104) mentions that this variety is very common in mountains; but it also occurs in lowlands, though principally in running water. There is then perhaps some reason to believe that it is less halophobous than the species, so for the present I will regard it as ... indifferent.

### *Fragilaria bicapitata Mayer

Hustedt in Rab. Krypt. Fl. Bd. VII, 2, p. 165, fig. 673 A. F. *bicapitata* var. *curta* A. Cleve-Euler 1934, p. 13, Tab. I, fig. 2. Fig. nostra 3.

Hustedt (l. c.) states that the cells of this species were joined together in closely connected chains. This was not the

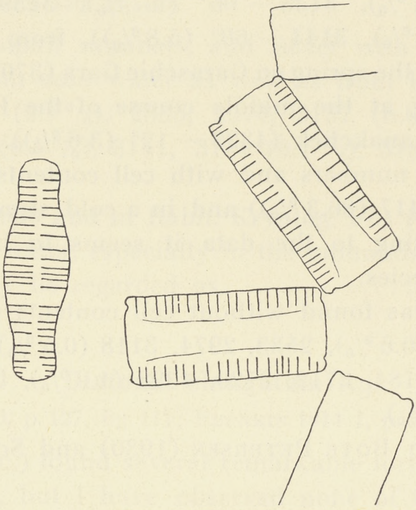

Fig. 3. *Fragilaria bicapitata* Mayer. × 1700.

case in the samples examined by me, especially No. 1526 (cold affluent to the hot spring in Paratunka), where, on the contrary, the cells were quite distinctly joined at the corners to zigzag bands as in a Diatoma. And in a preparation in water small clumps of jelly which kept the cells together were seen. Fig. 3 shows such a chain in an ignation preparation, in which the cells lie in their natural position in relation to each other. We have then here an example of Fragilaria forming zigzag chains.

The species occurred in 6 samples in all, 5 of which were from hot springs; in these it was not possible to see specimens with cell contents; it was best developed in the above-mentioned sample 1526, where there were also individuals with endochrome.

1526 (6.1 %), 3232, 3712, 3716 (0.7 %), 3720 (0.1 %), 3719 (0.7 %). According to HUSTEDT (1930) oligohalobous, perhaps halophobous ........................................ ?

### *Fragilaria brevistriata Grun.

HUSTEDT 1930, p. 145, fig. 151.

The species occurred in 22 samples, mainly from hot springs. Only in one sample from the hot spring near the middle course of the Paratunka river 3720 — 21° (0.8 %) were there specimens with cell contents.

Other occurrences: 1507 (5.0 %), 1526, 1521, 2528, 3137 (0.2 %), 3139 (0.5 %), 3140, 3141 (2.3 %), 3144 (1.6 %), 3176, 3180 (2.1 %), 3184 (1.0 %) 3232 (1.0 %) 3237 (3.3 %) 3703, 3712, 3716 (1.4 %), 4328 (1.9 %), 4329 (0.9 %), cold stream near camp 4, Paratunka — 29° (0.3 %).

According to BOYE PETERSEN 1943, p. 71, must be regarded as: indifferent.

### *Fragilaria brevistriata Grun. var. inflata (Pant.) Hust.

HUSTEDT 1930, p. 145, fig. 152.

Found in small number in 3 samples, but without cell contents.

2527 (3.0 %), 2974, 3138 (4.5 %).

Presumably like the species .................. indifferent.

### *Fragilaria brevistriata Grun. var. elliptica Hérib.

HUSTEDT Rabh. Kr. Fl. VII, 2, p. 169, fig. 676.

Occurred in 1 sample, but without cell contents.

1525.

Seems to appear in company with the species and is therefore like this presumably ........................ indifferent.

### *Fragilaria capitellata (Grun.) Boye P. n. comb.

*F. intermedia* var. *capitellata* A. Cleve Euler 1932, p. 21, fig. 27; *Synedra capitellata* Grun. V. Heurck Syn. Pl. 40, fig. 26. Fig. nostra 4.

So far this species has generally been regarded as a variety of *Fragilaria Vaucheriae*. However, it seems to me to differ so

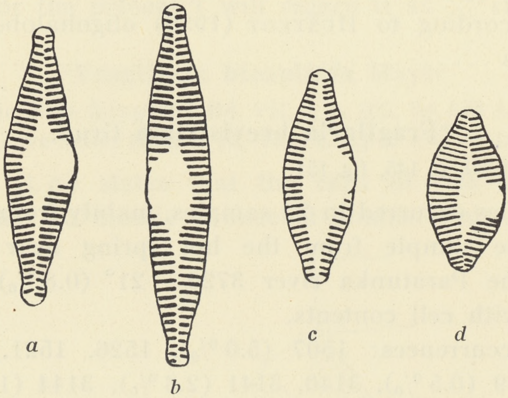


Fig. 4. *Fragilaria capitellata* Grunow. × 1700. From sample 3136.

distinctly from this that I cannot but believe that it is more probably a separate species; I base this especially on the fact that it has finer striae, which are distinctly radiate. *F. Vaucheriae* has c. 15 striae in 10 $\mu$, while *F. capitellata* has 18 striae in 10 $\mu$. Secondly, the cell form is different. *F. Vaucheriae* has linear, protracted valves, while *F. capitellata* has rhombic-lanceolate subcapitate valves. Thirdly, in this species the pseudoraphe is as a rule lanceolately expanded in the middle, and fourthly, the cell walls are altogether thinner. The species shows a similar variation as *F. Vaucheriae.*

Fig. 4a is the typical form. Length 21.7 $\mu$; breadth 5.8 $\mu$; striae 18 in 10 $\mu$.

- b approaches *F. Vaucheriae* somewhat in form, length 28 $\mu$; breadth 5.0 $\mu$; striae 18 in 10 $\mu$.

Fig. 4 c a short form with a large central area. Length 16 $\mu$; breadth 5.5 $\mu$; striae 18 in 10 $\mu$.

- d a still shorter form. Length 12.5 $\mu$; breadth 5.6 $\mu$; striae 22 in 10 $\mu$.

Seen in all in 12 samples from hot springs and with cell contents in 8 of them, namely from "Malenki klutchik" (3136 — 70° (29.3 $^0/_0$), 3137 — 77° (0.5 $^0/_0$), 3138 — 66° (11.0 $^0/_0$), 3139 — 66° (5.5 $^0/_0$), 3141 — 29° (1.8 $^0/_0$), 3144 — 60° (1.2 $^0/_0$)) and from Bannaja (3182 — temp. ?, 3184 — 46° (10.5 $^0/_0$)). In several of the samples there were long chains of cells, especially in sample 3141, in which the cells were in lively division.

Without cell contents the species was seen in the following samples: 3140 (3.4 $^0/_0$), 3142 (1.3 $^0/_0$), 3716, 3719 (1.0 $^0/_0$).

As regards the place of the species in the Halobion system there is hardly any certain information, but I presume that like *F. Vaucheriae* it is ........................ indifferent.

### *Fragilaria capucina Desm. var. acuta Grun.

HUSTEDT 1930, p. 138, fig. 129.

ELENKIN (1914 I, p. 324) only mentions *F. capucina* as a collective species from a number of localities, but not from any hot spring.

Found in small numbers in 7 samples from hot springs; but no specimens with cell contents were seen.

3139 (3.0 $^0/_0$), 3140, 3141 (0.5 $^0/_0$), 3144 (0.4 $^0/_0$) 3182, 3184 (0.3 $^0/_0$), 3716.

According to HUSTEDT 1938, p. 150, this variety is presumably a spring form. I therefore suppose that it is ............... halophobous?

### *Fragilaria capucina Desm. var. lanceolata Grun.

HUSTEDT 1930, p. 138, fig. 127.

Found in small numbers in 4 samples from hot springs, and never with cell contents.

2527, 3716 (3.3 $^0/_0$), 3720 (0.8 $^0/_0$), 3719 (0.3 $^0/_0$).

Like var. *acuta* this variety is also thought to be a spring form (HUSTEDT 1938, p. 150), and I suppose therefore that it is halophobous?

***Fragilaria capucina** Desm. var. **mesolepta** (Rabh.) Grun.
HUSTEDT 1930, p. 138, fig. 128.

Occurred in small numbers and without cell contents in two samples. 1516 (2.3 %), Paratunka, 29° (1.0 %).

According to Boye Petersen 1943, p. 71 ....... indifferent.

**Fragilaria construens** (Ehrb.) Grun. coll.
HUSTEDT 1930, p. 141; ELENKIN 1914 I, p. 324.

This highly variable species was on the whole very common in the samples, from hot as well as from cold springs. Small forms referable to var. *venter* were entirely dominant, and these are listed separately. In a number of samples, however, there also occurred larger forms approaching the type; but in the spectra it has been impossible to distinguish these forms, as the specimens in the preparations were often seen in girdle view, and therefore could not be exactly determined. ELENKIN (l. c.) only seems to have found the species in a single locality, and not from any hot spring.

*Fragilaria construens* forms found in the following samples, often in large numbers:

1516 (34.6 %), 1521 (49.3 %), 1526 (28.2 %), 2527 (29.1 %), 3118 (0.2 %), 3138 (31.8 %), 3141 (22.5 %), 3142 (12.0 %), 3232 (9.5 %), cold stream near camp 4 (35.3 %).

According to BOYE PETERSEN (1943, p. 71) both the species and its varieties must be regarded as............ indifferent.

***Fragilaria construens** (Ehrb.) Grun. var. **binodis** (Ehrb.) Grun.
HUSTEDT 1930, p. 141, fig. 137.

Occurred in small number in 8 samples, partly from cold streams, partly from hot springs, and was nowhere observed with cell contents.

1526, 3137 (0.3 %), 3139, 3140, 3144 (0.4 %), 3184 (0.3 %), 3712, cold stream near camp 4.

According to BOYE PETERSEN 1943, p. 71......... indifferent.

***Fragilaria construens** (Ehrb.) Grun. var. **venter** (Ehrb.) Grun.
HUSTEDT 1930, p. 141, fig. 138.

This variety was one of the commonest forms in the samples examined, and it was found in large number both in samples from cold streams and from hot springs, in 19 samples in all.

Specimens with cell contents occurred in 4 samples from hot springs, namely from "Malenki klutchik" (3137 – 77° (40.8 %)), Garaschie Gara (3703 — 16° (9.7 %)), and the spring by the middle reach of the Paratunka (3716 — 10° (50.9 %), 3720 — 21° (77.2 %)), that is, at temperatures of from 10° to 77° C. It is worth noting that at 77° this form constituted 40.8 % of the Diatoms occurring in the sample. At lower temperatures too it reached high figures.

Without cell contents it occurred in the following samples: Paratunka 29° (12.8 %) and 41° (1.5 %), cold stream near camp 4 (46.0 %), 2528 (3.4 %), 2533 (1.1 %), 2974, 3139 (27.4 %), 3140 (39.9 %), 3141, 3144 (50.8 %), 3184 (15.2 %), 3237 (1.1 %), 3712, 3719 (8.8 %), 4328 (5.7 %).

According to BOYE PETERSEN 1943, p. 71 ...... indifferent.

### *Fragilaria crotonensis Kitt.

HUSTEDT 1930, p. 137 fig. 125.

Found in no inconsiderable amount (6.1 %) in a sample taken with a plankton net in the bathing spring near the Paratunka (41°).

According to BOYE PETERSEN 1943, p. 71 ..... indifferent.

### Fragilaria leptostauron (Ehrb.) Hust.

HUSTEDT 1930, p. 139, fig. 132; *Odontidium Harrisonii* Elenkin 1914 I, p. 308.

The species found by ELENKIN (l. c.) in a number of localities in Kamtchatka but not from any hot spring. I have seen valves of it in 16 samples in all, especially from hot springs, but never with cell contents and never in large numbers.

2527 (0.5 %), 2528, 2533 (2.2 %), 2974, 3118, 3137 (0.2 %), 3139 (0.2 %), 3140 (0.5 %), 3141, 3144, 3184, 3239, 3712, 3716, cold stream near camp 4 (0.3 %), Paratunka 29°.

According to BOYE PETERSEN 1943, p. 72... halophobous?

### *Fragilaria Mágocsyi Lacsny

HUSTEDT 1930, p. 145, fig. 154.

Found in small numbers and without cell contents in a sample from the hot spring near Bannaja (3184).

Place in the Halobion system ......................... ?

### *Fragilaria nitzschioides Grun.

Hustedt 1930, p. 144, fig. 150.

A very rare species, only found a few times. Occurred in small number in 5 samples, partly from hot springs, partly from a cold stream; but I was not able to find specimens with cell contents.

1526 (0.2 %), 3703 (1.7 %), 3137 (1.1 %), 3140 (1.0 %), 3144 (0.7 %).

According to Hustedt (Rabh. Krypt Fl. Bd. VII, 2, p. 168) the species has been found in lakes and rivulets in mountains and on irrigated rocks. Hence it is probable that it is ..... halophobous?

### Fragilaria pinnata Ehrb.

Hustedt 1930, p. 142, fig. 141; *Odontidium mutabile* Elenkin 1914 I, p. 308.

Elenkin (l. c.) has seen this species in several samples from Kamtchatka. I have found it in 25 samples in all, principally from hot springs, but never with cell contents.

1507, 1526 (0.5 %), 2527 (1.5 %), 2528 (0.6 %), 2533 (1.1 %), 3136 (0.2 %), 3137 (5.1 %), 3138 (3.9 %) 3139 (10.8 %), 3140 (4.4 %), 3141 (5.0 %), 3142 (0.6 %), 3144 (11.2 %), 3176, 3180 (0.7 %), 3184 (2.5 %), 3232 (6.3 %), 3234 (1.2 %), 3236 (11.5 %), 3237, 3239, 3712, 3716 (1.5 %), 3719 (2.6 %), 3720 (0.6 %).

According to Boye Petersen 1943, p. 72 ..... indifferent.

### *Fragilaria Vaucheriae (Kütz.) Boye P.

Boye Petersen 1938, p. 167; *Exilaria Vaucheriae* Kütz. Alg. Dec. No. 24, 1833; *Synedra V.* Kützing Bacill. p. 65, 1844; *Fragilaria intermedia* Grun. V. Heurck Syn. Pl. 45, figs. 9—11.

This very variable species was one of the commonest in the material. Found in 30 samples in all, from hot springs as well as from cold streams, and in 9 samples there occurred cells with contents, namely from a cold stream near camp 4 (9.1 %), from a hot spring near the Savan river (2527 — 52° (5.1 %)), a hot spring near Karymchina (3118 — 14° (2.7 %)), "Malenki klutchik" (3136 — 70° (27.7 %), 3141 — 29° (4.6 %)), hot spring near Bannaja (3182 — temp. ?, 3184 - 46° (0.7 %)), hot spring near the middle reach of the Paratunka (3716—10° (2.0 %)), hot spring near Unkanakchek (4329—12° (22.7 %)).

Without cell contents it was observed in the following samples: 1507, 1513 (0.9 %), 1514, 1526 (1.8 %), 2533 (2.2 %), 2974, 3137 (15.5 %), 3138 (2.0 %), 3139 (9.1 %), 3140 (1.5 %), 3142 (2.5 %), 3144 (5.8 %), 3180 (0.7 %), 3703 (11.4 %), 3712, 3720 (0.3 %), 4328 (1.9 %), U.N. I and II, Paratunka 29° (2.2 %) and 41°.

According to BOYE PETERSEN 1943, p. 72..... indifferent.

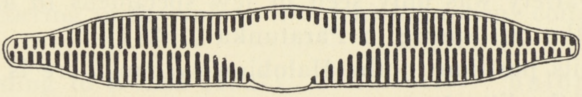

Fig. 5. *Fragilaria Vaucheriae* (Kütz.) Boye P. var. *kamtchatica* n. var. × 1700.

***Fragilaria Vaucheriae** (Kütz.) Boye P. var. **kamtchatica** n. var.

Valvis linearibus, apicibus protractis, medio leviter tumidis. Long. 40—82 $\mu$, lat. 6.5 $\mu$, striis paralelis, 13—15 in 10 $\mu$. Fig. nostra 5.

This characteristic variety was fairly common in the samples and was as a rule found in company with the type. Noted in 16 samples, but mostly in rather small numbers. Only in sample 4329 (a hot spring near Unkanakchek) was it observed in somewhat larger amount (14.6 %). Specimens with cell contents observed in sample 3141 from "Malenki klutchik" (29°) and in the above-mentioned sample 4329 (12°).

Seen without cell contents in the following samples: 1526 (0.5 %), 2528, 3137 (6.2 %), 3138, 3139 (0.4 %), 3140 (5.0 %), 3142, 3144, 3182, 3184, 3712, cold stream near camp 4, Paratunka 29° and 41°.

Place in the Halobion system........................... ?

## **Fragilaria virescens** Ralfs

HUSTEDT 1930, p. 142, fig. 144; ELENKIN 1914 I, p. 322.

ELENKIN (l. c.) found the species very common in Kamtchatka, e.g. also in hot springs at 17°—19° and 24° C., but otherwise in cold water.

I have observed it in 3 samples from hot springs, but in all of them only empty valves.

1526, 3184 (0.3 %), 3237, 3239.

Kolbe (1927) and Sprenger (1930) regard the species as halophobous, while Schulz (1928) lists it as oligohalobous.

Presumably ............................... halophobous.

### *Fragilaria virescens Ralfs var. elliptica Hust.

Hustedt 1930, p. 142, fig. 147.

This variety was only seen in few specimens in a cold affluent to the hot spring in Paratunka (1526).

As to its position in the Halobion system there is no information in the literature ..................................... ?

**Fragilaria** sp.: 1531 (1.4 %), 1514 (1.0 %), 2533 (16.7 %), 3136 (1.7 %), 3716 (1.8 %), 4329 (4.6 %).

### Meridion circulare Ag.

Hustedt 1930, p. 130, fig. 118; Elenkin 1914 I, p. 309.

Elenkin (l. c.) found this species in several localities in Kamtchatka, amongst other places in hot springs at a temperature of 17°—24° C. I have observed it in 23 samples in all, principally from hot springs, but as a rule only empty valves. Specimens with cell contents were, however, found in 3 samples, namely from the hot spring near the Savan river (2528 — 50°) from the hot spring "Malenki klutchik" (3139 — 66° (5.3 %)), and from the spring near the middle reach of the Paratunka river (3716 — 10° (0.7 %)).

