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Hymenial Algae in some Species of the Genus *Lecanora* (Lichenes)

Glony hymenialne u niektórych gatunków rodzaju *Lecanora* (Lichenes)

Гимениальные водоросли у некоторых видов рода *Lecanora* (Lichenes)

The synthesis of lichens from algae and fungi in nature has not yet been elucidated. This is especially true of the relationships between lichen fungi and those algae which occur in the hymenial layer of their fruiting bodies. Presumably, algae emerge from the ascocarps together with the ascospores, and, upon spore germination, unite with the fungus to form a new lichen thallus.

The occurrence of so-called "hymenial gonidia" has been observed in many lichens of the *Pyrenocarpeae*, e.g. *Staurothele*, *Endocarpon*, and *Thelenidia*; in the *Gymnocarpae*, they are known only in *Sporodium phyllocharis* Mass. In the hymenium of those lichens, the algae are situated between the asci. They are smaller than those in the thallus, and are often elongated as a result of being compressed by the asci. As demonstrated by Stahl (5), the release of hymenial algae coincides with that of spores and the combination of both components into a new thallus is easily effected. It is not yet known how the algae penetrate the hymenium.

Lange (3) found that in one species of *Thallinocarpon*, asci are formed in a layer of hyphae. The hypothecium was also intertwined with algae.

In *Gonohymenia*, the hymenium is covered with algae. The release of spores takes place through breaches in the epithecium. Then the joining of algae with fungi into a lichen thallus takes place.

Poelt (4) observed that in *Ochrolechia rosella* the hymenium is divided by a cluster of hyphae which is reminiscent of the parathecium.

In the top part of the hymenium, clusters of small algae were sometimes found. According to Versegghy (6), hymenial algae are supposed to occur in this genus, but this hypothesis has to be confirmed by more observations on a larger number of species. Nearly all lichenologists make free-hand sections of apothecia using razor blades (Vainio, Frey, Magnusson and others). Algae are often found in the hymenium, but in sections made by hand it is difficult to establish whether their presence is accidental or not.

In *Lecanora*, the phycobionts are species of *Trebouxia*. Ahmadjian (2) assumes that algae belonging to *Trebouxia* cannot be free-living in nature because of their slow growth rates and low optimal light intensity. He believes they occur only as lichen symbionts. Jaag and Degelius (2) also observed that *Trebouxia* was not or was seldom found in a free-living state in nature. On the other hand, some workers (Raths, Treboux, West) are of the opinion that species of *Trebouxia* do occur in nature (e.g., in England). Ahmadjian interprets these reports as pertaining to symbionts of the so-called *Lichenes imperfecti* or to decaying soredia. The question which then arises is this: in species of lichens unable to form soredia and isidia, and lacking hymenial algae, what causes the synthesis of lichen thalli?

In *Lecanora*, the distribution of algae in the excipulum thallinum varies in different species. Algae occur most frequently under the lower part of the excipulum proprium. They may be single and dispersed, or aggregated as they are in the thallus. In many species, they form agglomerations from 150 to 200 μ in diameter. In some species, algae occur also in the excipulum proprium. In young apothecia algae are relatively scarce, while in adult forms they are more numerous. *Trebouxia* forms autospores; they emerge from the mother cells and their appearance is reminiscent of "microgonidia", as described by Stahl (5).

In my studies on the anatomy of apothecia in *Lecanora*, I found algae in the excipulum proprium, hypothecium, and hymenium of many species. Their presence cannot be attributed to the procedure of making sections. The experimental material consisted of microtome sections with the apothecia cut from the surface to the bottom of the hymenium. The lichens were washed with pure water to remove possible epiphytic algae, mounted in paraffin, and cut into sections of 10 μ in thickness. After dissolving the paraffin with xylene, the sections were transferred into water. With this procedure, transporting algae from the medulla to the hymenium with the knife of the microtome is impossible.

In order to study the occurrence of algae in different parts of apothecia, observations were carried out on living plants, collected at

Konopnica near Lublin, in January 1969. The plants belonged to the *Lecanora chlarona* group, but they are not yet determined to species. [The proper name of this species will be available after a monographic treatment of the genus *Lecanora* has been made.] The excipulum proprium of all specimens consists of moderately-thick hyphae and differs only slightly from the hypothecium. Staining the hypothecium with iodine makes the structure clearer.

The presence of algae in different parts of the apothecium was very common in the specimens examined. The occurrence of algae in the hymenium is less frequent in plants collected in summer and preserved in herbaria. In this connection, it is interesting to note that winter is supposed to promote growth and reproduction of lichens since water relations, with regard to humidity and liquid water, are most favourable at this time.

