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**On some species of the genus *Homoeothrix* (Cyanophyceae):
H. juliana (Born. et Flah.) Kirchner, *H. nordstedtii*
(Born. et Flah.) Komárek et Kann, and *H. balearica*
(Born. et Flah.) Lemm.**

**O niektórych gatunkach z rodzaju *Homoeothrix*
(Cyanophyceae): *H. juliana* (Born. et Flah.) Kirchner,
H. nordstedtii (Born. et Flah.) Komárek et Kann
i *H. balearica* (Born. et Flah.) Lemm.**

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Abstract — The paper concerns three species of *Homoeothrix*: *H. juliana* (Born. et Flah.) Kirchner, *H. nordstedtii* (Born. et Flah.) Komárek et Kann, *H. balearica* (Born. et Flah.) Lemm. Original drawings of the species discussed were presented and in *H. nordstedtii* and *H. balearica* the tiers structure of trichomes, i.e. the ability of growing of new trichomes on the tops of hairs, was described. In the species of *Homoeothrix* genus the hairs end simply the growth of trichomes.

The genus *Homoeothrix* belongs to the family *Rivulariaceae*. In type it is similar to the genus *Calothrix*, from which it differs by its lack of heterocysts. The former authors used to identify these two genera. Born. et Flahault (1886) differentiated only the section *Homoeothrix* in the genus *Calothrix* and it was only Kirchner (1898) who established separate genus *Homoeothrix*. Fan (1956), admittedly, when revising the genus *Calothrix*, included the genus *Homoeothrix* again into it; the last name, however, remained as a "nomen conservandum" (11th Botany-Congress at Seattle). The point lies in that, in the species of the genus *Homoeothrix*, heterocysts are never formed, whereas in the genus *Calothrix* heterocysts occur as a rule and there are only some species without them.

Species of the genus *Homoeothrix* are found, before all, in the clear waters of mountain streams and lakes, but they also occur in the lowlands in the springs and on humic rocks as well. Some species are widely spread, almost cosmopolitan; in floristic registers, however, they are rarely mentioned, and ecologically and morphologically still poorly recognized. A more detailed taxonomic and ecological review of the species of the genus *Homoeothrix* was given in the recent years by Komárek et Kann (1973). They based their work upon their own collections from various localities in Austria and Czechoslovakia and in some other neighbouring countries, as well as on the herbaria from the Museum of Natural History in Paris. This paper largely helped to systematize and put order to the information on the genus *Homoeothrix* scattered all over the literature on the subject; although, however, it enlarged markedly the knowledge of the genus it did not elucidate everything, so that further studies prove necessary. Many species still require checking upon, while the confirmed species sometimes call for additional morphological and ecological information. Therefore, floristic