1526 (0.5 %), 2974, 3118 (0.7 %), 3136, 3137 (0.8 %), 3138 (0.6 %), 3140 (2.4 %), 3141 (1.4 %), 3144 (2.3 %), 3180, 3184 (1.2 %), 3703 (1.1 %), 3712, 3719, 3720 (0.5 %), 4328 (1.9 %), Paratunka 29° (0.7 %) and 41° (0.4 %), cold stream near camp 4 (1.3 %), U. N. II.

According to Boye Petersen 1943, p. 77... halophobous.

### Meridion circulare Ag. var. constrictum (Ralfs) V. Heurck

Hustedt 1930, p. 131, fig. 119; *M. constrictum* Elenkin 1914 I, p. 310.

Elenkin (l. c.) only found this variety in a couple of localities. According to my experience it is just as common in Kamtchatka as the species. I have seen it in 17 samples in all, principally from hot springs, but from the latter almost always empty valves only. Cells with cell contents I have only seen in one sample from the hot spring near the middle reach of the Paratunka river (3716 — 10°). Found, in addition, in the following samples: 1513, 1525, 1526, 2528 (0.6 %), 2530, 3139, 3140, 3144, 3237, 3703, 3712, 3720, 4328, cold stream near camp 4, Paratunka 29°, U. N. I.

In the Halobion spectra it was not possible to keep the variety distinct from the species as it can only be recognized when occurring in the valve view, which happens comparatively rarely.

According to Kolbe (1927) ................. halophobous.

### Synedra acus Kütz.

Hustedt 1930, p. 155, fig. 170; Elenkin 1914 I, p. 110, 312.

Elenkin (l. c.) found this species in several localities, amongst other places from hot springs at 17°—19° C.

I have seen it in 7 samples from hot springs. Specimens with cell contents were found in the following samples: "Malenki klutchik" (3136 — 70° (17.0 %), 3138 — 66°, 3139 — 66° (0.2 %), 3144 — 60° (0.7 %)), and Bannaja (3184 — 46° (0.3 %)). Further, I saw it without cell contents in samples: 3137 (0.8 %), 3140.

According to Boye Petersen 1943, p. 91 ..... indifferent.

### *Synedra parasitica (W. Sm.) Hust. var. subconstricta Grun.

Hustedt 1930, p. 161, fig. 196.

Found in small numbers but with cell contents in the hot spring on Garaschie Gara (3703 — 16°).

According to Hustedt (1938, 1939) the species is oligohalobous. Similarly the variety is presumably... indifferent?

### *Synedra rumpens Kütz.

Hustedt 1930, p. 156, fig. 175.

Found in small numbers and without cell contents in 3 samples: 1526 (0.2 %), 2528, 3716.

According to Boye Petersen 1943, p. 92...... indifferent.

***Synedra tabulata** (Ag.) Kütz. (= *S. affinis*)

HUSTEDT Rabh. Krypt. Fl. VII, 2, p. 218, fig. 710 a—d.

Found in small numbers and without cell contents in 3 samples: 1526, 3716, 3720 (1.8 ‰).

According to BOYE PETERSEN 1943, p. 92 ... halophilous.

**Synedra ulna** (Nitzsch) Ehrb.

HUSTEDT 1930, p. 151, fig. 158, 159; ELENKIN 1914 I, p. 310.

ELENKIN (l. c.) found this widespread and variable species in several localities in Kamtchatka, amongst other places in hot springs (temp. 41°, 55° C.). I have seen it in 19 samples in all, but everywhere only in small numbers. In 7 of the samples there occurred specimens with cell contents, namely from the hot springs near Paratunka (1514 — 32° (0.2° ‰), unnumbered — 25° (3.0 ‰)), "Malenki klutchik" (3136 — 70° (2.3 ‰), 3144 — 60°)), Bannaja (3182 — temp. ?), near the middle reach of the Paratunka river (3716 — 10° (0.5 ‰)), Unkanakchek (4329 — 12° (2.7 ‰)).

Further in the following samples: 3137 (0.3 ‰), 3138, 3140 (0.5 ‰), 3141 (0.5 ‰), 3184 (0.3 ‰), 3237, 3703, 3712, 3720, cold stream near camp 4 (0.2 ‰), Paratunka 29° (0.6 ‰), 41°.

According to BOYE PETERSEN 1943, p. 93 ..... indifferent.

***Synedra ulna** (Nitzsch) Ehrb. var. **æqualis** (Kütz.) Hust.

HUSTEDT 1930, p. 152, fig. 164.

Seen only in small numbers and without cell contents in 1 sample (1526). Presumably like the species ...... indifferent.

***Synedra ulna** (Nitzsch) Ehrb. var. **danica** (Kütz.) Grun.

HUSTEDT 1930, p. 154, fig. 168.

Found in small numbers and without cell contents in 1 sample: 2533 (1.1 ‰).

According to SCHULZ (1928) and HUSTEDT (1939): ....... indifferent.

### **Tabellaria fenestrata** (Lyngb.) Kütz.

Hustedt 1930, p. 122, fig. 99; Elenkin 1914 I, p. 325.

Found by Elenkin (l. c.) in several localities in Kamtchatka but not in any hot spring.

I have found it in small number in a cold stream near camp 4 (0.2 %). Kolbe (1927) and Schulz (1928) call the species halophobous, adding a large question mark, while Hustedt terms it indifferent.................................... indifferent?

### **Tabellaria flocculosa** (Roth) Kütz.

Hustedt 1930, p. 123, fig, 101; Elenkin 1914 I, p. 325.

Found by Elenkin (l. c.) in several localities in Kamtchatka. I have found the species in small numbers and without cell contents in 3 samples: 1526, 2527, U. N. II.

According to Boye Petersen 1943, p. 93 ..... halophobous.

## Raphidioideae.

## Eunotioideæ.

### *__Eunotia diodon__ Ehrb. f. **minor** V. Heurck

V. Heurck Syn. pl. 33, fig. 5.

Occurred in few specimens without cell contents in 1 sample (2527). Hustedt (Rabh. Krypt. Fl. p. 276) gives f. *minor* as a simple synonym of the species, and perhaps there is not sufficient reason to keep this little form distinct.

The species, according to Schulz (1928)... halophobous.

### *__Eunotia exigua__ (Bréb.) Rabh.

Hustedt 1930, p. 176, fig. 223.

Occurred in large numbers in 4 samples from the hot spring near the Savan river as well as from the spring near the Siku river. Specimens with cell contents were seen in samples 2527 (8.2 %) and 2530 (10.9 %), at 52° and 73° C. In addition in samples 2528 (58.8 %), 2533 (3.3 %) and 3037 (1.6 %).

According to Boye Petersen 1943, p. 69... halophobous.

### *Eunotia Faba (Ehrb.) Grun.

HUSTEDT 1930, p. 183, fig. 246.

Observed in small numbers and without cell contents in the hot spring near Natchika (3237).

According to HUSTEDT (Rabh. Krypt. Fl. VII, 2, p. 302) the species occurs principally in swamps and springs and is presumably ........................................ halophobous.

### Eunotia lunaris (Ehrb.) Grun.

HUSTEDT 1930, p. 183, fig. 249; *Pseudoeunotia lunaris* ELENKIN 1914 I, p. 330.

ELENKIN (l. c.) found the species in a couple of localities in Kamtchatka, but not in any hot spring.

I have seen it in 11 samples in all, principally from hot springs, but never with cell contents.

1516, 1521, 1526, 2527, 2528 (2.6 %), 2530 (4.7 %), 2533 (2.2 %), 3184, 3232, 3237, 3239, Paratunka 29°.

According to BOYE PETERSEN 1943, p. 70.... halophobous.

### *Eunotia monodon Ehrb.

HUSTEDT in Rabh. Krypt. Fl. VII, 2, p. 305, fig. 772 a.

Found in 6 samples from hot springs, and in 4 of them with cell contents, namely from Paratunka (1507 — 25°) and from Bannaja (3180 — 46° (1.9 %), 3184 — 46° (0.5 %), 3187 — 35° (6.8 %)). Further in samples 1516 (0.8 %), 3232.

According to HUSTEDT 1938, p. 172 ........ halophobous.

### *Eunotia parallela Ehrb.

HUSTEDT in Rabh. Krypt Fl. VII, 2, p. 302, fig. 768.

Only found in few specimens in "Malenki klutchik" (3140) and without cell contents. According to HUSTEDT (l. c.) especially in sphagnum swamps, and according to KOLBE (1937) .... halophobous.

### *Eunotia pectinalis (Kütz.) Rabh.

HUSTEDT 1930, p. 180, fig. 237.

Found in 7 samples, 6 of which were from hot springs and 1 from the cold affluent to a hot spring. In 2 samples only was it found in large numbers and with cell contents, namely from "Malenki klutchik" (3141 – 29° (1.4 %), 3142 – 29° (35.5 %)). Further in the following samples: 1514, 1521, 1525, 1526, 3184.

According to Boye Petersen 1943, p. 70 ................ halophobous.

***Eunotia pectinalis** (Kütz.) Rabh. var. **minor** (Kütz.) Rabh.

Hustedt in Rabh. Krypt. Fl. VII, 2, p. 298, fig. 763 l—o.

Small forms of the species occurred in 9 samples, all from hot springs, but as a rule in small amount and without cell contents. Only in 2 samples from the hot spring near the Savan river (2530 – 73° (12.5 %), 2528 – 50°) do I think I have seen specimens with endochrome. Found, in addition, in: 1516, 2527 (1.5 %), 2533 (2.2 %), 3139, 3232 (1.1 %), 3237, 3716. Like the species it is presumably ....................... halophobous.

***Eunotia polydentula** Brun

Hustedt in Rabh. Krypt. Fl. VII, 2, p. 292; *E. tridentula* Ehrb. var. *perminuta* Grun. Hustedt 1930, p. 180, fig. 233.

Found in few specimens in 5 samples, 3 from hot springs, 1 from the cold affluent to a hot spring, 1 without statement of locality.

1526 (0.2 %), 2528, 3037 (3.9 %), Paratunka 29° (0.3 %), U. N. I.

According to Schulz 1928.................. halophobous.

***Eunotia praerupta** Ehrb. var. **muscicola** Boye P.

Boye Petersen 1928 I, p. 377, fig. 3.

Found in 2 samples from hot springs: 2527, 3144 (0.4 %).

According to Boye Petersen (1928) and Hustedt (1938) it occurs principally in springs and I therefore take it to be: halophobous.

***Eunotia suecica** A. Cl.

Hustedt 1930, p. 174, fig. 210.

Occurred in small numbers in the hot spring near Bannaja (3232). The place of the species in the Halobion system has not yet been cleared up ........................................ ?

***Eunotia tenella** (Grun.) Hust.

HUSTEDT 1930, p. 175, fig. 220.

Occurred in the hot spring near the Savan river (2533 (6.7 %)) and in an unlabelled sample.

According to BOYE PETERSEN 1943, p. 70... halophobous.

**Eunotia** sp.: 3138 (0.6 %).

# Monoraphideae

## Achnanthoideae

***Achnanthes Biasolettiana** Kütz.

HUSTEDT 1930, p. 199, fig. 289, Rabh. Kr. Fl. VII, 2, p. 379, fig. 823 V. HEURCK Types Nr. 237.

Occurred in the hot spring "Malenki klutchik" (Bannaja) at temperatures of 29° and 60° C., but no living specimens were seen, and altogether there were very few.

3142, 3144 (0.4 %).

HUSTEDT (l. c.) thinks that it is a brackish water species and so at least .............................. halophilous.

***Achnanthes Clevei** Grun. var. **rostrata** Hust.

HUSTEDT 1930, p. 204, fig. 295; V. HEURCK Syn. Pl. 27, figs. 5—7.

In the contour of the valves this species very much resembles certain forms of *A. Hauckiana* Grun., but in striation the two species are quite different, *A. Clevei* having very fine striae on the lower valve (20—24 in 10 $\mu$), which in addition are distinctly punctate, while *A. Hauckiana* has coarse striae on the lower valve also (10—15 in 10 $\mu$).

It is therefore undoubtedly wrong of CLEVE-EULER (1932, pp. 58 and 60) to give *A. Hauckiana* SCHULZ (1926, p. 191, fig. 38—40) as a synonym of *A. Clevei*. SCHULZ has plainly drawn coarse striae on both valves.

Only few specimens seen and only empty valves.

3703.

Concerning the place of the species in the Halobion system see BOYE PETERSEN 1943, p. 57.................. indifferent.

### *Achnanthes exigua Grun.

Hustedt 1930, p. 201, fig. 288, Rabenh. Kryptogfl. VII. 2, p. 386, fig. 832.

This species is probably spread all over the world. It occurs in fresh water and in hot springs. Hustedt (Rabh. Kr. Fl. p. 387) mentions that it is extremely eurythermal as he has found it alive at 8°—10° C. and in tropical hot springs at 40°—45° C. I have observed it in 35 samples in all, principally from hot springs, and with cell contents in 8 samples. Corresponding to what Hustedt has found, the temperature in these springs was 29°—46° C. Cf. also Schwabe 1936, p. 517.

The 8 samples containing individuals with cell contents are from the springs near Paratunka (1513 — 37°, 1514 — 32°, 1521 — 32°, and without number — 29° and 41°), at the Siku river (3037 — 42°), at Bannaja (3180 — 46°, 3187 — 35°). It should be noted that the species in many of these samples occurred in very large numbers. Altogether it was found in the following samples:

1507 (9.2 %), 1513 (96.1 %), 1514 (0.2 %), 1516 (1.5 %), 1521 (28.3 %), 1525, 1526, 3037 (28.9 %), 3060, 3118, 3137 (0.5 %), 3138 (3.9 %), 3139 (2.3 %), 3140 (2.0 %), 3141 (1.4 %), 3144 (0.4 %), 3180 (71.2 %), 3182, 3184 (38.0 %), 3187 (68.9 %), 3232 (4.2 %), 3234 (1.2 %), 3236, 3237 (4.5 %), 3239, 3703, 3712, 3720 (0.2 %), 3716 (0.5 %), 3719 (0.7 %), 4328 (35.9 %), 4329, Paratunka 29° (39.6 %), 41° (87.6 %), U. N. I, cold stream near camp 4.

For its place in the Halobion system see Boye Petersen 1943, p. 58. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . indifferent.

### *Achnanthes Hauckiana Grun. var. rostrata Schulz forma.

Schulz 1926, p. 191, fig. 40, Hustedt in Rabh. Kr. Fl. VII, 2, pag. 388. Fig. nostra 6.

The form found differs from the typical var. *rostrata* in being somewhat more finely striated. While Schulz (l. c.) gives 10—12 striae in 10 μ, the form found by me has about 15 striae in 10 μ, both on the upper and the lower valve, while in all other respects it

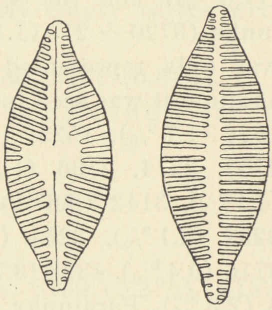

Fig. 6. *Achnantes Hauckiana* Grun. var. *rostrata* Schulz forma. × 1700.

resembles SCHULZ's picture. Under *A. Clevei* I have pointed out that the form figured by SCHULZ cannot be identical with *A. Clevei* as CLEVE-EULER thinks.

I have only seen empty valves of this form.

3703, 3716, 3720.

According SCHULZ (1928).................. mesohalobous.

### *Achnanthes hungarica Grun.

HUSTEDT 1930, p. 201, fig. 203; CLEVE Syn. II, p. 190.

Of this species, which is common in fresh water, few specimens without cell contents were found in the bottom mud from the hot spring near Unkanakchek (4328 (3.7 %)).

By KOLBE (1927) and SCHULZ (1928) it is mostly regarded as halophobous; but HUSTEDT (1938, 1939) merely gives it as oligohalobous. For the present I will regard it as .......... indifferent.

### Achnanthes lanceolata (Bréb.) Grun.

HUSTEDT 1930, p. 207, fig. 306 a; ELENKIN 1914 I, p. 291.

ELENKIN (l. c.) curiously enough only records this species from one locality, a hot spring with 53° C. It is therefore listed under "Euthermophilae" on p. 116.

I have found it in 37 samples in all. Only in 5 of these were specimens with cell contents observed, the 4 being from hot springs, namely from Paratunka (1514 — 32°), "Malenki klutchik" (3138 — 66° (1.3 %)), Garaschie Gara (3703 — 16° (17.6 %)), and the spring at the middle course of the Paratunka (3720 — 21° (1.1 %)). It should be noted that the species was only represented by few specimens in these samples. In addition it was seen in the following samples: 1507, 1516 (0.8%), 1521 (1.7 %), 1525, 1526 (2.7 %), 2527 (1.0 %), 2528 (0.7 %), 2533, 2974, 3136 (1.3 %), 3137 (2.2 %), 3140 (2.9 %), 3141 (4.1 %), 3142 (0.6 %), 3144 (2.3 %), 3180, 3182, 3184 (1.0 %), 3232 (2.1 %), 3234 (0.6 %), 3236, 3237 (7.8 %), 3239, 3712, 3716 (0.4 %), 4328 (3,7 %), 4329 (1.8 %), cold stream near camp 4 (2.3 %), Paratunka 29° (1.6 %), 25° (0.4 %) and 41° (1.3 %), U. N. I and II.

According to BOYE PETERSEN 1943, p. 58 ..... indifferent.

***Achnanthes lanceolata** (Bréb.) Grun. var. **capitata** O. Müll.

Hustedt 1930, p. 208; A. l. var. *Haynaldii* Cl. Syn. II, p. 192.

Found in 18 samples in all, but with cell contents in one sample only (1417, fresh water stream, Akhomten Bay). In addition it occurred in the following samples: 1507, 2974, 3118 (0.5 ‰), 3136 (0.2 ‰), 3137 (1.3 ‰), 3138, 3139 (4.5 ‰), 3140 (1.0 ‰), 3141 (1.8 ‰), 3144 (1.2 ‰), 3182, 3184 (0.3 ‰), 3716, 4328 (1.9 ‰), 4329, cold stream near camp 4, U. N. I, Paratunka 41°.