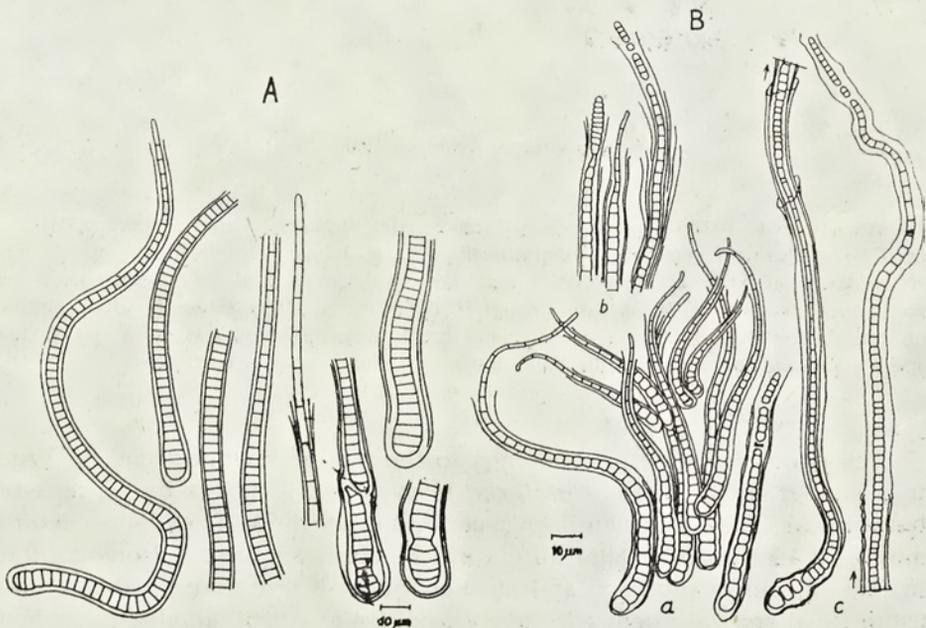


Fig. 1. A — *Homoeothrix juliana*, various fragments of the filaments; B — *Homoeothrix nordstedtii*, a — the most frequently encountered groups of filaments; b — various endings of filaments and the forming hormogonia; c — filament of the growth in tiers
 Ryc. 1 A — *Homoeothrix juliana*, różne fragmenty nici; B — *Homoeothrix nordstedtii*, a — najczęściej spotykane grupy nici; b — różne zakończenia nici i tworzące się hormogonia; c — nić o wzroście piętrowym

elaborations of blue-green algae further necessitate a more detailed description of the thalli and the conditions of their occurrence.

The descriptions of three species collected by the author (Star-mach 1976, 1977) in the streams at the village Poręba Wielka and in the towns Krynica, Poland and Varna, Bulgaria are given below. They can serve as a complement of the existing data on the species *Homoeothrix juliana*, *H. nordstedtii*, and *balearica*.

Homoeothrix juliana (Born. et Flah.) Kirchner 1898 (fig. 1A) Syn. *Calothrix juliana* Bornet et Flahault 1886, as a starting species, described, however, previously by Meneghini as *Lyngbya juliana* (after Elenkin 1949 p. 1826).

This species occurs in the stream Źródłany on the southern slopes of the Góra Parkowa Mt. in the town Krynica in a water rich in calcium carbonate and CO₂, pH 7.5. On sandstones it forms small tufts, but it also occurs rather as individual specimens among calcareous incrustations; these tufts contain mainly *Phormidium incrustatum* (Näg.) Gom., *Homoeothrix nordstedtii* and some species of the genus *Schizothrix*. In the stream Źródłany, on whose borders some mineral springs of calcium carbonate type are found, calcareous incrustations are everywhere common forming on the stone surface more or less crusted, gray, bluish-green or brown covers and papillae.

In a similar way *H. juliana* occurs in the stream Poręba at the localities Poręba Wielka and Koninki (in the Gorce Mts) forming small insertions among the crustaceous blue-green algae covering the stones and partly incrustated with limestone.

At both these stations, fairly distant from each other, the filaments of *H. juliana* were up to 1 mm long, straight or curved, unbranched, sometimes hooked at the base, bulbously widened or not widened, 12.2 to 14 µm and exceptionally to 16 µm wide. Trichomes at the base were also slouglty widened or sometimes almost not widened, gradually narrowing towards the top and ending with a colourless hair of varying length. The trichome cells, as a rule shorter than wide, were within the range from (2.0) — 3.3 — 4.0—(5.5) µm. The cells were grey blue-green, rather pale, less frequently with an olive shade, at transversal walls not incised and not granulated. In the hairs the cells were always elongated, up to 13.3 µm long, in most cases empty, often broken. The sheaths were colourless of varying thickness, stratified or not stratified, the stratification being more distinct in the lower part of the filament. At the top by the end of the hair, or in the place where the trichome narrows into a hair, the sheaths were more or less frayed, or middly and gradually disappearing.

In the diagnosis corrected by Komárek and Kann (1973) the filaments of that species occur individually, in groups or in clumpy

communities, at the base they are (5.5) — 10—15 — (20) μm wide and 2 — (3) mm long; the sheaths are thin, not stratified or stratified in their lower part, colourless or yellowish, trichomes 5.4—12.5 μm wide.

Hence, the features of the specimens from the town Krynica and from the village Poręba are almost completely consistent with the diagnosis and correspond with the species *H. juliana* var. *juliana*. It differs from var. *lyngbyoides* Geitler, by a smaller width of the filaments. There is still *f. brevicellularis* Geitler et Ruttner characterized by exceptionally short cells, which would be difficult to distinguish in the investigated material, though in some specimens cells by 1/5 shorter than their width were also found.