Presumably, like the species .................. indifferent.

***Achnanthes lanceolata** (Bréb.) Grun. var. **rostrata** (Østr.) Hust.

Hustedt in Rabh. Krypt. Fl. VII, 2. p. 410, fig. 863 i—m.

This form was found in 7 samples, as a rule in company with the species, and I have only seen specimens with cell contents in 1 sample from the hot spring near the middle reach of the Paratunka river (3720 — 21°). Seen, in addition, in the following samples:

3180 (1.2 ‰), 3184 (1.7 ‰), 3187 (5.3 ‰), 3232, 3703 (1.7 ‰), 4328.

Presumably, like the species .................. indifferent.

***Achnanthes linearis** W. Sm.

Hustedt 1930, p. 198, fig. 276.

Occurred in 5 samples in all, but only empty valves were observed.

1512 (21.0 ‰), 1526, 2528 (0.7 ‰), 2530, 3137 (0.8 ‰).

According to Boye Petersen 1943, p. 58 ..... indifferent.

***Achnanthes marginulata** Grun.

Hustedt 1930, p. 205, fig. 299.

Found as dead valves in 3 samples: 3139 (0.2 ‰), 3182, 3237 (2.2 ‰). According to Hustedt in Rabh. Krypt. Fl. VII, 2, the species inhabits wet rocks and moss, according to Hustedt (1939) it is oligohalobous. I take it to be..... halophobous.

***Achnanthes minutissima** Kütz. var. **cryptocephala** Grun.

HUSTEDT 1930, p. 198, fig. 275.

Occurred in 10 samples, principally from hot springs. In no case was it possible to find cells with contents.

2533 (1.1 ‰), 3176, 3232 (3.2 ‰), 3236, 3237 (2.2 ‰), 3239, 3702, 3716 (0.3 ‰), 3719 (9.5 ‰), 4328 (1.9 ‰).

As to the place of the species in the Halobion system see BOYE PETERSEN 1943, p. 59 ...................... indifferent.

***Achnanthes Peragalli** Brun et Héribaud

HUSTEDT 1930, p. 207, fig. 300.

This on the whole not very common species was only found in 2 samples and without cell contents.

3712, cold stream near camp 4.

According to HUSTEDT 1939, p. 610 ........... indifferent.

**Achnanthes** sp.: 3234 (0.7 ‰).

**Cocconeis pediculus** Ehrb.

HUSTEDT 1930, p. 188, fig. 259; ELENKIN 1914 I, p. 289.

I have come across empty valves of the species in 3 samples: 3138, 3141 (0.4 ‰), cold stream near camp 4.

According to BOYE PETERSEN 1943, p. 62...... indifferent.

**Cocconeis placentula** Ehrb.

HUSTEDT 1930, p. 189, fig. 260; ELENKIN 1914 I, p. 290.

ELENKIN (l. c.) only records this species from a single locality. I found it one of the most commonly occurring Diatoms (in 27 samples in all). It was found with cell contents in samples from hot springs near Paratunka (1507 — 25° (57.5 ‰), 1514 — 32° (19.9 ‰)), near Bannaja (3182 — temp. ?), and at the middle course of the Paratunka river (3716 — 10°, 3719 — 35° (26.0 ‰), 3720 — 21° (0.4 ‰)), that is to say, at temperatures between 10° and 35°. Found in addition in the following samples: 1516 (33.8 ‰), 1521 (1.8 ‰), 1525, 1526 (0.2 ‰), 2528, 2974, 3138, 3139, 3140, 3141 (0.9 ‰), 3142 (1.3 ‰), 3144 (0.4 ‰), 3184 (0.5 ‰), 3703, 3712, 4328 (5.7 ‰), 4329, cold stream near camp 4 (0.4 ‰), Paratunka 29° (0.7 ‰), 25° (3.0 ‰), and 41°.

According to BOYE PETERSEN 1943, p. 62...... indifferent.

***Cocconeis scutellum** Ehrb. var. **parva** Grun.

HUSTEDT 1930, p. 192, fig. 268.

A single valve of this form found in a sample from the hot spring near the Savan river (2528). Presumably this valve has been accidentally carried to this locality.

According to BOYE PETERSEN 1943, p. 62.. mesohalobous.

***Eucocconeis lapponica** Hust.

HUSTEDT 1930, p. 194, fig. 272.

Observed in few specimens in a sample from "Malenki klutchik" (3137) without cell contents.

According to BOYE PETERSEN 1943, p. 69 ... halophobous.

**Rhoicosphenia curvata** (Kütz.) Grun.

HUSTEDT 1930, p. 211, fig. 311; ELENKIN 1914 I, p. 288.

ELENKIN (l. c.) found the species in several places in the peninsula, but not in any hot spring. I have observed it in 15 samples in all, most of which were from hot springs. Specimens with cell contents occurred in 5 samples from hot springs, namely from Paratunka (1514 – 32° (1.0 $^0/_0$)), "Malenki klutchik" (3141 — 29°), Bannaja (3182 — temp. ?), Garaschie Gara (3703 — 16° (5.1 $^0/_0$)) and near the middle reach of the Paratunka (3720 — 21° (1.6 $^0/_0$)). Also seen in the following samples: 1507 (0.8 $^0/_0$), 1521 (0.4 $^0/_0$), 1525, 1526 (0.5 $^0/_0$), 3118, 3140, 4328 (1.9 $^0/_0$), cold stream near camp 4, Paratunka 29° and 41° (0.2 $^0/_0$).

According to BOYE PETERSEN 1943, p. 89 ..... indifferent.

## Biraphideae.

### Naviculoideae.

***Amphora Normanii** Rabh.

HUSTEDT 1930, p. 343, fig. 630.

This small species, which is common on earth, moss, and rocks, occurred in 14 samples in all, principally from hot springs. Specimens with cell contents occurred in a sample from the hot spring near Bannaja (3184 — 46°) and in the spring on

Garaschie Gara (3703 — 16°). Seen in addition in the following samples: 1512, 1521 (0.4 ‰), 3138, 3139, 3140 (0.5 ‰), 3144 (0.4 ‰), 3170, 3180 (0.2 ‰), 3182, 3232 (6.3 ‰), 3236 (1.6 ‰), 3237 (5.6 ‰).

According to Hustedt 1938, p. 414......... halophobous.

### Amphora ovalis Kütz.

Hustedt 1930, p. 342, fig. 628; Elenkin 1914 I, p. 284.

Elenkin (l. c.) records the species from several localities, amongst others from hot springs with temperatures of 11.5° — 35° C.

I have noted the species in 17 samples, principally from hot springs. In most of the samples there were, however, only empty valves. Only in 2 was I able to establish the presence of cell contents in some of the specimens, namely from the spring by the middle reach of the Paratunka river (3716 — 10° (0.1 ‰), 3720 — 21° (0.1 ‰)); in addition in the following samples: 1526 (0.2 ‰), 2528, 2533, 2974, 3037, 3118, 3138, 3139 (0.2 ‰), 3232 (1.1 ‰), 3234, 3237, 3703 (0.6 ‰), 3712, 4328, Paratunka 29°.

According to Boye Petersen 1943, p. 60...... indifferent.

### *Amphora ovalis Kütz. var. pediculus Kütz.

Hustedt 1930, p. 343, fig. 629.

Found in 18 samples in all, principally from hot springs. With cell contents in the hot spring on Garaschie Gara (3703 — 16° (2.3 ‰)) and in "Malenki klutchik" (3138 — 66° (2.0 ‰)). In addition in the following samples: 2527 (0.5 ‰), 2533 (1.1 ‰), 2974, 3137 (1.9 ‰), 3139 (1,0 ‰), 3140 (0.5 ‰), 3141 (1.8 ‰), 3142 (0.6 ‰), 3144 (0.8 ‰), 3182, 3184 (0.3 ‰), 3712, 3716 (0.1 ‰), 4328 (3.8 ‰), cold stream near camp 4 (0.4 ‰), U.N. II.

According to Boye Petersen 1943, p. 60...... indifferent.

### *Amphora perpusilla Grun.

Hustedt 1930, p. 343, fig. 627.

Found in 3 samples only, and merely empty valves.

1521, 2527 (0.5 ‰), 2528.

According to Boye Petersen 1930........... indifferent.

### *Amphora veneta Kütz.

Hustedt 1930, p. 345, fig. 631; Cl. Syn. II, p. 118.

This species is known from all parts of the world and no doubt occurs in very different environments, e. g. both in fresh water and in brackish water. It was found in 13 samples in all from hot springs. In 6 of these the occurrence of cells with cell contents was observed. These samples were derived from the following hot springs: Karymchina (3118 — 14° (93.5 %)), "Malenki klutchik" (3141 — 29° (2.8 %), 3142 — 29° (18.4 %)), Natchika (3234 — 27° (3.2 %)), Bannaja (3184 — 46° (3.3 %)), Paratunka (unnumbered — 25° (8.2 %)). Its most luxuriant growth was seen in sample 3118. Further, it occurred in the following samples: 1521 (0.4 %), 3117 (0.9 %), 3137 (0.2 %), 3140 (1.5 %), 3180 (2.1 %), 3187 (1.0 %), 3703 (1.7 %).

According to Boye Petersen 1943, p. 60...... indifferent.

### *Anomoeoneis exilis (Kütz.) Cl.

Hustedt 1930, p. 264, fig. 429; V. Heurck Syn. Pl. 12, fig. 11—12.

Grunow (V. H. l. c.) has figured a *N. serians* var. *thermalis* which is referred by Cleve (Syn. II, p. 8) to *A. exilis*. It is not stated where Grunow found this form, but the name would seem to indicate that it was derived from a hot spring.

Found in 7 samples in all and especially in the samples from the hot spring at Natchika where they were very numerous. In 3 samples from Natchika (3234 — 27° (83.9 %), 3236 — 38° (82.0 %), 3237 — 40° (6.7 %)) there were individuals with cell contents. In these samples were seen different variants of the species, amongst others some corresponding to var. *thermalis* Grun.

Found in addition in the following samples: 2533 (1.1 %), 3232 (12.6 %), 3239, U. N. II.

According to Boye Petersen 1943, p. 60...... indifferent.

### Anomoeoneis sphærophora (Kütz.) Pfitzer

Hustedt 1930, p. 262, fig. 422; Elenkin 1914 I, p. 274.

Found by Elenkin in one locality at 25° C. I came across a few specimens from the hot spring near Natchika (3237 (1.1 %)) and Bannaja (3232).

According to Boye Petersen 1943, p. 61.... halophilous.

### *Caloneis bacillum (Grun.) Mereschk.

Hustedt 1930, p. 236, fig. 360; *C. fasciata* Cl. Syn. I, p. 50; *Stauroneis Bacillum* Grun. 1863, p. 155, Tab. 13, fig. 16.

Recognizing that the many forms which it is attempted to distinguish in V. H. Syn. can hardly be kept distinct by means of the characters given there, Cleve (l. c.) has resolutely united all these forms into one species which he calls *Caloneis fasciata* (Lagst.). The choice of this name is not very fortunate, however, for there can hardly be any doubt that the species was first called *Stauroneis bacillum* by Grunow, which name the author himself later altered to *Navicula lacunarum* (V. H. Syn. pl. 12, fig. 31). This, however, does not warrant the rejection of the specific name *bacillum*, which should be retained even if the species is transferred to another genus. It is correct therefore of Mereschkowsky (1906, p. 12) to call it *C. bacillum* (Grun.).

Hustedt (1930, p. 236) has separated *N. fasciata* Lagerst. from the other forms and referred it to *Pinnularia*, evidently because of a note on V. H. Syn. Pl. 12, fig. 34, in which Grunow expresses the opinion that *N. fasciata* is in reality a *Pinnularia*. I have seen an abundance of forms belonging to this species, amongst others also the typical *N. fasciata*; but I cannot find any difference in structure between this form and the other forms of *N. bacillum*. I have therefore also previously dissociated myself from Hustedt's view (B. P. 1935, p. 141).

But so much is certain that *Caloneis bacillum* is a polymorphous species whose forms merge. For the present it will no doubt be best to treat the species as a collective species, though this is unsatisfactory, because the various forms probably also show ecological differences (Boye Petersen 1932, p. 17).

Forms of the species were found in 21 samples in all, nearly all of them from hot springs. Specimens with cell contents were found in 3 samples, namely from the hot springs at Paratunka (1507 — 25° (6.7 ‰), 1521 — 32°) and from a hot spring near the Siku river (3037 — 42° (26.5 ‰)). Further seen in the following samples: 1516 (0.8 ‰), 1526 (0.7 ‰), 3060, 3118, 3137 (1.0 ‰), 3138, 3139 (1.3 ‰), 3141 (0.4 ‰), 3170, 3180 (0.4 ‰), 3182, 3184 (0.3 ‰), 3232 (1.0 ‰), 3237 (3.3 ‰), 3239, Paratunka 29° (0.7 ‰) and 25°, U. N. I.

According to Boye Petersen 1943, p. 61 ...... indifferent.

### *Caloneis bannajensis n. sp.

Fig. nostra 7.

Valva lineari, apicibus rotundatis, long. 28.5$\mu$, lat. 6.8$\mu$. Area apicali angusta, centrali rotundata, striis radiantibus usque ad apices, 18 in 10$\mu$; linea apicali marginali.

Found in small number in sample 3144 ("Malenki klutchik"). Place in the Halobion system .......................... ?

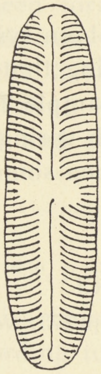

Fig. 7. *Caloneis bannajensis* n. sp. × 1700.

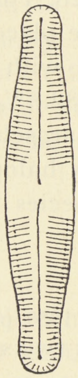

Fig. 8. *Caloneis Hultenii* n. sp. × 1700.

### *Caloneis Hultenii n. sp.

? *C. Clevei* HUSTEDT 1930, p. 236, fig. 359; Fig. nostra 8.

Valva symmetrica, lineari-lanceolata, subcapitata, long. 28—34$\mu$, lat. 5—6$\mu$; striis in media parte radiantibus, prope apices convergentibus, 22—24 in 10$\mu$; area apicali anguste-lanceolata, in medio in fasciam transapicalem dilatata. Linea apicali distincta prope marginem valvæ.

That the form figured by HUSTEDT (l. c.) cannot be identical with *Navicula Clevei* Lagerstedt (1873, p. 34, Pl. 1, fig. 10) will easily be seen on a comparison of the figures; neither the form of the cell nor the striae are alike; notably *N. Clevei* has almost parallel striae, while HUSTEDT's form has markedly radiating and converging striae. On the other hand, it bears a striking resemblance to the forms found by me in everything except the size, the limits of its dimensions being stated to be 47—65$\mu$ in length, 8.5—14$\mu$ in breadth. Hence I will not venture to identify with certainty *C. Clevei* HUSTEDT with the form found by me.

This species proved to be not uncommon in the hot springs of Kamtchatka, being found there in 13 samples in all. In 4 samples I found specimens with cell contents, namely from Paratunka (1507 — 25° (0.8 ‰), 1512 — 45°), Bannaja (3176 — temp. ?) and the spring at the upper Paratunka (3702 — 12°–13° (82.8 ‰)). In addition it was seen in the following samples: 3170, 3180 (0.2 ‰), 3184, 3232 (1.0 ‰), 3234 (0.7 ‰), 3237, 3701 (2.9 ‰), 4328, Paratunka 29° (1.3 ‰).

As to the place of the species in the Halobion system nothing can be said with certainty. It is worth noting that this species constitutes 82.8 ‰ of all individuals in a sample from the hot spring on Garaschie Gara (3702), from which spring I have also found many halophobous forms. There is then some probability that this species too is halophobous ...................... ?

### **Caloneis silicula** (Ehrb.) Cl.

Hustedt 1930, p. 236, fig. 362; Elenkin 1914 I, p. 273; *Navicula limosa* f. *truncata* Gutwinski 1891, p. 305.

Elenkin (l. c.) has not found the species himself but cites Gutwinski's find. I have observed the species (without cell contents) in the following samples: 1521 (0.7 ‰), 1525, 1526, 3232 (1.0 ‰), 3237.

According to Boye Petersen 1943, p. 61 ..... indifferent.

### ***Caloneis silicula** (Ehrb.) Cleve var. **inflata** (Grun.) Cleve

Cl. Syn. I, p. 51.

Some few specimens found in the following samples: 2533, 2974.

Presumably like the species .................. indifferent?

### ***Caloneis silicula** (Ehrb.) Cl. var. **truncatula** Grun.

Hustedt 1930, p. 238, fig. 363, 364; Cl. Syn. I, p. 52.

Some few specimens found in 3 samples, but with cell contents only from the hot spring near the middle course of the Paratunka river (3716 — 10° (0.1 ‰)). Further in samples 1516, 3139.

According to Boye Petersen 1943, p. 61 ..... indifferent.

**Caloneis** sp.: 4329 (0.9 %).

**Cymbella aspera** (Ehrb.) Cl.

HUSTEDT 1930, p. 356, fig. 580; *C. gastroides* ELENKIN 1914 I, p. 280.

According to ELENKIN (l. c.) the species has been observed in material from Kamtchatka and has been mentioned in several places by the name *Cocconema kamtchaticum* Grun.

I have seen forms which must be referred to this species in 2 samples from hot springs; but only empty valves were observed. 3232, 3712. KOLBE (1927) and SCHULZ (1928) call the species indifferent, while HUSTEDT (1938) terms it an oligohalobous littoral and spring form. Must therefore be regarded as indifferent.

***Cymbella Brehmii** Hust.

HUSTEDT 1930, p. 363, fig. 673.

The species found in 2 samples without cell contents: 1526, U. N. I. According to HUSTEDT's remarks (l. c.) about its occurrence it must probably be regarded as ....... halophobous.

**Cymbella cistula** (Hempr.) Grun.

HUSTEDT 1930, p. 363, fig. 676 a; ELENKIN 1914 I, p. 282.