The species *H. juliana* is not known to the author from the territory of Poland. It has a large distribution and is known from a number of places in Europe, Africa, India, and Indonesia, as well as from the Balearic Islands and Antilles.

Homoeothrix nordstedtii (Born et Flah.) Komárek et Kann 1973 (fig. 1B). Syn. *Dichotrix nordstedtii* Born et Flah. 1886 as a starting point; *Calothrix caespitosa* Rabenhorst; 1873; *Homoeothrix caespitosa* (Rabenh.) Kirchner 1898; Geitler 1932, Elenkin (1949), Starmach (1966), Golubić 1967.

The species *H. nordstedtii* was described for the first time by Rabenhorst (1873) under the name *Calothrix caespitosa*. In view of its absence of heterocysts it was classified by Kirchner (1898) in the genus *Homoeothrix* and reported under the name *Homoeothrix caespitosa* (Rabenh.) Kirchner. In the monograph by Born et Flahault (1886) it appears under the name *Dichotrix nordstedtii*; the authors stressed to the fact that it formed branchings of the type *Dichotrix*. The name *Calothrix caespitosa* was given in synonyms. In Wittrock's and Nordstedt's herbarium (Alg. exc. No. 857) it appears under the name *Dichotrix nordstedtii*. These specimens, checked upon and compared with the specimens of Rabenhorst in Alg. Europ. No. 2315, did not show any significant differences, hence finally the name *H. caespitosa* was adopted and is found in later elaborations of blue-green algae; its only illustration was given by Golubić (1967). In spite of the fact that the similarity of these two: *H. caespitosa* and *D. nordstedtii* was known to Geitler (1932), he introduced into his elaboration these two species separately, as mentioned by Elenkin (1949, p. 1829). Komárek and Kann (1973), basing on their own investigations and on the herbarial material, gave another description and original illustrations under the name *Homoeothrix nordstedtii*, including into synonyms the names: *H. caespitosa* and *Calothrix caespitosa*. The illustrations given by Komárek and Kann and by Golubić do not show any branchings; however, in their new diagnosis

the authors write that the filaments can be branched brush-like or according to the type *Dichothrix*. Trichomes, on the average 100 to 200 μm long, narrow towards the top changing into a colourless hair. The filaments are at the base (6) — 11—15 μm wide, trichomes 4 to 11 μm wide. Cells at the transversal walls markedly stratified incised, rather barrel-shaped, isodiametric or shorter or longer than their width, without granulation. Sheaths thin, not stratified or slightly stratified, colourless.

Two forms were given: f. *nordstedtii*, of blue-green thalli, filaments mostly 11 to 13 μm wide, situated at the base and f. *salisburgensis* (Beck) Komárek and Kann (equals *H. caespitosa* var. *salisburgensis* Beck), of grey-green thalli to 1 cm high, filaments 12 to 15 μm wide, sheaths yellow or brownish.

The form *salisburgensis* is known from Austria and Sweden. *F. nordstedtii* occurs at several localities in Europe, Africa, and Indonesia (?). Komárek and Kann (1973) give as similar species *H. balearica* (Born. et Flah.) Lemm. and Vozžennikova (1953) *H. flagelliformis*.

According to Komárek *H. balearica* differs insignificantly from *H. nordstedtii* by the shape of thalli, by brown-yellow, stratified sheaths, and frequent branchings of the filaments. Great similarity is also shown by *H. flagelliformis* growing on *Nostoc verrucosum* thalli in one of the stream in Tadzhikistan.

The author has been fortunate to find *H. nordstedtii* twice, once in the stream Szopczański and in the stream Ociemny in the Pieniny Mts (Starmach 1975), and then in the spring stream in the town Krynica. In the Pieniny Mts it grows on limestone rocks along with *Oocardium stratum* and *Phormidium incrustatum*. The specimens from the Pieniny Mts were most resembling the illustrations given by Komárek and Kann in their paper (1973). Trichomes blue-green, at the bottom 4 — 5—6 μm wide, cells markedly incised at the transversal walls without granulation, sheaths colourless, mostly not stratified. In the material from the Pieniny Mts intensive calcium carbonate incrustations of the thalli were characteristic, so that the filaments became well visible only after calcium carbonate dissolution in acetic acetate. Above the surface of flat, papillary, calcareous crusts the ends of filaments only stick out; they give the covers on the stones a green-bluish colour. In the specimens from the Pieniny Mts branchings occurred very rarely.

Specimens found in the spring stream at the town Krynica were, as a rule, similar, forming, however, larger clumps or loose communities on the surface of sandstones, however, also incrustated with calcium carbonate. The colour of the communities was grey blue-green or gray olive. The filaments were clustered into bundles or in places into compact thalli, sometimes composed of two stratifications. The filaments curved in various ways, at the base usually hooked, 80—300—(460) μm long, at the

base 8.9 to 14.4 μm wide. Trichomes were (5)—6.7—9 μm wide, composed of cells markedly incised at the transversal walls, barrel-shaped, not granulated, isodiametric, but sometimes also a little shorter or longer than their width. The hair cells were of course 3 to 5 times longer than wide. In the upper part trichomes grew gradually narrower, less frequently rapidly, into a hair of various length, but not longer than the rest of the trichome. In the meristic zone, situated in the middle, or in some cases, at the top of the trichome, the cells were always shorter than wide, incised at the transversal walls. Some of the filaments had open sheaths; the trichomes, on the other hand, formed shorter or longer hormogonia after the falling off of the hairs. Hormogonia of 3 to 8 cells 3.9—4.5 μm wide, 2—2.22—3 μm long were found; cells up to 4 μm long occurred less frequently. Individual hormogonia were sometimes divided by necrotic cells. Germinating hormogonia are polarized and get quickly developed with a sheath closed at the lower end and open at the top end. In very rare cases growth of hormogonia was observed at both ends, forming short trichomes narrowed at both ends (type *Ammatoidea*). Similar trichomes were drawn by Skuja (1937, Table I, fig. 7c) in the species *H. cartilaginea* which is a synonym of the species *H. nordstedtii*. Skuja reported very long filaments growing on both ends; in the material from the town Krynica, however, such filaments were absent.

Thalli in whose vertical section two distinct strata were more or less marked, were built of filaments of, so to say, a structure in tiers. At the top of the hair-like ending of the trichome a meristic zone was formed and a new trichome was formed and a new trichome was developed. The sheaths of these filaments were, as a rule, built in strata, had a telescopic structure, and a marked rhythm in the growth of filaments (fig. 1A). In such cases the filament ends blindly but at the top a normal trichome, composed of barrel-shaped cells of various size, develops.

The type of trichome growth in tiers had not been observed so far in the species *Homoeothrix nordstedtii*. It was still more noticeable in the specimens of *Homoeothrix balearica* growing on humid rocks in Varna and described below.

Homoeothrix balearica (Born. et Flah.) Lemmermann.

Specimens collected in the Pieniny Mts, as well as those from the town Krynica correspond as concerns taxonomy with the species *H. nordstedtii* var. *nordstedtii* sensu Komárek et Kann. Specimens collected on the stones of the steep rocks of the sea-shore in Varna are quite different. As a matter of fact, they have trichomes of a similar structure to that of *H. nordstedtii*, but differ in type and dimensions, so that it would be difficult to include them into that species.

The algae from the humic sea-shore walls in Varna were discussed by the present author still in 1964 (Starmach 1964) when their cha-

racteristic association of species forming coloured spots on humid, vertical, calcareous rocks was described. During the author's second stay in 1976 in the same place on the wall he found unchanged covers of algae. They were formed, above all, by species of the order *Chlorococcales* (*Chroococcus*, *Gloeocapsa*, *Microcystis*, *Chlorogloea* and others) but also green algae of the order *Zygnemales* and moss clumps. Where thin streams of water were flowing down the walls, red patches of *Bangia atropurpurea* (Roth.) Ag. developed; these had not been found by the author in 1964. Beside low moss clumps and among them grey blue, yellowish brown, in places dark brown covers of blue-green algae developed. Upon examination they proved to be almost pure communities of *Homoeothrix*, which had not been noticed by the author in 1964. Thalli of those blue-green algae occurred under the form of loose bundles or compact clumpy communities among mosses and light yellow mucous covers of *Chroococcus*, mainly *Ch. turicensis* and *Ch. helveticus*, in form of nests occupying 1—10 cm² of surface area. They form a layer 1 to 2 mm thick, brittle, incrustated with calcium carbonate, easily removable with a penknife. Under a magnifying glass small separate groups of filaments or more compact thalli in which, in the vertical section, 2 to 3 layers were separated from one another with darker stripes.