ELENKIN (l. c.) found the species in hot springs at temperatures of 17°—19° and 24°. In one sample only did I find cells with cell contents, namely from the hot spring near the middle reach of the Paratunka river (3720 — 21°). Further seen in the following samples: 1526, 3136 (0.6 %), 3139, 3140, 3141, 3144, cold stream near camp 4.

According to BOYE PETERSEN 1943, p. 64 ..... indifferent.

**Cymbella cuspidata** Kütz.

HUSTEDT 1930, p. 357, fig. 650; ELENKIN 1914 I, p. 279.

CLEVE (Syn. I, p. 166) cites finds of this species from Kamtchatka without giving any locality. I have seen a few specimens without cell contents in 3 samples: 3138, 3139, 3141 (0.5 %).

According to BOYE PETERSEN 1943, p. 64..... indifferent.

### **Cymbella cymbiformis** (Ag.) Van Heurck

Hustedt 1930, p. 362, fig. 671; Elenkin 1914 I, p. 281.

Elenkin has noted the species from several localities in Kamtchatka but not from any hot spring. I have found it with cell contents in a sample from the hot spring near the middle reach of the Paratunka river (3716 — 10°).

According to Boye Petersen 1943, p. 64 ..... indifferent.

### *__Cymbella gracilis__ (Rabh.) Cleve

Hustedt 1930, p. 359, fig. 663.

Occurred in small number and without cell contents in 2 samples: 1526, Paratunka 29°.

According to Boye Petersen 1943, p. 64... halophobous.

### **Cymbella naviculiformis** Auersw.

Hustedt 1930, p. 356, fig. 653; Elenkin 1914 I, p. 279.

Elenkin notes this species from Kamtchatka but not from any hot spring. I have found empty valves of it in 4 samples from hot springs: 3139 (0.2 ‰), 3144, 3703, 3712.

Kolbe (1927) and Schulz (1938) record the species as indifferent, whereas Hustedt (1938) calls it oligohalobous. ... indifferent.

### *__Cymbella perpusilla__ A. Cl.

A. Cleve 1895, p. 19, Pl. 1, fig. 13.

Found in small number and only as empty valves in a total of 7 samples from hot springs: 3139 (0.2 ‰), 3140, 3141, 3144, 3170, 3712, 3716 (0.1 ‰).

According to Hustedt 1938, p. 428 ....... halophobous.

### *__Cymbella pusilla__ Grun.

Hustedt 1930, p. 354, fig. 646.

Found in small number in 4 samples from hot springs; but no specimens with cell contents were seen: 3232 (1.0 ‰), 3236, 3237 (2.2 ‰), 3239.

According to Boye Petersen 1943, p. 66 ... halophilous.

### *Cymbella sinuata Greg.

HUSTEDT 1930, p. 361, fig. 668.

Occurred in small amount and without cell contents in 11 samples from hot springs: 2528, 3137, 3138 (0.7 %), 3139, 3141 (0.5 %), 3142, 3144, 3182, 3184, 3712, 3716.

According to BOYE PETERSEN 1943, p. 66..... indifferent.

### Cymbella ventricosa Kütz.

HUSTEDT 1930, p. 359, fig. 661; *Encyonema ventricosum* ELENKIN 1914 I, p. 283.

This very common and widely distributed species was only observed by ELENKIN in comparatively few samples from Kamtchatka and not from any hot spring. In the present material I have noted it in 32 samples in all, most of them from hot springs. In 10 of the samples I have seen specimens with cell contents. 3 of these samples are not provided with indication of the temperature. The 7 remaining samples are derived from "Malenki klutchik" (3137 — 77° (0.8 %), 3138 — 66° (5.9 %), 3139 — 66° (1.5 %), 3141 — 29° (0.9 %), 3144 — 60° (1.2 %)), the spring by the middle course of the Paratunka river (3716 — 10° (0.2 %)) and Unkanakchek (4329 — 12° (18.2 %)). Further it was seen in the following samples: 1417 (11.5 %), 1526 (0.2 %), 2527 (1.0 %), 2528 (2.0 %), 2530 (7.8 %), 2533 (6.7 %), 2974, 3037, 3118, 3136 (5.6 %), 3140 (1.5 %), 3142, 3182, 3184 (0.3 %), 3236, 3237 (1.1 %), 3703 (1.1 %), 3712, 3720 (0.1 %), 4328, cold stream near camp 4 (1.3 %), Paratunka 29°, 41°, U. N. I and II.

According to BOYE PETERSEN 1943, p. 66..... indifferent.

### Cymbella sp.: 1521 (0.4 %) 4329 (1.8 %).

### *Diatomella Balfouriana Grev.

HUSTEDT 1930, p. 214, fig. 312.

This species I have only found in small numbers and without cell contents in one of the samples from "Malenki klutchik": 3140. HUSTEDT (1938, p. 208) states that it is oligohalobous, aërophilous, the leading form in aërated biotopes in springs and waterfalls.

Hence it must presumably be regarded as.... halophobous.

**Didymosphenia geminata** (Lyngbye) M. Schmidt

HUSTEDT 1930, p. 367, fig. 682; *Gomphonema geminatum* ELENKIN 1914 I, p. 286.

Of this large and conspicuous species I have only seen few specimens and only with cell contents from the outfall of the warm rivulet from the springs at Bannaja (3182 — temp.?). Seen in addition in the following samples: 2527 (0.5 ‰), 4329, U. N. II.

Place in the Halobion system ........................ ?

**Diploneis elliptica** (Kütz.) Cl.

HUSTEDT 1930, p. 250, fig. 395.

Only found in few specimens and without cell contents: 3144.

According to BOYE PETERSEN 1943, p. 67 ..... indifferent.

**Diploneis ovalis** (Hilse) Cleve

HUSTEDT 1930, p. 249, fig. 390; ELENKIN 1914 I, p. 237.

ELENKIN states that the species was found by GUTWINSKI; it is, however, *Navicula oblongella* = *Diploneis ovalis* var. *oblongella*, which the latter has mentioned. ELENKIN himself found the species in a single locality not of a thermal nature.

In the present material it occurred in small numbers in 5 samples from hot springs. Only in one of them were cells with contents seen, namely from "Malenki klutchik" (3137 — 77°). Further in the following samples: 2533, 3138, 3140, 3232.

According to BOYE PETERSEN 1943, p. 67 ..... indifferent.

***Diploneis ovalis** (Hilse) Cleve var. **pumila** Cleve

Seen in small number and without cell contents in a sample from "Malenki klutchik" (3139).

According to KOLBE (1927) and SCHULZ (1928) ........ indifferent.

***Diploneis pseudovalis** Hust.

HUSTEDT 1930, p. 253, fig. 403.

This species occurred in small number in 8 samples, partly from hot springs, partly from a cold stream (1526). In this sample specimens with cell contents were found. In addition it occurred in the following samples: 1521, 3140, 3141, 3232 (2.1 ‰), 3234 (0.7 ‰), 3237, 3249.

Concerning the habitat of the species HUSTEDT (l. c.) states that it is a brackish water species. I have therefore for the present classed it as ...................... mesohalobous?

**Diploneis** sp.: 3037 (0.8 ‰).

*__Frustulia rhomboides__ (Ehrb.) De Toni var. **saxonica** (Rabh.) De Toni

HUSTEDT 1930, p. 221, fig. 325.

ELENKIN (1914 I, p. 277) does not mention var. *saxonica*; but he must be presumed to have seen this very widely distributed variety, but not to have distinguished it from the species. The latter he found in several hot springs at temperatures of 17°—35°.

According to ELENKIN, *Schizonema viridulum* GUTWINSKI 1891, p. 358 is = *Frustulia rhomboides*. The name *Schizonema viridulum* is not mentioned by CLEVE in Synopsis, whereas he has given one of GUTWINSKI's synonyms, *Colletonema viridulum*, according to CLEVE Syn. I, p. 123 = *Frustulia rhomboides* var. *viridula*.

I found *F. rhomboides* var. *saxonica* in 12 samples from hot springs and cold streams. 6 samples from hot springs contained individuals with cell contents, namely the 4 samples from the hot springs near the Savan river (2527 — 52° (2.0 ‰), 2528 — 50° (3.4 ‰), 2530 — 73° (12.5 ‰), 2533 — 63° (4.4 ‰)), one from Bannaja (3176 — temp. ?), and one from the spring on Garaschie Gara (3701 — temp. ? (2.6 ‰)). Seen in addition in the following samples: 1526, 3037 (0.8 ‰), 3170, 3237, Paratunka 29° (0.3 ‰), U. N. II.

According to KOLBE (1927), SCHULZ (1928), and HUSTEDT (1938) this species is halophobous. KRIEGER (1930, p. 142) says: hardly lacking in any high moor. ............. halophobous.

*__Frustulia vitrea__ Østr.

ØSTRUP 1901, p. 262, fig. 30; BOYE PETERSEN 1932, p. 17, fig. 3; 1935, p. 142; *Navicula vitrea* HUSTEDT 1930, p. 289, fig. 489.

Mrs. A. CLEVE-EULER (1934, p. 84) has identified the small *Navicula* species which I recorded from Iceland (1928 II, p. 16, fig. 3) with *Navicula festiva* Krasske. This is correct and has already been established earlier (BOYE PETERSEN 1932 l. c.); but at the same time it was cleared up that *N. festiva* Krasske is = *Frustulia vitrea* Østr., and the species must then retain the specific name *vitrea*, even though it is thought best (like HUSTEDT l. c.) to refer it to the genus *Navicula*. CLEVE-EULER further suggests that the species is actually an *Achnanthes*; but this is by no means the case. Partly I have seen the raphe on both valves in many specimens, partly I must refer the reader to my drawing of the cell in girdle view (B. P. 1932, p. 17, fig. 3), which shows a quite symmetrical form.

Found in 10 samples in all, and in 3 of these with cell contents. For the 2 of them (3176, 3701 (45.6 ‰)) no temperature is recorded; the third is from the hot spring on Garaschie Gara (3702 — 12°-13° (7.8 ‰)). Further seen in the following samples: 1526, 2527, 2533, 3139 (0.2 ‰), 3140 (0.5 ‰), 3232 U. N. II.

According to my experience this species must be regarded as halophobous; I have found it on peaty soil and among Sphagnum. Recorded from similar localities by KRIEGER (1929 and 1930). halophobous.

### *Frustulia vulgaris Thwaites

HUSTEDT 1930, p. 221, fig. 327.

Found in 5 samples from hot springs, but without cell contents, namely in: 2530, 2974, 3180 (0.2 ‰), 3237, 3712. Several authors (KOLBE 1927, SCHULZ 1928, SPRENGER 1930) have classed the species as halophobous; but HUSTEDT (1938, p. 216) regards it as indifferent (not halophobous). I have therefore thought it most cautious for the present to call it ................ indifferent.

### *Frustulia vulgaris Thw. var. capitata Krasske

HUSTEDT 1930, p. 221, fig. 328.

Found in small numbers in 1 sample: 1521.

Place in the Halobion system ........................ ?

### Gomphonema acuminatum Ehrb.

HUSTEDT 1930, p. 370, fig. 683; ELENKIN 1914 I, p. 287.

The species is stated by ELENKIN (l. c.) to have been found in hot springs in Kamtchatka at temperatures of 11.5°—35° C. I have found it in 9 samples from the peninsula, chiefly from hot springs, but nowhere did I see specimens with cell contents, and they always occurred in small numbers: 1525, 1526, 3180, 3184, 3712, 3720, Paratunka 29° (0.7 ‰), 25°, 41°.

According to Boye Petersen 1943, p. 72 ...... indifferent.

***Gomphonema acuminatum** Ehrb. var. **Brebissonii** (Kütz.) Cl.

Hustedt 1930, p. 370, fig. 685.

Found in small numbers and without cell contents in 2 samples: 3716, 3720.

According to Boye Petersen 1943, p. 72 ...... indifferent.

***Gomphonema acuminatum** Ehrb. var. **trigonocephala** (Ehrb.) Grun.

Hustedt 1930, p. 371, fig. 686.

A few valves found in one sample: 1525.

According to Kolbe (1927), Schulz (1828), and Hustedt (1939) oligohalobous and so presumably .......... indifferent.

***Gomphonema angustatum** (Kütz.) Rabh. var. **productum** Grun.

Hustedt 1930, p. 373, fig. 693.

Found in 15 samples in all, always in somewhat small numbers, and I have not seen specimens with cell contents: 2528 (0.6 ‰), 2530 (3.2 ‰), 3136 (0.2 ‰), 3137 (0.2 ‰), 3138 (3.3 ‰), 3139 (1.0 ‰), 3144, 3234 (0.7 ‰), 3237 (4.4 ‰), 3703 (0.6 ‰), 3716 (0.2 ‰), 4328 (1.9 ‰), Paratunka 25° (0.9 ‰), 29° (2.9 ‰), and 41° (0.8 ‰).

According to Kolbe (1927) oligohalobous, indifferent, and according to Schulz (1928) oligohalobous .......... indifferent.

***Gomphonema bohemicum** Reichelt und Fricke

Hustedt 1930, p. 377, fig. 718.

Found in small numbers and without cell contents in 1 sample: 3180 (0.2 ‰). Place in the Halobion system ............. ?

**Gomphonema gracile** Ehrb. var. **dichotomum** W. Sm.

Cleve Syn. I, p. 182; V. Heurck Syn. Pl. 24, fig. 19—21; *G. gracile* Elenkin 1914 I, p. 287.

Found by Elenkin in one locality only and not in any hot spring. I have likewise only found this form in 1 sample and without cell contents (3037 (0.8 ‰)).

KOLBE (1927) classes it as indifferent, while SCHULZ (1928) and HUSTEDT (1939) merely call it oligohalobous. . . . . . . . . . . indifferent.

***Gomphonema lanceolatum** Ehrb. var. **insignis** (Greg.) Cleve

HUSTEDT 1930, p. 376, fig. 701.

Occurred in small number and without cell contents in 1 sample (3139). According to KOLBE (1927) and SCHULZ (1928) indifferent, while HUSTEDT (1938, 1939) calls it oligohalobous. indifferent.

**Gomphonema olivaceum** (Lyngb.) Kütz.

HUSTEDT 1930, p. 378, fig. 719; GUTWINSKI 1891, p. 360; ELENKIN 1914 I, p. 288.

The species was recorded from Kamtchatka already by GUTWINSKI; later it was observed by ELENKIN. In HULTÉN's material I have found empty valves of it in 8 samples, chiefly from hot springs: 2527, 2528, 2533, 2974, 3137, 3182, 4329 (1.8 $^0/_0$), U. N. II.

According to BOYE PETERSEN 1943, p. 74 . . . . . indifferent.

***Gomphonema olivaceum** (Lyngb.) Kütz. var. **minutissimum** Hust.

HUSTEDT 1930, p. 378, fig. 720.

Observed in 2 samples from hot springs, but without cell contents and in small number: 3144, 3182.

Probably like the species . . . . . . . . . . . . . . . . . . indifferent.

***Gomphonema parvulum** (Kütz.) Grun.

HUSTEDT 1930, p. 372, fig. 713 a.

This species was exceedingly common in the samples, even though it was only found in small number in some of them. Observed in 43 samples in all, and in 7 samples specimens with cell contents were seen. These samples were from the hot spring near the Savan river (2528 — 50°, 2530 — 73° (21.8 $^0/_0$)), "Malenki klutchik" (3138 — 66° (2.6 $^0/_0$), 3142 — 29° (0.7 $^0/_0$)), the hot spring near the middle course of the Paratunka river (3716 — 10° (0.3 $^0/_0$), 3720 — 21° (0.2 $^0/_0$)) and finally in the hot spring in

Paratunka (unnumbered — 29° (6.4 %)). Seen in addition in the following samples: 1417, 1512 (0.5 %), 1513 (0.2 %) 1516 (2.3 %), 1525, 1526 (0.2 %), 2527 (18.9 %), 2533 (2.2 %), 3037 (11.6 %), 3060, 3118 (0.2 %), 3137 (0.5 %), 3139 (1.6 %), 3140 (1.5 %), 3141 (1.4 %), 3144, 3176, 3180 (0.2 %), 3182, 3184 (1.7 %), 3187 (0.5 %), 3232 (1.0 %) 3236, 3237 (3.4 %), 3239, 3702 (1.6 %), 3703 (1.1 %), 3712, 3719 (0.3 %), 4328, 4329 (0.9 %), cold stream near camp 4 (0.2 %), Paratunka 25°, 41°, U. N. I and II.

Hustedt (1938, p. 434) notes that the species is entirely absent from the hot springs of Java and Sumatra, from which he concludes that it is temperate-stenothermal. The experience from Kamtchatka does not confirm this view, the species having been found here in numerous hot springs and being alive in springs with temperatures of 10°—73°.

According to Boye Petersen 1943, p. 74 ..... indifferent.

***Gomphonema parvulum** (Kütz.) Grun. var. **micropus** (Kütz.) Cl.

Hustedt 1930, p. 373, fig. 713 c.

Found in small numbers and without cell contents in 3 samples: 1514, Paratunka 29°, U. N. I.

According to Kolbe (1927) and Hustedt (1938) ....... indifferent.

***Gomphonema subclavatum** Grun.

Cleve Syn. II, p. 183; *G. montanum* v. *subclavatum* V. Heurck Syn. Pl. 23, fig. 39—43; *G. longiceps* v. *subclavatum* Hustedt 1930, p. 375, fig. 705.

Found in small numbers and without cell contents in 2 samples from hot springs: 1521 (0.4 %), 3719 (0.4 %).

According to Boye Petersen 1943, p. 74 .............. halophilous?

***Gomphonema ventricosum** Gregory

Hustedt 1930, p. 377, fig. 716.

Found in small numbers and without cell contents in 5 samples: 2533, 2974, 4329, Paratunka 29° (0.3 %), U. N. II.

Place in the Halobion system ...................... ?

**Gomphonema** sp.: 3037 (3.1 %), 3141 (0.5 %), 3144 (0.7 %).

***Navicula anglica** Ralfs

Hustedt 1930, p. 303, fig. 530, 531.

Only some few empty valves found in one sample: 3237. According to Kolbe (1927) indifferent, while Schulz (1928) and Hustedt (1938, 1939) class it as oligohalobous ....... indifferent.

***Navicula bacillum** Ehrb.

Hustedt 1930, p. 280, fig. 465.

Found in small numbers and without cell contents in one sample: 1507. Kolbe (1927) and Schulz (1928) regard the species as indifferent-halophobous, while Hustedt (1928) records it as indifferent. For the present I will regard it as... indifferent.

***Navicula bacillum** Ehrb. forma **trinodis** n. f.

Fig. nostra 9.

Valva lineari, medio et apicibus inflatis, long. 63 μ, lat. 13.3 μ, striis in medio 12 in 10 μ, ad apices 18 in 10 μ.

This form which is somewhat deviating in shape was only found in one sample and in few specimens: 3237 (1.1 %).

In the Halobion system it has presumably the same place as the type ............................ indifferent?

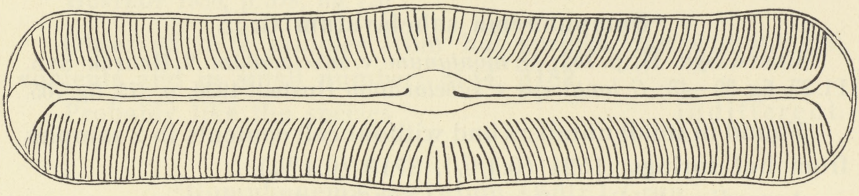

Fig. 9. *Navicula bacillum* Ehrb. f. *trinodis* n. f. × 1700.

***Navicula bannajensis** n. sp.

Fig. nostra 10.

Valva lanceolata, long. 20 μ, lat. 6.7 μ, striis radiantibus, distincte punctatis, 18 in 10 μ, punctis circiter 20 in 10 μ. Area apicali angusta, centrali rotundata.

This species of which I have only seen one specimen is nearly allied to *Navicula infirma* Grun. (Foss. Diat. Østerr.-Ungarns, p. 146, Taf. XXX, f. 53) but differs from it by another form of the valve and a coarser punctuation. 3139.

Place in the Halobion system ...................... ?

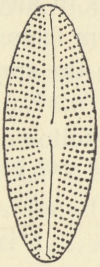

Fig. 10. *Navicula bannajensis* n. sp. × 1700.

Fig. 11. *Navicula bryophila* Boye P. × 1700.

### *Navicula brekkaensis Boye P.

Boye Petersen 1928 I, p. 389, fig. 16; Hustedt 1938, p. 242, Taf. XVIII, fig. 24—27.

Seen only in few specimens without cell contents in 3 samples from hot springs: 3139, 3144, 3701 (0.4 %).

According to Hustedt's information (l. c.) about its life conditions it must be presumed to be ........... halophobous.

### *Navicula bryophila Boye P.

Boye Petersen 1928, I, p. 388, fig. 13; Hustedt 1938, p. 248, Taf. 18, fig. 18—23. Fig. nostra 11.

Found in 2 samples from hot springs, but without cell contents: 3144 (0.8 %), 3170.

### *Navicula Cari Ehrb.

Hustedt 1930, p. 299; *N. cincta* v. *cari* Cl. Syn. II, p. 17.

Observed in small numbers in a sample from a hot spring: 3232 (1.1 %).

According to Hustedt (1938) oligohalobous and probably indifferent.

### *Navicula cincta (Ehrb.) Kütz.

Hustedt 1930, p. 298, fig. 510.

Only noted in one sample: 3182.

According to Boye Petersen 1943, p. 77 ... halophilous.

### **Navicula cryptocephala** Kütz.

Cleve Syn. II, p. 14; Van Heurck Syn., Pl. VIII, fig. 1, 5; Elenkin 1914 I, p. 269.

Elenkin (l. c.) did not observe this species in any hot spring. I have seen it in 9 samples in all, most of them from hot springs. With cell contents I saw it in 2 samples from the spring near the middle reach of the Paratunka (3716 — 10° (0.3 °/₀), 3720 — 21° (0.2 °/₀)). In addition it was found in the following samples: 1507 (0.8 °/₀), 1526 (0.2 °/₀), 3144, 3237 (4.5 °/₀), 3239, 3703 (1.1 °/₀), U. N. I.

According to Boye Petersen 1943, p. 78 .... indifferent.

### *Navicula cryptocephala Kütz. var. angusta Boye P.

Boye Petersen 1928 I, p. 399, fig. 21.

This small variety was seen in small numbers in 2 samples from hot springs and in one from newly formed marsh: 2974, 3138, 3140 (0.5 °/₀). Place in the Halobion system ....... ?

### *Navicula cryptocephala Kütz. var. exilis Kütz.

Cleve Syn. II, p. 14; V. Heurck Syn., Pl. 8, fig. 2, 4.

Seen in 2 samples only, and without cell contents: 1513 (0.2 °/₀), 2974.

According to Boye Petersen 1943, p. 78 .... indifferent.

### *Navicula cryptocephala Kütz. var. veneta (Kütz.) Grun.

Hustedt 1930, p. 295, fig. 497 a.

Seen in few specimens without cell contents in one sample: 1521 (1.8 °/₀).

According to Boye Petersen 1943, p. 79 it is indifferent; but since all authors mostly agree that it is halophilous but also very euryhaline, it may be safe to regard it as......

halophilous.

### *Navicula cuspidata Kütz.

Cl. Syn. I, p. 109.

Found in small numbers in affluents to the hot spring near Paratunka: 1526.

According to Boye Petersen 1943, p. 79 .... indifferent.

### *Navicula dicephala (Ehrb.) W. Sm.

Hustedt 1930, p. 302, fig. 526.

Found in small numbers in 5 samples but without cell contents, partly from hot springs, partly from newly formed marsh: 2974, 3138, 3139, 3184, 3239.

According to Boye Petersen 1943, p. 80 .... indifferent.

### *Navicula fossalis Krasske

A. S. Atl. Taf. 396, fig. 46, 47. Fig. nostra 12.

The forms found by me correspond closely in dimensions to the figures in A. S. Atlas: length 10 $\mu$, breadth 3.5 $\mu$, striae in the middle: 18 in 10 $\mu$, towards the apices closer; only the valve is somewhat more lanceolate in shape. This species is highly reminiscent of *N. Saugerri* Desm. (V.H. Syn., Pl. 14, fig. 8 a), which by Cleve (Syn. I, p. 128) is united with *N. Seminulum*. This is hardly right, but unfortunately the figure i V. H. is not distinct enough to establish the identity. Probably the species should be called *N. Saugerri*.

Fig. 12. *Navicula fossalis* Krasske. × 1700.

Found in small numbers in a sample from the hot spring near the Savan river (2533 (1.1 $^0/_0$)), but in large amount (34.6 $^0/_0$) from the spring on Garaschie Gara: 3701.

*N. fossalis* was found by Krasske in sphagnum tufts, so it is presumably halophobous, sphagnophilous ... halophobous.

### *Navicula gastrum Ehrb. var. exigua (Greg.) Grun.

Cl. Syn. II, p. 23; V. H. Syn., Pl. 8, fig. 32.

Seen in 3 samples in all, 2 of which were from hot springs: 2974, 3703, 3716.

Regarded by Kolbe (1927) as indifferent (euryhaline?), while Schulz (1928) thinks that it is slightly halophilous. For the present I presume that it is best regarded as ... indifferent.

### *Navicula gothlandica Grun.

Hustedt 1930, p. 296, fig. 499.

Found in small numbers in a sample from the hot spring on Garaschie Gara: 3703.

Place in the Halobion system ........................ ?

### *Navicula gregaria Donk.

HUSTEDT 1930, p. 269, fig. 437.

Found in 15 samples in all, most of them from hot springs; but I have seen no specimens with cell contents: 1521, 1526 (1.1 ‰), 3137 (0.2 ‰), 3139, 3140 (2.4 ‰), 3141 (0.4 ‰), 3180 (0.2 ‰), 3184, 3232, 3237 (1.1 ‰), 3703 (2.3 ‰), 3716, 3719, 3720, 4329 (1.8 ‰).

According to BOYE PETERSEN 1943, p. 80 . . . halophilous.

### *Navicula hungaria Grun. var. capitata (Ehrb.) Cl.

HUSTEDT 1930, p. 298, fig. 508.

Found in 6 samples in all, chiefly from hot springs. Cell contents were seen in specimens in a sample from the hot spring near the middle course of the Paratunka river: 3720 — 21° (0.3 ‰). In addition it was found in the following samples: 1526, 3184, 3703, 3712, 3716.

According to KOLBE (1927) and BUDDE (1930) it is halophilous, while SCHULZ (1928) regards var. *capitata* as indifferent. I should think that it will be best to regard it as . . . . . . . halophilous.

### *Navicula importuna Hust.

HUSTEDT 1942, p. 67, fig. 24, 25. Fig. nostra 13.

As HUSTEDT (l. c.) too remarks, this species comes very near to *N. minuscula* Grun. (V. HEURCK Syn., Pl. 14, fig. 2, 3), and I am not quite convinced that the two species are not identical. The specimens found by me had the following dimensions: length 13.4 μ, breadth 4.3 μ, striae 36—40 in 10 μ in the middle, somewhat closer at the apices. That I have determined it as HUSTEDT's species is due chiefly to the raphe and its surrounding more silicified area. Whether anything similar is found in *N. minuscula* cannot be seen in the figures, and unfortunately VAN HEURCK's collection contains no preparation with this species. I have not been able to detect the short striae in the middle of the valve which HUSTEDT mentions (l. c.). Occurred in small numbers in a sample from "Malenki klutchik": 3139.

Fig. 13. *Navicula importuna* Hustedt. × 1700.

Originally found by HUSTEDT among moss and liver wort in the bed of a rivulet in a wood. I therefore presume that it is .................................... halophobous?

### *Navicula laterostrata Hust.

HUSTEDT 1930, p. 301, fig. 521.

Seen only in small amount in a cold affluent to the hot spring in Paratunka: 1526.

Place in the Halobion system ........................ ?

### *Navicula minima Grun.

CLEVE Syn. I, p. 128; VAN HEURCK Syn., Pl. 14, fig. 15, 16. Fig. nostra 14.

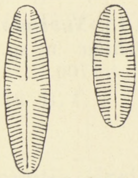

Fig. 14. *Navicula minima* Grun. ×1700.

This species is among the most commonly occurring in the samples and is often present in large numbers, thus in sample 1512, where it constitutes 48.2 %. Found in 28 samples in all, and in 5 of these, specimens with cell contents were seen, namely from the hot spring in Paratunka (1507 — 25° (11.7 %), 1514 — 32° (0.8 %)), "Malenki klutchik" (3139 — 66° (1.5 %)), Bannaja (3176 — temp. ?, 3187 — 35° (11.1 %)). In addition seen in the following samples: 1512 (48.2 %), 1513 (0.2 %), 1516 (1.5 %), 1526 (0.7 %), 1521 (2.4 %), 3138 (3.9 %), 3140 (1.0 %), 3141 (1.4 %), 3144 (0.8 %), 3180 (4.8 %), 3182, 3184 (3.7 %), 3232 (1.1 %), 3237, 3239, 3703 (7.4 %), 3716 (0.3 %), 3719 (2.3 %), 3720 (0.3 %), 4328 (3.7 %), Paratunka 29° (1.3 %), 25° (0.9 %), U. N. I.

According to BOYE PETERSEN 1943, p. 81 .... indifferent.

### *Navicula mutica Kütz. f. Cohnii (Hilse) Grun.

CLEVE Syn. I, p. 129; V. HEURCK Syn., Pl. 10, fig. 17.

Occurred in 3 samples only, and in small numbers: 2974, 3170, 3144. In earlier days *Navicula mutica* and its varieties were regarded as brackish water forms (V. HEURCK Traité p. 206, CLEVE (l. c.)). Recently it has become clear that it should rather be regarded as a terrestrial species (BOYE PETERSEN 1915, P. 287, 1928, p. 391). Designated by SCHULZ (1928) as oligohalobous, while Hustedt (1939) considers the species and its varieties as halophilous and euryhaline.

According to my experience it would be best to call it . . indifferent.

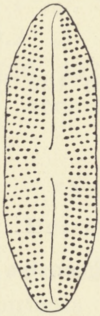

Fig. 15. *Navicula Natchikœ* n. sp. × 1700.

### *Navicula Natchikæ n. sp.

Fig. nostra 15.

Valva lineari, apicibus cuneatis, long 24 μ, lat. 7 μ, striis 18—20 in 10 μ, punctis 18—20 μ. Area apicali angusta, centrali rotundata, striis radiantibus.

This new species, of which I have only seen few whole frustules, must be referred to *Naviculae punctatae*.

Occurred in 2 samples, namely from the hot spring near Paratunka (1513 — 37°) and a hot spring near Natchika (3234 — 27°).

Place in the Halobion system . . . . . . . . ?

### *Navicula Paratunkæ n. sp.

Fig. nostra 16.

Valvis lineari-lanceolatis, apicibus levissime productis. Poris centralibus raphes approximatis. Long. 15 μ, lat. 2.8 μ, striis 24 in 10 μ, in medio radiantibus, ad apices convergentibus. Area centrali minuta, rotundata.

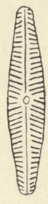

Fig. 16. *Navicula Paratunkœ* n. sp. × 1700.

This small species is related to *N. tenelloides* Hustedt (1938 p. 269, Taf. 19, fig. 13); but it differs distinctly from that species by the finer striae, which are strongly divergent and convergent.

Found in 2 samples: Hot spring near Paratunka (1512 — 45° (8.0 ‰)) and in this were seen cells with cell contents and hot spring near Paratunka 29° (0.3 ‰).

Place in the Halobion system . . . . . . . . . . . . . . . . . . . . . . ?

### *Navicula perpusilla Grun.

Hustedt 1930, p. 278, fig. 459.

Occurred in small amount and without cell contents in 1 sample: 3139.

Place in the Halobion system . . . . . . . . . . . . . . . . . . . . . . ?

**Navicula placenta** Ehrb.

Hustedt 1930, p. 290, fig. 492; Elenkin 1914 I, p. 272; *N. Rostellum* Gutwinski 1891, p. 305.

Elenkin (l. c.) merely cites Gutwinski's find. I have seen some few specimens without cell contents in 2 samples: 3141, 3239.

According to Boye Petersen 1943, p. 81 . . . . indifferent.

*__Navicula placentula__ (Ehrb.) Grun.

Cleve Syn. II, p. 23; *N. Gastrum* v. *Placentula* V. Heurck Syn., Pl. VIII, fig. 26, 28.

Found in few specimens in the sample from the bathing spring at Paratunka (41°). According to Kolbe (1927) indifferent, while Schulz (1928) and Hustedt (1938, 1939) designate it as oligohalobous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . indifferent.

*__Navicula placentula__ (Ehrb.) Grun. f. **minuta** n. f.

Fig. nostra 17.

Long. 29 μ, lat. 10 μ, striis 11—15 in 10 μ, punctis circiter 30 in 10 μ. Area centrali transversa.

Is somewhat reminiscent of *N. amphibola* Cl. but differs from it by the much finer punctuation of the striae, nearly lineate; in addition it is much smaller and has finer striae.

Occurred in a few specimens in 3 samples, but was not seen with cell contents: 1526, 2528, 4328.

Place in the Halobion system . . . . . . . . ?

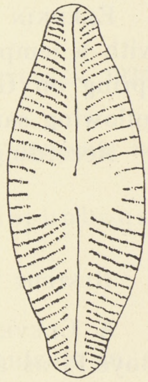

Fig. 17. *Navicula placentula* Ehrb. *forma minuta* n. f. ×1700.

**Navicula pupula** Kütz.

Hustedt 1930, p. 281, fig. 467 a; Elenkin 1914 I, p. 271.

Found by Elenkin in 3 localities in Kamtchatka, but not in hot springs. I have found a few empty valves in 4 samples: 3139, 3237, 3720 (0.2 $^0/_0$), 4328 (1.9 $^0/_0$).

According to Boye Petersen 1943, p. 82 . . . . indifferent.

### *Navicula pupula Kütz. var. capitata Hust.

Hustedt 1930. p. 281, fig. 467 c.

Found in small numbers in 6 samples, partly from cold water, partly from hot springs: 1516, 1521, 1525, 1526, 2974, 3716 (0.1 %). Nothing is known about its place in the Halobion system, but I presume that like the species it is . . indifferent.

### Navicula radiosa Kütz.

Hustedt 1930, p. 299, fig. 513; Elenkin 1914, I, p. 268.

Not found by Elenkin (l. c.) in any hot spring. I have come across it in 4 samples in small numbers. From the hot spring near the middle course of the Paratunka river it was found with cell contents (3720 — 21°). In addition in the following samples: 1526 (0.2 %), 3232, 3712, 3716 (0.2 %).

According to Boye Petersen 1943, p. 82 . . . . indifferent.

### Navicula rhynchocephala Kütz.

Hustedt 1930, p. 296; Elenkin 1914 I, p. 269.

Elenkin states that the species was found in a hot spring with a temperature of 11.5° C. I have found it alive in the hot spring on Garaschie Gara (3703 — 16° (0.6 %)). Also in the following samples: 1526 (0.2 %), 3716, 3720.

According to Boye Petersen 1943, p. 82 . . . . indifferent.

### *Navicula rotaeana (Rabh.) Grun.

Hustedt 1930, p. 273, fig. 445.

A. Cleve-Euler (1934, p. 85) gives *Achnanthes kryophila* Boye P. as a synonym of this species. This is a mistake, since *A. kryophila* really is an *Achnanthes*, as I have ascertained by examining the whole frustule.

The species was observed in a total of 12 samples from hot springs, but always in small numbers and without cell contents: 2527, 3136, 3137, 3139 (1.3 %), 3140, 3141 (1.4 %), 3144 (0.8 %), 3182, 3237, 3712, 3716 (0.1 %), 3720 (0.2 %).

According to Boye Petersen 1943, p. 83 . . . . indifferent.

### *Navicula salinarum Grun.

HUSTEDT 1930, p. 295, fig. 498; V. HEURCK Types Nr. 95.

Found with cell contents in a sample from a hot spring near Unkanakchek (4329 — 12° (2.7 $^0/_0$)).

According to BOYE PETERSEN 1943, p. 83 . . mesohalobous.

### *Navicula seminulum Grun.

HUSTEDT 1930, p. 272, fig. 443.