The length of the filament varies: filaments in loose bundles were (60)—100—300—(450) μm long, in tiers structured thalli they reached to 1.5 mm. The width of the filament at the base 8—10—(15) μm . The width of the trichome at the base (2.5)—3.6—6.2—(7) μm . The length of the cells varies; in the lower part of the trichome, as a rule slightly longer than wide, in the meristic zone slightly barred-shaped, isodiametric, sometimes almost spherical, 3 to 6 times longer than wide in the hairs.

The base of the trichomes is sometimes bulbously thickened or not thickened; cells at the base slightly narrowed in comparison with the higher situated ones are also encountered. The cells were incised at the transversal walls; there were, however, also trichome fragments without any incision at the transversal walls. The colour of the trichomes pale-blue, green, grey blue-green or yellowish. Hairs colourless or pale-glaucous, at the top about 1 mm wide, built of long cells without incisions at the transversal walls. Hairs brittle and relatively short, not longer than the rest of the trichome. Branching apparent, frequent, developed either in the place where a necrotic cell is formed in consequence of growth of the trichome fragment under the necrotic cell or by germination of hormogonia on the stem.

In larger communities of thalli the growth in tiers was continuously repeated. The author called so the phenomenon of a repeated development of trichomes at the top of the hairs which in normal cases always end the growth. The top of the hair begins to grow anew, a new trichome is

formed which again ends a hair. 2 to 3 phases of growth of the same trichome were found to repeat themselves in the same way, manifested in successive narrowing and subsequent enlarging and narrowing again (fig. 2A, B). It also happens that the loosened top cells of the hair germinate so that at the top of one trichome 2 or 3 new ones are formed (fig. 2A). In some cases 3 or 8 cell hormogonia are formed. These leave the sheaths and settle down in new places, often on the same filament. The hormogonia germinate in a normal way forming at one end cells narrowing into a hair, or in rare cases, they grow for a time at both ends. The sheaths are developed variously, very rarely colourless, usually yellow-brownish, stratified, smooth or frayed outside. At least in the lower parts and at the top of the filaments small layers of sheaths are found to stick outside. Sections of frayed sheaths repeat themselves on one filament so many times as the number of growth in tiers of the trichome.