Found in small amount in one sample: 3703 (1.1 $^0/_0$).

According to HUSTEDT (1939) oligohalobous. Probably indifferent.

### *Navicula tantula Hust.

A. S. Atl., Taf. 399, fig. 54—57; HUSTEDT 1935, p. 383. Fig. nostra 18.

This small species was found in 3 samples partly from a cold rivulet, partly from the hot spring "Malenki klutchik"; but I was unable to find specimens with cell contents.

Occurred in the following samples: 3137, 3141 (0.9 $^0/_0$), cold rivulet near camp 4 (0.4 $^0/_0$).

Place in the Halobion system . . . . . . . . ?

Fig. 18. *Navicula tantula* Hustedt. × 1700.

### *Navicula tridentula Krasske

HUSTEDT 1930, p. 276, fig. 456; *N. bidentula* BOYE PETERSEN 1928, p. 388, fig. 14.

Found in small numbers only and without cell contents in 1 sample: 3139.

According to BOYE PETERSEN 1930, p. 39 . . . halophobous.

### *Navicula variostriata Krasske

HUSTEDT 1930, p. 273, fig. 447.

Found in small numbers and without cell contents in 1 sample: 3144.

According to BOYE PETERSEN 1943, p. 83 . . . halophobous.

### *Navicula viridula Kütz.

HUSTEDT 1930, p. 297, fig. 503.

Specimens with cell contents were found in a sample from the hot spring near the middle course of the Paratunka river

(3720 — 21° (0.2 ‰)). Further in small numbers in the following samples: 2974, 4329.

According to Boye Petersen 1943, p. 84 .... indifferent.

***Navicula viridula** Kütz. var. **rostellata** (Kütz.) Cleve

Cl. Syn. II, p. 15; V. Heurck Syn., Pl. 8, fig. 23; Hustedt 1930, p. 297, fig. 502.

Found in 10 samples in all from hot springs. With cell contents in 6 samples, namely from Karymchina (3118 — 14°) and "Malenki klutchik" (3136 — 70° (3.0 ‰), 3137 — 70° (2.2 ‰), 3138 — 66° (1.3 ‰), 3139 — 66° (0.2 ‰), 3141 — 29°). In addition in the following samples: 3140 (0.5 ‰), 3144 (0.4 ‰), 3184, 3720 (0.5 ‰). Schulz (1928) thinks that perhaps it is halophilous, while Hustedt (1938, 1939) merely calls it oligohalobous. For the present I will designate it as ............ halophilous?

***Navicula viridula** Kütz. var. **slesvicensis** (Grun.) Cleve

Hustedt 1930, p. 297.

Found in one sample (3712) but without cell contents. Kolbe (1927) considers it halophilous (or at most euryhaline—indifferent), and Budde (1932) likewise thinks that it is halophilous. Schulz (1928) classes it as indifferent. For the present I will regard it as ......................... halophilous.

***Navicula vulpina** Kütz.

Hustedt 1930, p. 297, fig. 504.

Seen in one sample only, and without cell contents: 3239. Place in the Halobion system ...................... ?

**Navicula** sp.: 1512 (0.5 ‰), 1513, Paratunka 29° (0.6 ‰), 41° (0.2 ‰), 3037 (16.4 ‰), 3232 (2.1 ‰), 3719 (0.4 ‰), 4329 (1.8 ‰).

***Neidium affine** (Ehrb.) Cleve

Hustedt 1930, p. 242, fig. 376.

Found only in one sample in small numbers and without cell contents: 2533. Schulz (1928) considers it halophobous;

but HUSTEDT (1938) merely terms it oligohalobous. For the present I will presume that it is ...................... indifferent.

***Neidium affine** (Ehrb.) Cl. var. **amphirhynchus** (Ehrb.) Cl.

HUSTEDT 1930, p. 243, fig. 377.

Met with in small numbers and without cell contents in 4 samples: 1526 (0.2 ‰), Paratunka 29° (1.0 ‰), U. N. I, II.

According to BOYE PETERSEN (1943, p. 84). . halophobous.

***Neidium bisulcatum** (Lagerst.) Cl.

HUSTEDT 1930, p. 242, fig. 374.

Found in rather a small amount and without cell contents in 1 sample: 3702 (1.6 ‰). It is true that SCHULZ (1928) has classed it as halophobous, but for the present I will regard its position in the Halobion system as doubtful ........... ?

***Neidium iridis** (Ehrb.) Cl.

HUSTEDT 1930, p. 245, fig. 379.

Found in small numbers and without cell contents in 4 samples: 1526, 3037, 3140, Paratunka 29° (0.3 ‰).

According to BOYE PETERSEN 1943, p. 84 . . . halophobous.

**Neidium iridis** (Ehrb.) Cl. var. **ampliata** (Ehrb.) Cl.

HUSTEDT 1930, p. 245, fig. 381.

Occurred in small numbers and without cell contents in 1 sample: 1525.

According to BOYE PETERSEN 1943, p. 84 . . . halophobous?

***Neidium iridis** (Ehrb.) Cl. var. **amphigomphus** (Ehrb.) V. Heurck

HUSTEDT 1930, p. 245, fig. 382.

Found in small numbers in 3 samples, of these with cell contents in a sample from the hot spring in Natchika (3237 — 40° (1.1 ‰)). Also in 1512, 2527 (0.5 ‰).

According to SCHULZ (1928) ............... halophobous?

***Pinnularia acrosphæria** Bréb.

Hustedt 1930, p. 330, fig. 610.

Found in small numbers only, and without cell contents in 1 sample: 3237.

According to Boye Petersen 1943, p. 87 . . . indifferent?

**Pinnularia appendiculata** (Ag.) Cleve

Hustedt 1930, p. 317, fig. 570 a; Elenkin 1914 I, p. 266; *Navicula appendiculata* Gutwinski 1891, p. 357.

Recorded from Kamtchatka already by Gutwinski and later found by Elenkin (l. c.) at temperatures of 25°—53° C. I myself have observed a small form in the hot spring near the Savan river (2528) but only dead valves.

According to Kolbe (1927) and Sprenger (1930) it is halophilous, while Hustedt (1938) classes it as oligohalobous.

Halophilous?

***Pinnularia appendiculata** (Ag.) Cl. var. **irrorata** Grun.

Boye Petersen 1928, p. 401, fig. 22.

Found in small numbers in 1 sample: 2974.

According to Hustedt (1939) it is oligohalobous. For the present I will not attempt to place it in the Halobion system ?

**Pinnularia borealis** Ehrb.

Hustedt 1930, p. 326, fig. 597; Elenkin 1914 I, p. 263; Gutwinski 1891, p. 303.

Evidently Elenkin did not see this species himself but cites Gutwinski's find. It is common knowledge that the species is most widely distributed on the surface of the soil and among mosses, hence scattered valves are frequently found in samples from water. Thus I have found it in 16 samples in all, but everywhere in few specimens and merely empty valves: 1513 (0.2 %), 1521, 2527, 2528 (0.6 %), 3137, 3139, 3141, 3144, 3170, 3176, 3182, 3184, 3703, 4328, Paratunka 25° (0.4 %), 41°.

According to Boye Petersen 1943, p. 88 . . . . indifferent.

***Pinnularia Braunii** (Grun.) Cl.
var. **amphicephala** (A. Mayer) Hustedt

HUSTEDT 1930, p. 319, fig. 578.

Found in no small numbers (5.1 %) in one sample from the hot spring near the Savan river (2527 — 52°), but without cell contents.

According to HUSTEDT (1938) the species is considered indifferent—halophobous and grows best in acid water. In contrast herewith v. *amphicephala* is said to thrive best at pH 7.5 and at high temperatures, being therefore regarded as an ecological variety. I think it best to regard it as . . . indifferent.

***Pinnularia brevicostata** Cleve

HUSTEDT 1930, p. 329, fig. 609.

Occurred in small numbers in 2 samples and merely empty valves: 2974, 3138; according to HUSTEDT (1938) oligohalobous and therefore presumably . . . . . . . . . . . . . . . . . . . . indifferent?

***Pinnularia divergentissima** (Grun.) Cleve

HUSTEDT 1930, p. 320, fig. 581.

Found in no small numbers in 1 sample (2533 — 11.2 %), but no individuals with cell contents were seen.

No information is available as to the place of the species in the Halobion system . . . . ?

Fig. 19. *Pinnularia divergentissima* (Grun.) Cl. var. *subrostrata* A. Cl. ×1700.

***Pinnularia divergentissima** (Grun.) Cl.
var. **subrostrata** A. Cl.

A. CLEVE 1895, p. 10, Pl. 1, fig. 5; Fig. nostra 19.

Occurred in small numbers and without cell contents in 2 samples: 3139, 3703. Nothing is recorded as to its place in the Halobion system. ?

***Pinnularia gentilis** (Donk.) Cleve

HUSTEDT 1930, p. 335, fig. 618.

Found in small numbers in 2 samples. In one of these from the hot spring near the middle course of the Paratunka river there occurred specimens with cell contents (3720 — 21°). Also in 1526. According to KOLBE (1927) it is indifferent, while SCHULZ (1928) and HUSTEDT (1938) class it as oligohalobous....... indifferent.

**Pinnularia gibba** Ehrb.

HUSTEDT 1930, p. 327, fig. 600; ELENKIN 1914, p. 264.

ELENKIN (l. c.) states that the species was found in water of a temperature of 25°—55° C. I have seen it in 9 samples in all. With cell contents specimens occurred in a sample from the hot spring near the Savan river (2533 — 63° (4.4 %)), but in most cases merely in small numbers and without cell contents: 1526 (0.2 %), 2527 (0.5 %), 3176, 3232 (1.1 %), 3237 (1.1 %), 3720, Paratunka 29° (0.3 %), 41°.

According to HUSTEDT (1938, 1939) it is oligohalobous and thus presumably........................... indifferent.

**Pinnularia gibba** Ehrb. var. **parva** (Ehrb.) Grun.

HUSTEDT 1930, p. 327, fig. 603: *P. parva* ELENKIN 1914 I, p. 264; *P. stauroptera parva* GUTWINSKI 1891, p. 304.

Mentioned by ELENKIN and GUTWINSKI (l. c.) but without statement of temperature. I have come across it in 5 samples from hot springs. Specimens with cell contents were observed in a sample from the hot spring near Bannaja (3180 — 46°); also seen in the following samples: 1514, 1516, 3184, 3712.

Of its place in the Halobion system nothing is recorded. ?

***Pinnularia gibba** Ehrb. f. **subundulata** Mayer

HUSTEDT 1930, p. 327, fig. 601.

Found in small numbers and without cell contents in 2 samples: 1521, 2974. Of its place in the Halobion system nothing is known.................................. ?

***Pinnularia globiceps** Greg. var. **Krookii** (Grun.) Cl.

HUSTEDT 1930, p. 319, fig. 580.

Occurred in small numbers in a cold affluent to the hot spring in Paratunka (1526 (0.2 %)). KOLBE (1927) gives its place in the Halobion system as dubious, while Schulz (1928) classes it as oligohalobous. For the present I will regard its position in the system as doubtful ..................... ?

### *Pinnularia interrupta W. Sm. f. minor Boye P.

Boye Petersen 1928 I, p. 405, fig. 25.

Elenkin mentions the species *P. interrupta* from temperatures of 25°—30°. I have found f. *minor* in small number in 4 samples. In the unnumbered sample from Paratunka (29°) there were some few specimens with cell contents. Further it was found in the following samples: 3170, 3176. According to Schulz (1928) and Hustedt (1938, 1939) the species is oligohalobous, indifferent, and Hustedt (1939) seems to think that f. *minor* occupies the same position ..................... indifferent.

### *Pinnularia leptosoma Grun.

Hustedt 1930, p. 316, fig. 567.

Occurred in small numbers and without cell contents in 2 samples: 3237, 3239.

According to Schulz (1928) halophobous, while Hustedt (1938) calls it halophobous—indifferent ...... Halophobous.

### Pinnularia major (Kütz.) Cleve

Hustedt 1930, p. 331, fig. 614; Elenkin 1914 I, p. 261.

Occurred in small numbers and without cell contents in 1 sample: 3232 (1.1 %).

According to Kolbe (1927) it is indifferent, whereas Schulz (1928) and Hustedt (1938) class it as oligohalobous .... indifferent.

### Pinnularia mesolepta (Ehrb.) W. Sm.

Hustedt 1930, p. 319, fig. 575a; Elenkin 1914 I, p. 266.

Elenkin (l. c.) found the species in several localities but not in hot springs. I have seen empty valves of it in 5 samples in all: 2528, 2974, 3141 (0.9 %), 3712, 4329.

According to Boye Petersen 1943, p. 88... halophobous.

***Pinnularia microstauron** (Ehrb.) Cleve

Hustedt 1930, p. 320, fig. 582.

Found in small numbers and without cell contents in 2 samples: 2974, 3139.

According to Boye Petersen 1943, p. 88 . . . . . indifferent.

***Pinnularia molaris** Grun.

Hustedt 1930, p. 316, fig. 568.

Occurred in small numbers and without cell contents in 3 samples: 3037 (0.8 %), 3170, 3702 (4.6 %).

According to Schulz (1928) oligohalobous; the exact place of the species in the Halobion system is therefore uncertain . . ?

***Pinnularia Lagerstedtii** (Cl.) A. Cl. var. **minuta** Østr.

*P. parva* v. *minuta* Østrup 1918, p. 36, tab. 4, fig. 55; Boye Petersen 1928 I, p. 408, fig. 29: *P. Lagerstedtii* A. Cl. 1934, p. 57 (partim).

Fig. 20. *Pinnularia savanensis* n. sp. × 1700.

Found in small numbers and without cell contents in 3 samples: 1526, 3037 (1.6 %), 3232. Its place in the Halobion system is not mentioned in the literature . . . . . . . . . . . . . . . . . . . . . . . ?

***Pinnularia savanensis** n. sp.

Fig. nostra 20.

Valva lineari-lanceolata, apicibus protractis vel subcapitatis, long. 26—44 $\mu$, lat. 6.5 $\mu$, striis 12—13 in 10 $\mu$. Area apicali anguste lanceolata, in fasciam transversalem dilatata.

Evidently it belongs to the Tabellarieae, but is much smaller of dimensions than any of the forms classed under this group. Very similar to A. S. Atl. Taf. 45, fig. 59. The larger specimens come very near to *P. appendiculata*, but are much more coarsely striated. Found in no small number in the hot spring by the Savan river (2528 — 50° (8.8 %)). Individuals with endochrome were seen. Place in the Halobion system . . . . . . . . . . . . . . . . . . ?

### *Pinnularia stomatophora Grun.

HUSTEDT 1930, p. 327, fig. 605.

Found in small numbers in 2 samples. With cell contents it occurred from the hot spring near Paratunka (1507 — 25°). Without cell contents in 3237 (1.1 ‰).

According to HUSTEDT (1938) oligohalobous and so presumably .................................... indifferent.

### Pinnularia subcapitata Greg.

HUSTEDT 1930, p. 317, fig. 571; ELENKIN 1914 I, p. 265.

ELENKIN records the species from water with a temperature of 35.5°. I have seen it in 2 samples from hot springs, but merely empty valves: 3136, 3232 (1.1 ‰). To KRIEGER's statement (1930, p. 143) that this species in conjunction with *Eunotia exigua* is often the only Diatom in dried up high moors, when other algae are excluded, it must be remarked that the form he depicts on Taf. IV, fig. 9 must be referred to var. *Hilseana*, to which the above-cited statement applies, while it is not true of the species.

According to BOYE PETERSEN 1943, p. 88: ... indifferent.

### *Pinnularia subcapitata Greg. var. Hilseana (Janisch) O. Müll.

HUSTEDT 1930, p. 317, fig. 572.

Found in 3 samples, but it was only possible to find specimens with cell contents in 1 sample from the hot spring near the Savan river (2530 — 73° (14.0 ‰)). Further found in the following samples: 2527 (6.1 ‰), U. N. II.

According to BOYE PETERSEN 1943, p. 89... halophobous.

### Pinnularia viridis (Nitzsch) Ehrb.

HUSTEDT 1930, p. 334, fig. 617 a; ELENKIN 1914 I, p. 262; GUTWINSKI 1891, p. 303.

First recorded from Kamtchatka by GUTWINSKI (l. c.) later by ELENKIN (l. c.), who states that it was found at temperatures of from 5.5° to 55° C.

I have come across it in 10 samples, in most of them in small numbers. In 5 samples specimens with cell contents were seen, namely from an affluent to the hot spring near Paratunka

(1526), a hot spring near the Savan river (2527 — 52° (3.0 %), 2528 — 50° (0.6 %)), a hot spring at Natchika (3237 — 40° (3.4 %)) and a hot spring on Garaschie Gara (3703 — 16°). Further in the following samples: 1521, 3037 (0.8 %), 3232, Paratunka 29° (0.3 %), 41°, U. N. II.

According to Boye Petersen 1943, p. 89 ..... indifferent.

### *Pinnularia viridis (Nitzsch) Ehrb. var. intermedia Cleve

Hustedt 1930, p. 335.

Found in small numbers and without cell contents in 2 samples: 1507, 1526.

I should think it probable that this variety has the same place in the Halobion system as the species .... indifferent?

### *Pinnularia viridis (Nitzsch) Ehrb. var. rupestris (Hantzsch) Cleve

Cleve Syn. II, p. 92; Boye Petersen 1932, p. 22, fig 5.

Found in small numbers, lacking cell contents, in 2 samples: 3144, 3139.

Place in the Halobion system ........................ ?

### Pinnularia sp.:

2527 (0.5 %), 2530 (6.3 %), 2533, 3037 (1.6 %), 3232 (2.1 %).

### Stauroneis anceps Ehrb.

Cleve Syn. I, p. 147; Elenkin 1914, I, p. 276.

The presence of the species in some few localities of Kamtchatka was pointed out by Elenkin (l. c.). I have found it in small numbers and without cell contents in 2 samples: 3138, Paratunka 41°.

According to Hustedt (1938) it is indifferent, while Hustedt (1939) gives it as oligohalobous ............... indifferent.

### *Stauroneis anceps Ehrb. f. gracilis (Ehrb.) Cl.

Hustedt 1930, p. 256, fig. 406.