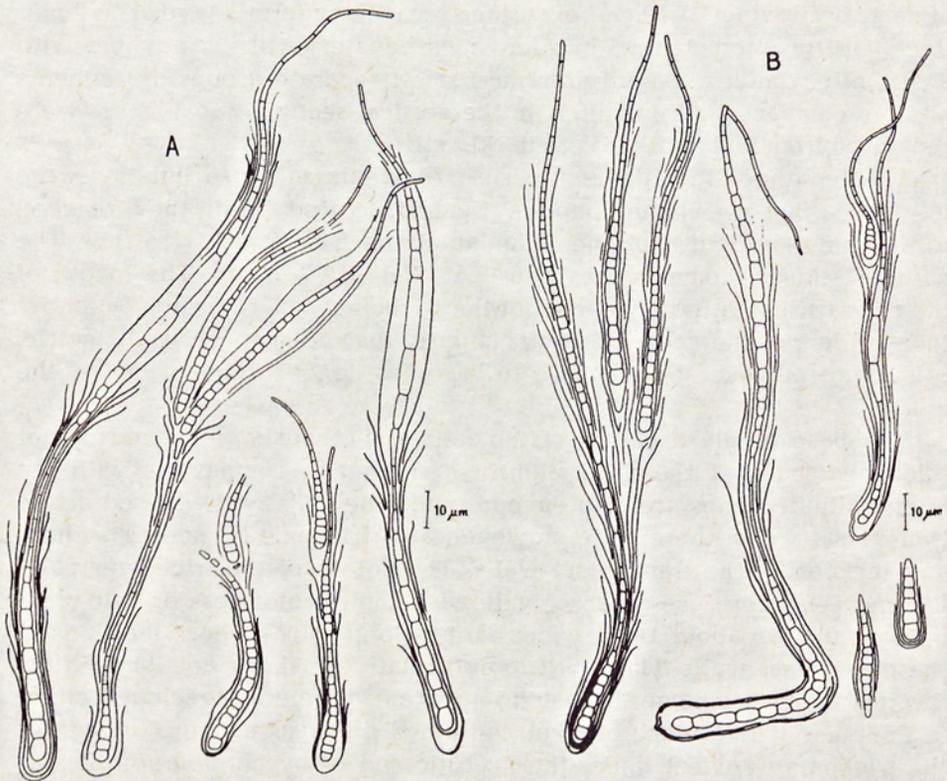


Fig. 2. *Homoeothrix balearica*. A — filaments of various development, growth in tiers of trichomes; B — various types of filaments and germinating hormogonia

Ryc. 2. *Homoeothrix balearica*. A — nici w różnym wykształceniu, piętrowy wzrost trychomów; B — różne typy nici i kielkujące hormogonia

The ability of phase growth and development in tiers of the thalli is a characteristic feature of the species *Homoeothrix* growing on humid rocks. This is connected with the living conditions of these blue-green algae at a given locality. A steep rock is humidified by the water flowing out from below the clumps covering its top. The water flows are of various intensity in dependence on rainfalls and the season of the year; the rock, however, is never completely dry. In periods of greater or smaller humidity, the blue-green algae accordingly grow more intensively, or their growth is inhibited. The symptoms of intensive growth are cell division and formation of exceptionally big cells (fig. 2A, B). At the time of growth inhibition, a hair-like thinning of trichomes takes place. Colourless, apparently decaying hair cells do not lose, however, their ability for further development, and under favourable conditions they develop further on. A rhythmical growth of thalli takes place, this being reflected in their layer structure.

The above material gives a good example of the influence of particular ecological factors prevailing on humid rock walls on the growth of blue-green algae. This growth proceeds periodically and depends, above all, on the degree of humidity, since variations in temperature, even at intensive sun irradiation, are relatively very small, equalized by evaporation of the thin layer of the water flowing down the rocks. A rhythmic growth of the blue-green algae on humid rocks was investigated by J a a g (1945) in the Alps. He observed this phenomenon in *Gloeocapsa Kützingeriana* and in *Gl. sanguinea*; the stratified thalli of *Homoeothrix* from the humid rocks in Varna illustrate that phenomenon very well.

The specimens growing on humid rocks in Varna correspond best with the species *Homoeothrix balearica* (B o r n. et F l a h.). L e m m., and also to a certain extent with the form described by W e s t (1898) from England with trichomes 3.5 to 5 μm wide. The width of the trichomes, according to B o r n e t et F l a h a u l t, is 7 to 9 μm .

Homoeothrix balearica var. *tenuis* W. et G. S. W e s t is known from the Tatra Mts where it occurs on humid rocks on calcareous substrate in the Kocioł Wielkiej Świstówki and in the Valley Dolina Białego among other blue-green algae forming crusts partly incrustated with calcium carbonate (S t a r m a c h 1934). In the material from the Tatra Mts the author did not meet a thallus structure in tiers.

The trichomes of *H. balearica* are, in fact, similar to *H. nordstedtii*, differing, however, in dimensions and development and in the colour of the sheath. This gives them a form evidently different from the specimens known to the author from the Pieniny Mts and from the town Krynica; its illustration was given by K o m á r e k and K a n n in their publication. From *H. nordstedtii* which has yellow-brownish sheaths, it differs in the size of the filaments and thalli. Extremely simplified illustrations of *H. balearica* were given by S e r p e t t (1948). They are closer to

the specimens from Varna than to those from the town Krynica and from the Pieniny Mts.

Hence for the species from Varna the name should be preserved:

Homoeothrix balearica (Born. et Flah.) Lemmermann 1910
Syn. *Calothrix balearica* Bornet et Flahault 1886, *Calothrix cartilaginea* G. S. West 1907, *Homoeothrix cartilaginea* (G. S. West) Lemm. 1910.