Occurred in small numbers lacking cell contents in 2 samples: 2530(1.6 %), 3137 (0.8 %).

Place in the Halobion system ........................ ?

**Stauroneis phoenicenteron** Ehrb.

HUSTEDT 1930, p. 255, fig. 404; ELENKIN 1914, I, p. 275.

The species found by ELENKIN in a number of localities in Kamtchatka, but hardly in any of a thermal nature. I have encountered it in small numbers and without cell contents in 2 samples: 1526, 3712.

According to BOYE PETERSEN 1943, p. 90 .... indifferent.

**Stauroneis** sp.: Paratunka 29° (0.3 $^0/_0$).

## Epithemioideae.

***Epithemia argus** Kütz.

HUSTEDT 1930, p. 383, fig. 727 a.

Occurred in small numbers and without cell contents in a sample from the hot spring near Bannaja: 3232.

According to BOYE PETERSEN 1943, p. 67 .... indifferent.

**Epithemia zebra** (Ehrb.) Kütz. var. **saxonica** (Kütz.) Grun.

HUSTEDT 1930, p. 385, fig. 730.

ELENKIN (1914 I, p. 328) records *Cystopleura zebra* from various localities in Kamtchatka, for instance from a hot spring with a temperature of 55° C. He does not mention, however, which form of the species he saw.

I have only met with var. *saxonica* in 2 samples: 1526 (0.5 $^0/_0$), 3237 (2.2 $^0/_0$).

According to BOYE PETERSEN 1943, p. 68 .... indifferent.

**Rhopalodia gibba** (Ehrb.) O. Müll.

HUSTEDT 1940, p. 390, fig. 740; *Epithemia gibba* GUTWINSKI 1891, p. 364; *Cystopleura gibba* ELENKIN 1914 I, p. 327.

GUTWINSKI as well as ELENKIN has previously found this species in Kamtchatka. The latter states that he saw it in a hot spring at a temperature of 55°—66°.

I have only seen few specimens of it in a cold spring: 1526.

According to BOYE PETERSEN 1943, p. 89 .... indifferent.

**Rhopalodia gibberula** (Ehrb.) O. Müll. var. **producta** Grun.

*Epithemia g.* var. *producta* V. Heurck Syn. Pl. 32, fig. 11—13; Gutwinski 1891, p. 364; *Cystopleura g.* Elenkin 1914 I, p. 329.

Elenkin (l. c.) did not see this form himself in Kamtchatka but cites Gutwinski's find. This may seem strange since I found it in a total of 27 samples, predominantly from hot springs, where, however, it was usually sparsely represented, and as a rule I saw only empty valves.

Cells with contents were observed in 2 samples only: a hot spring at Natchika (3237 — 40° (14.4 $^0/_0$)), a cold affluent to the hot spring near Paratunka (1526 — 10° (2.0 $^0/_0$)). In addition it was found in the following samples: 1512 (2.2 $^0/_0$), 1513, 1514, 1516 (0.8 $^0/_0$), 1521 (0.7 $^0/_0$), 1525, 3037, 3117, 3138, 3139, 3140, 3170, 3176, 3180 (0.2 $^0/_0$), 3184 (0.5 $^0/_0$), 3187 (0.5 $^0/_0$), 3232 (2.1 $^0/_0$), 3234, 3236, 3239, 3702, 3703, 3712, 4328, Paratunka 25°.

As to the life conditions required by this form most authors are in agreement that it possesses the greatest capacity of adaptation to widely different environments. Thus it is called euryhaline by Hustedt (1938) and Budde (1932), just as Hustedt (1939) terms it a eurytopic species which may occur in fresh water as well as in the sea. While Kolbe (1927) calls it indifferent, Hustedt (1938) classes it as halophilous, and Budde (1932) as $\alpha$-mesohalobous. Boye Petersen (1943) adopted Kolbe's view and classes it as indifferent. I have later come to recognise that since it usually occurs very sparsely in fresh water, it is more probable that a certain content of salt in the water will favour its growth. I should think therefore that it may most correctly be designated ........................... halophilous.

***Rhopalodia musculus** (Kütz.) O. Müll.

Hustedt 1930, p. 392, fig. 745.

Found in small numbers in 3 samples. Specimens with cell contents were only seen in one sample from a cold affluent to the hot spring near Paratunka (1526 — 10° (0.2 $^0/_0$)). Further in the following samples: 1512, 3712.

According to Boye Petersen 1943, p. 89 ............... mesohalobous.

## Nitzschioideae.

### Hantzschia amphioxys (Ehrb.) Grun.

HUSTEDT 1930, p. 394, fig. 747; ELENKIN 1914 I, p. 295.

ELENKIN (l. c.) only found this species in one sample from Kamtchatka. HUSTEDT (1938, p. 461) states that he found it in hot springs at up to 45°.

I have seen it in 5 samples but without cell contents, namely in 1513, 1526, 3703, Paratunka 29° (0.3 %), 41°.

According to BOYE PETERSEN 1943, p. 75 .... indifferent.

### *Hantzschia amphioxys (Ehrb.) Grun. f. capitata Hust.

HUSTEDT 1930, p. 394.

Some few cells found in one sample: 3139.

Place in the Halobion system ...................... ?

### *Nitzschia amphibia Grun.

CL. et GRUN. 1880, p. 98; VAN HEURCK Syn. Pl. 68, figs. 15—17.

Decidedly the commonest species in the hot springs, where in many cases it was extremely predominant and often with numerous cells with cell contents. Found in all the groups of springs except those by the Savan river. In the group of springs near Paratunka it occurred in the cold affluent to the springs (1526), but only in small numbers (1.8 %) and without cell contents. With cell contents and in quantity in the samples: 1507 — 25° (4.1 %), 1514 — 32° (76.7 %), 1521 — 32° (10.9 %), unnumbered — 25° (69.5 %), unnumbered — 29° (11.2 %).

In the spring near Karymchina it occurred with cell contents and in overwhelming quantities in sample 3117 — 37° (99.1 %) and further in sample 3118 — 14° in smaller quantities (1.2 %).

In "Malenki klutchik" near Bannaja it was present in all the samples, in some of them with cell contents and in great quantities, thus in samples: 3137 — 77° (7.2 %), 3139 — 66° (2.0 %), 3141 — 29° (29.8 %), 3142 — 29° (25.9 %), 3144 — 60° (4.6 %).

From the hot springs near Bannaja specimens were found with cell contents in the following samples: 3176 — temp. ?, 3184 — 46° (13.5 ‰), 3187 — 35° (4.9 ‰).

From the hot spring in Natchika, specimens with cell contents were found in sample 3237 — 40° (12.2 ‰); from the spring on Garaschie Gara in sample 3703 — 16° (6.2 ‰), and from the spring near the middle course of the Paratunka in samples 3716 — 10° (1.4 ‰), 3719 — 35° (47.0 ‰) and 3720 — 21° (0.3 ‰).

Seen without cell contents in the following samples: 1512, 1516 (7.7 ‰), 1525, 1526 (1.8 ‰), 3037 (0.8 ‰), 3060, 3136 (0.6 ‰), 3138 (3.9 ‰), 3140 (11.8 ‰), 3170, 3180 (8.5 ‰), 3182, 3232 (18.9 ‰), 3234 (6.4 ‰), 3236 (4.9 ‰), 3239, 4328 (11.3 ‰), U. N. I, Paratunka 41°.

Thus it was found containing endochrome in water of temperatures up to 66°. The very high percentages are derived from samples with temperature of 25°—37°, which may be interpreted to mean that the species tolerates this temperature very well; but both at higher and at lower temperatures there are other species that thrive better. HUSTEDT (1938, p. 475), however, regards it as eurythermic and remarks that as a mass form it does not seem to occur above 35° C. This is in good agreement with my results. SCHWABE (1936, p. 318) also found the species at similar temperatures (29°, 40° C.).

According to BOYE PETERSEN 1943, p. 85 . . . . indifferent.

### *Nitzschia Clausii Hantzsch

V. HEURCK Syn. Pl. 66, fig. 10; Rabh. Algen Nr. 944; *N. sigma* var. *Clausii* Grunow 1878, p. 119.

Found in 15 samples in all, but in most of them in small numbers and without cell contents. Cells with endochrome seen in 3 samples, namely: Paratunka (1512 — 45° (16.0 ‰)), unnumbered 29° (2.2 ‰), and Garaschie Gara (3702 — 12° - 13°). Further seen in the following samples: 1513, 1521, 2527 (4.5 ‰), 2528, 2533, 3170, 3176, 3237 (3.3 ‰), 3701, 3712, Paratunka 41°, U. N. II.

Stated by KRASSKE to be mesohalobous, but HUSTEDT (1938, 1939) considers it indifferent, euryhaline. This I should think is the most correct view . . . . . . . . . . . . . . . . . . . . . indifferent.

### *Nitzschia debilis (Arnott) Grun.

Cleve and Grunow 1880, p. 68; *N. tryblionella* var. *debilis* Hustedt 1930, p. 400, fig. 759.

Occurred in small numbers in one sample: 3712.

According to Boye Petersen 1943, p. 85 . . . indifferent.

### Nitzschia Denticula Grun.

Hustedt 1930, p. 407, fig. 780; Elenkin 1914 I, p. 292; *Denticula Kützingii* Gutwinski 1891, p. 361.

Elenkin merely cites Gutwinski's find of this species from Kamtchatka. I have seen dead valves of it in samples from hot springs near Bannaja and Natchika: 3232 (5.3 %), 3234, 3237.

According to Kolbe (1927) ................ indifferent.

### *Nitzschia dissipata (Kütz.) Grun.

Hustedt 1930, p. 412, fig. 789.

Found in 13 samples in all, from cold streams as well as from hot springs. Only in 1 sample were specimens found with cell contents, namely from the spring on Garaschie Gara (3703 — 16°), where the species constituted 5.6 %. Further found in the following samples: Cold rivulet near camp 4, 1526 (2.3 %), Paratunka 41°, 3118, 3136, 3139, 3140 (0.5 %), 3144, 3182, 3716 (0.9 %), 3720 (0.5 %), 4329.

According to Boye Petersen 1943, p. 86 . . . . indifferent.

### *Nitzschia fonticola Grun.

Hustedt 1930, p. 415, fig. 800.

Occurred in small numbers and without cell contents in 5 samples: 3139 (2.6 %), 3140 (0.5 %), 3142, 3144 (0.8 %), cold rivulet near camp 4 (0.6 %).

According to Boye Petersen 1943, p. 86 . . . . indifferent.

### *Nitzschia frustulum (Kütz.) Grun.

Hustedt 1930, p. 414, fig. 795.

Occurred in small numbers and without cell contents in 2 samples: 3144 (0.4 %), 4329 (1.8 %).

According to Boye Petersen 1943, p. 86 . . . . indifferent.

***Nitzschia frustulum** (Kütz.) Grun.
var. **perpusilla** (Rabh.) Grun.

Hustedt 1930, p. 415.

Only observed in one sample in rather small numbers and without cell contents: 4329 (6.4 %).

According to Hustedt (1938) especially the small forms of the species are indifferent ...................... indifferent.

***Nitzschia gracilis** Hantzsch

Hustedt 1930, p. 416, fig. 794.

Found in small numbers lacking cell contents in 5 samples: 1526 (0.9 %), 3182, cold rivulet near camp 4 (0.2 %), Paratunka 41°, U. N. I.

According to Boye Petersen 1943, p. 86 .... indifferent.

***Nitzschia Hantzschiana** Rabh.

Hustedt 1930, p. 415, fig. 797.

Observed in small numbers and without cell contents in 2 samples: 3139 (1.0 %), 3232 (4.2 %).

According to Schulz (1928) oligohalobous: for the present, however, I will not give it a definite place in the Halobion system ........................................ ?

***Nitzschia Kützingiana** Hilse

Hustedt 1930, p. 416, fig. 802.

Only found in 2 samples, both from hot springs: 3144 (0.4 %), Paratunka 25° (5.6 %). No specimens with cell contents were observed.

According to Hustedt (1938) oligohalobous, and according to Legler and Krasske (1940) extremely euryhaline. Must therefore be regarded as ...................... indifferent.

***Nitzschia linearis** W. Sm.

Hustedt 1930, p. 409, fig. 784.

Found in 8 samples in all, partly from a cold affluent to the hot spring near Paratunka, where it was very common (1526 — (15.3 %)), partly from hot springs where individuals with cell contents were found in 3 samples, namely from Garaschie Gara (3703 — 16° (2.9 %)) and the hot spring near the middle reach of the Paratunka river (3716 — 10° (0.2 %), 3720 — 21° (4.4 %)).

Further seen in the following samples: 1514 (0.2 %), 1525, 3180, Paratunka 29° (0.6 %). By Kolbe (1927) it was classed as indifferent, while Schulz (1928) and Hustedt (1938, 1939) records it as oligohalobous .................... indifferent.

### *Nitzschia microcephala Grun.

Hustedt 1930, p. 414, fig. 791.

Noted in small numbers and without cell contents in 2 samples: 3232 (1.1 %), 3237.

According to Kolbe (1927) halophilous, while Hustedt (1938) designates it as oligohalobous, eurythermic ....... halophilous?

### Nitzschia palea (Kütz.) W. Sm.

Hustedt 1930, p. 416, fig. 801; Gutwinski 1891, p. 361; Elenkin 1914 I, p. 294.

Elenkin (l. c.) found this species in several localities in Kamtchatka, for instance in hot springs (temp. 1,5°–24° C.). I have observed forms that must be referred to this species in 9 samples from various hot springs. With cell contents its presence was ascertained in a hot spring near Natchika (3237 — 40° 5.6 %), the spring by the middle reach of the Paratunka (3720 — 21° (0.9 %)), and Unkanakchek (4329 — 12°). In addition in the following samples: 1525, 2528 (3.4 %), 2533 (1.1 %), 3170, 3176, Paratunka 29° (3.2 %).

According to Boye Petersen 1943, p. 87.... indifferent.

### *Nitzschia palea (Kütz.) W. Sm. var. debilis (Kütz.) Grun.

Cleve and Grunow 1880, p. 96; V. Heurck Syn. Pl. 69, fig. 28—29.

Seen in small amount in 1 sample: 3139 (0.7 %).

Place in the Halobion system ...................... ?

### *Nitzschia romana Grun.

Hustedt 1930, p. 415, fig. 799.

Noted in small numbers in 1 sample: 2527.

Place in the Halobion system ...................... ?

***Nitzschia romana** Grun. var. **curta** n. var.

Fig. nostra 21.

Valva long. 11.7 μ, lat. 5.0 μ, striis 24 in 10 μ, punctis carinalibus 6—10 in 10 μ.

This little form was observed in small numbers in 2 samples from the hot spring near the Savan river: 2528, 2533 (2.2 %).

Place in the Halobion system ........ ?

Fig. 21. *Nitzschia romana* Grun. var. *curta* n. var. ×1700.

**Nitzschia sigma** (Kütz.) W. Sm.

Hustedt 1930, p. 420, fig. 813; Elenkin 1914 I, p. 293. *N. curvula* Gutwinski 1891, p. 361.

First found in Kamtchatka by Gutwinski, later by Elenkin, who records it from various localities, but not from any hot spring.

I have found it in 2 samples but only in one sample with cell contents, namely in a cold affluent to a hot spring near Paratunka (1526 (0.2 %)). Further in 3137.

According to Boye Petersen 1943, p. 87 . . mesohalobous.

***Nitzschia sublinearis** Hust.

Hustedt 1930, p. 411, fig. 786.

A few empty valves seen in sample 2528.

Place in the Halobion system ...................... ?

***Nitzschia subtilis** (Kütz.) Grun.
var. **paleacea** Grun.

V. Heurck Syn. Pl. 68, figs. 9, 10.

Occurred in small numbers and without cell contents in sample 2527 (1.0 %).

According to Kolbe (1927) ............... indifferent.

**Nitzschia thermalis** (Kütz.) Grun. var. **minor** Hilse

Cleve and Grunow 1880, p. 78; V. Heurck Syn. Pl. 59, fig. 22.

The species was found by Elenkin (1914 I, p. 291) in a hot spring at 60° C., but on p. 588 it is seen that it was only represented by empty valves. I have seen var. *minor* with well preserved cell contents in a sample from a hot spring near the

Savan river (2530 — 73°), as also in the spring on Garaschie Gara (3701 — temp. ? (13.9 °/₀)). Further in the following samples: 1512 (3.6 °/₀), 1521 (0.4 °/₀), 2527 (3.0 °/₀), 2528 (10.8 °/₀), 2533 (17.9 °/₀), Paratunka 41°, U. N. II.

The species is usually regarded as indifferent (Kolbe 1927, Budde 1932). Schulz (1928) discusses var. *minor* and calls it oligohalobous? For the present I will class it as . . indifferent.

### *Nitzschia vermicularis (Kütz.) Grun.

Hustedt 1930, p. 419, fig. 811.

Some few empty valves found in sample 3237.

According to Kolbe (1927) indifferent and according to Schulz (1928) oligohalobous . . . . . . . . . . . . . . . . . . . . . . . . indifferent.

**Nitzschia** sp.: 1526 (2.3 °/₀), 1513 (0.8 °/₀), 1516 (0.8 °/₀), Paratunka 41° (0.2 °/₀), 2528 (0.6 °/₀), 3138 (7.1 °/₀), 3141 (0.9 °/₀), 3180 (0.7 °/₀), 3703 (1.7 °/₀), 4329 (4.6 °/₀).

## Surirelloideae.

### *Surirella angusta Kütz.

Hustedt 1930, p. 435, fig. 844, 845 (*S. angustata*).

Found in small numbers in 3 samples but with cell contents only in one sample from a cold affluent to the hot spring in Paratunka (1526). Further in the following samples: 3182, Paratunka 29°.

According to Hustedt (1938, 1939) oligohalobous, and presumably . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . indifferent.

### *Surirella ovata Kütz.

Hustedt 1930, p. 442, fig. 863, 864.

Found in small numbers in 2 samples and in one of them from the hot spring near Unkanakchek (4329 — 12°) with cell contents. Also in 3182.

According to Boye Petersen 1943, p. 91 . . . . indifferent.

### *Surirella ovata Kütz. var. pinnata (W. Sm.) Hustedt

HUSTEDT 1930, p. 442, fig. 865.

Found in small numbers without cell contents in 3 samples: 1513, 1526, 3182.

According to HUSTEDT (1939) .............. indifferent.

### *Surirella robusta Ehrb.

HUSTEDT 1930, p. 437, fig. 850.

Found in 2 samples in small quantity. Specimens with cell contents were seen in a sample from the hot spring near the Savan river (2527 – 52° (0.5 ‰)). Further in sample 3232.

According to BOYE PETERSEN 1943, p. 91 .. halophobous.

### Surirella robusta Ehrb. var. splendida (Ehrb.) V. Heurck

HUSTEDT 1930, p. 437, fig. 851, 852; *S. splendida* GUTWINSKI 1891, p. 362; *Suriraya splendida* ELENKIN 1914 I, p. 297.

ELENKIN (l. c.) has noted this form from various localities in the peninsula, but not from any hot spring. GUTWINSKI (l. c.) has seen it in the outlet from the hot spring near Banna.

I found it in 10 samples and with cell contents in 4 of them: Cold affluent to the hot spring near Paratunka (1526 — 10° (0.2 ‰)), "Malenki klutchik" (3141 — 29°), hot spring near the upper Paratunka (3703 — 16°), and the spring near the middle reach of the Paratunka river (3720 — 21°). In addition in the following samples: 1514, 1521, 1525, 3140, 3184, 3716.

According to KOLBE (1927) and HUSTEDT (1939) ..... indifferent.

**Surirella** sp.: 3180.

# *Chlorophyceae.*

## Euchlorophyceae.

### Protococcales.

**Chlamydomonas nivalis** Wille

Pascher 1927, p. 196; Elenkin 1914 I, p. 400.

Found in 2 samples of red snow: from the Shalsan Pass 700 m. above the level of the sea (3834) and from the Gorelaja volcano near the upper Opala river.

***Scenedesmus denticulatus** Lagerh.

Lemmermann, Brunnthaler und Pascher 1915, p. 163, fig. 212.

Occurred in a sample from the hot spring near the Savan river (2528 — 50 ⁰/₀).

**Scenedesmus quadricauda** (Turp.) Bréb.

Elenkin 1914 I, p. 348.

Only seen in a sample from the hot spring near Paratunka (unnumbered — 29°).

***Scenedesmus rostrato-spinosus** Chod.

Chodat 1926, p. 211, fig. 114.

Observed in small numbers in a sample from the hot spring near the Savan river (2533 — 63°).

**Scenedesmus** sp.

Some few specimens observed in one sample: U. N. II.

***Schizochlamys gelatinosa** A. Br.

Lemmermann, Brunnthaler und Pascher 1915, p. 43, fig. 22 a—f.

Found in a sample without further designation (U. N. II).

### Chaetophorales.

***Enteromorpha intestinalis** (L.) Link

Hauck 1885, p. 426.

Occurred in a dried sample from a hot spring near Unkanakchek (4329 — 12°). The occurrence is remarkable seeing that the locality is more than 30 km. from the coast, in mountainous country. Otherwise the species is a native of salt water; but it is well known that it often passes far up into the fresh water and also to considerable heights above the sea. The Diatom spectrum for this sample did not seem to indicate that the water in the locality was saline.

**Microspora** sp.

Hot spring near the Savan river, temperature ?

**Oedogonium** sp.

Sterile *Oedogonia* were seen in 2 samples: U. N. I and II.

**Prasiola** sp.

Cold rivulet near camp 4. May possibly be *P. velutina* (Lyngb.) Wille in the *Hormidium* form.

**Ulothrix** sp.

Found in sample 3716 — 10°.

## Siphonocladiales.

**Rhizoclonium hieroglyphicum** (C. A. Ag.) Kütz.

Heering 1921, p. 20; Elenkin 1914 I, p. 377.

Found in 6 hot springs with the temperature 14°–32° C., namely from Paratunka (1514 — 32°, unnumbered 25°), Karymchina (3118 — 14°), "Malenki klutchik" (3141 — 29°, 3142 — 29°) and Bannaja (3182 — temp. ?). Vouk (1937, p. 57) mentions this species as one of the most commonly occurring Chlorophyceae in hot springs.

## Siphonales.

***Vaucheria hamata** Walz

Heering 1921, p. 90, fig. 81.

Found in a sample from a hot spring near Paratunka (1512 — 45°).

**Vaucheria** sp.

A sterile *Vaucheria* found in sample 2974.

# Conjugatae.

## Desmidiaceae.

### ***Cosmarium amoenum** Bréb.

W. and G. S. West, Monogr. IV, p. 29, Pl. 102, fig. 1—4.

Occurred in a hot spring near the upper Paratunka river (on Garaschie Gara: 3701). Temperature not stated, but it can hardly have been high.

### ***Cosmarium Meneghinii** Bréb.

W. and G. S. West, Monogr. III, p. 90, Pl. 72, fig. 29—32.

In a hot spring near the Savan river (2527 — 52°); the material taken with a plankton net. Found in company with living Diatoms and *Spirogyra* sp. Famin (1931, p. 80) found this species at 37° C. Vouk mentions it (1937, p. 5) as one of the commonest species in hot springs.

### ***Cosmarium sexnotatum** Gutw. var. **tristriatum** (Lütkem.) Schmidle

W. and G. S. West, Monogr. III, p. 228, Pl. 86, fig. 8, 9.

Found in a sample from a hot spring near the Siku river (3060 — 67°) in company with *Mastigocladus laminosus* and *Phormidium laminosum*. As in the Diatoms present, all the cells were empty, so it is possible that they have not lived at that high temperature but have been carried there from some other locality.

### ***Cylindrocystis Brebissonii** Menegh.

W. and G. S. West, Monogr. I, p. 58.

Found in 2 samples from hot springs near the upper Paratunka (on Garaschie Gara: 3701 — temp. ?, 3702 — 12°-13°).

## Zygnemataceae.

### **Mougeotia** sp.

Sterile specimens in sample 3720 — 21°.

### **Spirogyra** sp.

Sterile specimens in samples: 2527 — 52°, 3187 — 35°, Paratunka — 25°.

# Charophyta.

### *Chara Braunii Gmelin

Zaneveld 1940, p. 137; *Chara coronata* Migula 1925, p. 225, fig. VII, 1, 2; 1897, p. 321.

Occurred in the hot springs near Paratunka (1507 — 25°) and in the spring near the middle reach of the Paratunka river (3719 — 35°). According to Migula (1897, p. 326) the species is annual in nature in Europe. In cultures he ascertained that it may become perennial, and he supposes that it will likewise be perennial in warmer countries. In Europe he found it fructifying in August—November. The fact that Hultén found it fructifying and well developed in February and March may probably be explained by the circumstance that it came from hot springs where the temperature is fairly constant all the year round and thus allows the plant to vegetate all the year and probably become perennial. For the determination of this species I am indebted to Mr. Sigurd Olsen.

### Nitella sp.

Found in a sterile condition in sample 1516 — 25°.

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## Literature cited.

BOHLIN, K. 1901. Étude sur la flore algologique d'eau douce des Açores. Bih. till Sv. Vet.-Akad. Handl. Bd. 27, Afd. III, Nr. 4.

BRUES, C. F. 1924. Observations on animal life in the thermal springs of Yellowstone Park. Proceed. Americ. Acad. Arts and Sc. **59**: 371.

— 1928. Studies on the Fauna of hot springs in the Western United States and the biology of thermophilous animals. Proceed. Americ. Acad. Arts and Sc. **63**: 139.

BUDDE, H. 1930. Die mesohaloben und halophilen Diatomeen der Lippe in Westfalen. Ber. d· d. Bot. Ges. **48**: 415.

— 1932. Die Algenflora westfälischer Salinen und Salzgewässer (I). Arch. f. Hydrobiologie **23**: 462.

CHODAT, R. 1926. Scenedesmus. Revue d'Hydrologie III Année Nr. 314.

CLEVE, ASTRID 1895. On recent Freshwater Diatoms from Lule Lappmark in Sweden. Bih. till K. Sv. Vet.-Akad. Handl. Bd. 21, III, Nr. 2.

CLEVE, P. T. 1894—95. Synopsis of the Naviculoid Diatoms. Kgl. Sv. Vet.-Akad. Handl. **26**: Nr. 2, **27**: Nr. 3.

CLEVE und GRUNOW 1880. Beiträge zur Kenntnis der arctischen Diatomeen. Kgl. Sv. Vet.-Akad. Handl. **17**: Nr. 2.

CLEVE-EULER, A. 1932. Die Kieselalgen des Tåkernsees in Schweden. Kgl. Sv. Vet.-Akad. Handl., Ser. III, Bd. **11**: Nr. 2.

— 1934. The Diatoms of Finnish Lapland. Societas Sc. Fennica Comm. biologicæ. IV, 14.

COPELAND, J. J. 1936. Yellowstone thermal Myxophyceæ. Ann. New York Acad. Sc. Vol. **36**.

DE-TONI, G. B. 1907. Sylloge Algarum, Vol. V Myxophyceæ curante Dr. Achille Forti. Patavii.

ELENKIN, A. A. 1914 I. Die Süsswasseralgen Kamtschatka's. Moskva.

— 1914 II. Über die thermophilen Algenformationen. Bull. Jard. imp. bot. Pierre le Grand XIV, p. 62.

EMOTO, J. 1933. Die Mikroorganismen der Thermen. The Bot. Mag. Tokyo **47**: 268.

FAMIN, M. 1931. Contribution à l'étude systematique et biologique de la flore thermale française. Trav. Cryptog. dediés à Louis Mangin. Paris.

GEITLER, L. 1925. Cyanophyceæ in Pascher: Die Süsswasserflora Deutschlands Heft 12.

— 1932. Cyanophyceæ in Rabenhorst Kryptogamenflora Bd. 14.

Gomont, M. 1892. Monographie des Oscilariées. Ann. des Sc. nat., Bot. Série 7, **15**: 263; **16**: 91.

Grunow, A. 1863. Über einige neue und ungenügend bekannte Arten und Gattungen von Diatomaceen. Verh. der k.k. zool.bot Ges. Wien **13**: 137.

— 1878. Algen und Diatomaceen aus dem Kaspischen Meere. In Dr. O. Schneiders Naturwiss. Beitr. z. Kenntnis d. Kaukasusländer.

Gutwinski, R. 1891. Algarum e lacu Baykal et e peninsula Kamtschatka a clariss. prof. Dr. B. Dybowski anno 1877 reportatarum enumeratio. Nuova Notarisia **2**: 300.

Hansgirg, A. 1885. Über den Polymorphismus der Algen. Bot. Centralblatt **22**.

Hauck, F. 1885. Die Meeresalgen Deutschlands und Österreichs. In Rabenhorsts Kryptogamenflora. 2. Auflage, Bd. II.

Heering, W. 1906–07. Die Süsswasseralgen Schleswig-Holsteins. 1. Einleitung-Heterokontæ 2. Chlorophyceæ (Allgemeines-Siphonales) 3. Beiheft zum Jahrb. d. Hamb. Wiss. Anst. **23**, **24**.

— 1921. Siphonocladiales, Siphonales in Pascher: Die Süsswasserflora Deutschlands etc. Heft 7.

Hultén, E. 1923. Some geographical notes on the map of South Kamtchatka. Geografiska Annaler.

— 1928. Flora of Kamtchatka and the adjacent islands I, Kgl. Sv. Vet.-Akad. Handl. Ser. 3, Bd. 5.

Hustedt, F. 1930. Bacillariophyta (Diatomeæ) in Pascher: Die Süsswasserflora Mitteleuropas Heft 10, 2. Aufl.

— 1930. — Die Kieselalgen in Rabenhorsts Kryptogamen-Flora Bd. VII.

— 1935. Die Diatomeenflora von Poggenpohls Moor. Abh. und Vorträgen der Bremer Wiss. Ges. Jahrg. 8/9, der Festschrift etc.

— 1938. Systematische und ökologische Untersuchungen über die Diatomeenflora von Java, Bali und Sumatra. I. Systematischer Teil. II. Allgemeiner Teil. Arch. f. Hydrobiologie Suppl. Bd. XV, XVI.

— 1939. Die Diatomeenflora des Küstengebietes der Nordsee vom Dollart bis zur Elbemündung I. Abh. Nat. Ver. Bremen **31**: 572.

— 1942. Aërophile Diatomeen in der nordwestdeutschen Flora. Ber. d. d. bot. Ges. **60**: 55.

Kolbe, R. W. 1927. Zur Ökologie, Morphologie und Systematik der Brackwasser-Diatomeen. Pflanzenforschung Heft 7.

— 1932. Grundlinien einer allgemeinen Ökologie der Diatomeen. Ergebnisse der Biologie herausgegeben von K. v. Frisch etc. Bd. 8.

Krasske, G. 1938. Beiträge zur Diatomeen-Vegetation von Island und Spitzbergen. Arch. f. Hydrobiologie **33**: 503.

Krieger, W. 1929. Algologisch-monographische Untersuchungen über das Hochmoor am Diebelsee. Beitr. z. Naturdenkmalpflege III.

— 1930. Algenassoziationen von den Azoren und aus Kamerun. Hedwigia **70**: 140.

Kützing, F. T. 1844. Die kieselschaligen Bacillarien oder Diatomeen. Nordhausen.

Lacsny, J. L. 1912. Beiträge zur Algenflora der Thermalwässer bei Nagyvarad. Bot. Közlem. **11**: 167.

Lagerstedt, N. G. W. 1873. Sötvattens-Diatomaceer från Spetsbergen och Beeren Eiland. Bih. till kgl. sv. Vet.-Akad. Handl. **1**: Nr. 14.

Lemmermann, E. 1905. Über die von Herrn Dr. W. Volz auf seiner Weltreise gesammelten Süsswasseralgen. Abh. Naturw. Ver. Bremen **18**: 143.

Lemmermann, Brunnthaler und Pascher 1915. Chlorophyceæ II in Pascher: Süsswasserflora Heft 5.

Mereschkowsky, C. 1906. Diatomées du Tibet. Soc. imp. russe de Géogr. St. Pétersbourg.

Migula, W. 1897. Die Characeen in Rabenhorsts Kryptogamenflora 2. Aufl. Bd. V.

— 1925. Charophyta in Pascher: Süsswasserflora Heft 11.

Molisch, H. 1926. Pflanzenbiologie in Japan. Jena.

Pascher, A. 1927. Die Süsswasserflora Mitteleuropas, Chlorophyceæ I: Volvocales.

Petersen, J. Boye 1923. The fresh-water Cyanophyceæ of Iceland. The Botany of Iceland, Vol II, Nr. 7.

— 1928 I. The aërial Algæ of Iceland. The Bot. of Iceland, Vol. II, Nr. 8.

— 1928 II. Algefloraen i nogle Jordprøver fra Island. Dansk bot. Arkiv **5**: Nr. 9.

— 1930. Algæ from O. Olufsen's second Danish Pamir Expedition 1898–99. Dansk bot. Arkiv **6**: Nr. 6.

— 1932. The algal Vegetation of Hammer Bakker. Bot. Tidskr. **42**: 1.

— 1935. Studies on the Biology and Taxonomy of soil Algæ. Dansk Bot. Arkiv **8**: Nr. 9.

— 1938. Fragilaria intermedia—Synedra Vaucheriæ? Bot. Notiser.

— 1943. Some halobion spectra (Diatoms). Det Kgl. Danske Vidensk. Selskab, Biol. Medd. **17**: Nr. 9.

Printz, H. 1914. Kristianiatraktens Protococcoideer. Videnskapsselsk. Skr. I. Math.-Naturv. Kl. 1913 Kristiania.

Quint, J. 1905. Beiträge zur Bacillarien-Flora des Budapester Römer Bades. Növénytani Közlemények **4**: 149.

— 1906. Neue Beiträge zur Bacillarienflora des Römer Bades bei Budapest. Növenytani Közlemények **5**: 74.

Savicz, V. P. 1914. Algologische Exkursionen nach der Avatcha Bucht im Mai 1909.

— Expédition à Kamtchatka, organisée par Th. P. Riabouchinsky. Sect. de Botanique. Livr. II. Moscou. (not seen)

Schmidt, Ad. 1875—. Atlas der Diatomaceenkunde.

— C. 1885. Hydrologische Untersuchungen XLIV: Thermalwässer Kamtschatkas. Mém. Acad. Imp. Sc. St. Pétersb. Ser. VII, Bd. 32, Nr. 18.

Schulz, P. 1926. Die Kieselalgen der Danziger Bucht. Bot. Archiv **13**: 149.

— 1928. Brackwasserdiatomeen aus der Gebiete Danzig. 50. Bericht d. Westpreuss. Bot.-Zool. Vereins. Danzig.

Schwabe, G. H. 1936. Beiträge zur Kenntnis isländischer Thermalbiotope. Arch. f. Hydrobiologie. Suppl. Bd. VI.

Setchell 1903. The upper temperature limits of life. Science **17**: 934.

Sljunin, N. V. 1900. La région Ochotsko—Kamtschatsk. Sct. Pétersb. (not seen).

Sprenger, E. 1930. Bacillariales aus den Thermen und der Umgebung von Karlsbad. Arch. f. Protistenk. **71**: 502.

Van Heurck, H. 1880–85. Synopsis des Diatomées de Belgique. Anvers.

— 1899. Traîté des Diatomées. Anvers.

Vouk, V. 1937. Vergleichende biologische Studien über Thermen. Bull. Intern. de l'Acad. Yougoslave des sc. et beaux Arts. Livre **31**. Zagreb.

West, G. S. 1902. On some Algæ from hot springs. Journ. of Bot. vol. **40**: 241.

West, W. and G. S. 1904–1923. British Desmidiaceæ. London.

Zaneveld, J. S. 1940. The Charophyta of Malaysia etc. Blumea **4**: 138.

Østrup, E. 1901. Freshwater Diatoms from the Færöes. Botany of the Færöes, Part I.

— 1916. Marine Diatoms from the coasts of Iceland. The Botany of Iceland I, 3 (1918).

— 1918. Fresh water Diatoms from Iceland. The Botany of Iceland **2**: 1.

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