A short description of the species *Homoeothrix balearica*. Filaments clustered in bundles or clumps, form stratified rather flat thalli, 1 to 2 mm thick, in the vertical section, olive or yellow-brownish or from grey blue-green to dark green. Filaments curved, at the base usually hooked, slightly barrel-like widened or not widened, 5 to 15 μm wide, usually branched. Sheaths thick and, yellow-brownish, less frequently yellowish, or colourless, usually at the lower and upper part frayed. Trichomes at the base (2.5)—4—9 μm wide, pale or grey blue-green, olive, or yellowish, built of various length, incised at transversal walls, not granulated, at the top ending with a hair of long, colourless or glaucous cells. Hormogonia of 3 to 8 cell, often germinate on stems. Individual cells of hairs are also able to germinate. In the conditions of varying humidity the trichomes have the ability of growing in tiers, and new trichomes develop on the tops of the hairs.

They occur on humid rocks and on stony or peaty banks of water reservoirs.

Distribution: the Balearic Islands, China, Africa, France, England, Bulgaria; in Poland in the Tatra Mts.

The following varieties are known:

var. *balearica*, var. *tenuis* W. et G. S. West, of filaments 3.5 to 5 μm wide.

STRESZCZENIE

Opracowanie dotyczy trzech gatunków z rodzaju *Homoeothrix*, zebranych w ostatnich latach na trzech odmiennych stanowiskach: w Gorcach w Porębie Wielkiej i Koinkach, w Krynicy oraz na wilgotnych skałach nadmorskich w Warnie (Bułgaria). Gatunki te wprawdzie znane są z kilku stanowisk w Europie, Azji i Afryce, jednak rzadko podawane w spisach florystycznych sinic i niedokładnie jeszcze znane pod względem morfologicznym i ekologicznym. Przedstawione opisy form znalezionych na poszczególnych stanowiskach pogłębiają znajomość gatunków i uzupełniają ich diagnozy.

Homoeothrix juliana (Born. et Flah.) Kirchner (ryc. 1A), znaleziony był w potoku Poręba w Gorcach i w potoku Źródlanym w Krynicy, gdzie występował na piaskowcach wśród skorupiastych sinic, mniej lub więcej inkrustowanych węglanem wapnia. Cechy były niemal zgodne z diagnozą u Borneta i Flahaulta, z tym, że zarówno wymiary nici i trychomów, jak i wykształcenie pochw mieściły się w szerszych granicach.

Homoeothrix nordstedtii (Born. et Flah.) Komárek et Kann (ryc. 1B), znaleziony był na dwóch stanowiskach w Pieninach i w potoku Źródlanym w Krynicy. Przedstawiono oryginalne rysunki i opis uzupełniający dane w znanych diagnozach, szczególnie w opracowanej ostatnio i poprawionej przez Komárka i Kann. Spośród charakterystycznych i nieznanych dotąd szczegółów należy wymienić piętrową budowę trychomów, zdolność do wyrastania nowych trychomów na szczytach włosów, które normalnie zawsze kończą wzrost plechy.

Homoeothrix balearica (Born. et Flah.) Lemm. (ryc. 2A, B), znaleziony został na wilgotnej ścianie skalnej nad brzegiem morza w Warnie (Bułgaria). Przedstawiono rysunki i obszerny opis tego gatunku, nie mającego w dotychczasowych opracowaniach wystarczającego opisu morfologicznego. I w tym przypadku zwrócono uwagę na wzrost piętrowy plech, polegający na odnawiającym się wzroście trychomów ze szczytowych komórek włosów. Zjawisko to nie opisywane dotąd wyjaśniono wielofazowością wzrostu trychomów w miarę zmian nawilgocenia podłoża. Przy obfitej wilgotności sinice rosną intensywnie, przy niedostatku wilgoci hamują wzrost i tworzą na szczytach cienkie włosy, z których po nowym dopływie wilgoci mogą się rozwijać nowe trychomy. Opisano również sposób rozgałęziania się plech i kielkowania hormogoniów. Gatunek ten jest zbliżony do *H. nordstedtii*, jednak wyodrębnia się dostatecznie wyraźnie.

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