Microtome sections are suitable for observing all stages of the migration of algae from the thalline excipulum throughout the hypothecium, hymenium, and epithecium, and their emergence outside the apothecium. In many sections, it is easy to observe the release of fungal hyphae around the clusters of algae which have started to migrate (Figs. 1, 2). At the first stage the algae are situated in the thalline excipulum. Next, they migrate to the excipulum proprium and hypothecium, thus forming dense clusters (Fig. 1). In the hypothecium, hyphae become loose and folded back in the form of an arch. This stage is considered to be the first migration stage of the hymenial algae. Next, clustered algae migrate towards the hymenium (Fig. 2). Paraphyses are released by the algae and the epithecium is disrupted here and there. At the next stage the algae migrate towards the surface of the apothecium through the epithecium, as illustrated in Fig. 3.

The hyphae of the fungus are not compact either in the paraplectenchymatous excipulum proprium or in the hypothecium and hymenium. No penetration of algae through the cortex of the thalline excipulum was found. The migration of algae from the thalline excipulum takes place simultaneously with the ripening of spores in the asci. The migration of the algae from between the asci coincides with that of spores.

The migration of algae from the thalline excipulum of the apothecium is possibly due to the pressure of the quickly multiplying algae themselves on the pseudoparenchyma of the fungus, as well as to its loosening of and migration through the hymenium. The reproduction of the algae by the formation of autospores coincides, to a certain degree, with the growth of the apothecia. Apothecia stop growing after they have attained their proper size, while algae continue their multiplica-

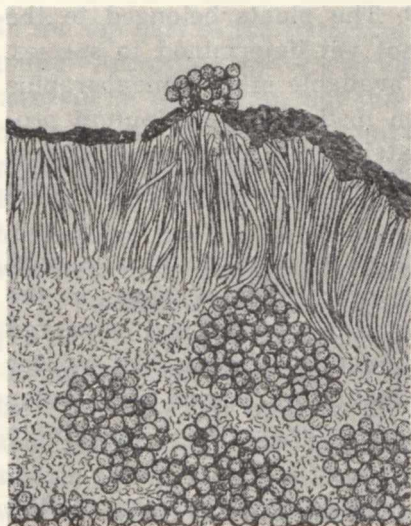


Fig. 1

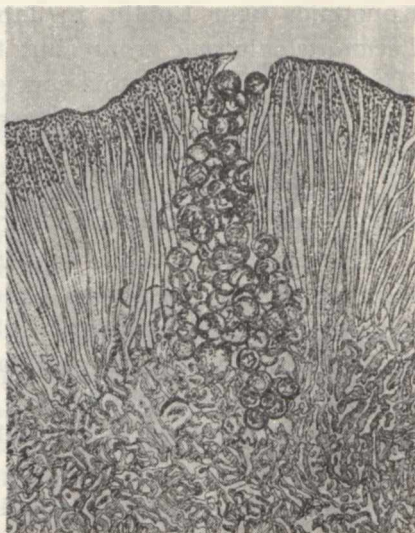


Fig. 2

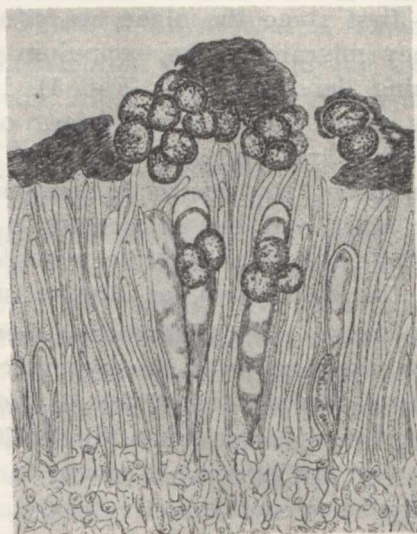


Fig. 3

tion and growth. Growth affects the pressure on the pseudoparenchyma and migration of algae from the thalline excipulum.

The way in which algae, released from the apothecium, are entwined by hyphae, and the actual synthesis of a new thallus still remains an

unexplored problem. Studies are being carried out to answer some of these questions, and to investigate the occurrence of hymenial algae in other groups of lichens.

Subsequent stages of migration of the algae from the thallic excipulum are illustrated in Figs. 4—7 (Tables I and II).

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STRESZCZENIE

Przechodzenie glonów z plechowej otoczki przez właściwą otoczkę, hypotecjum do hymenium i wydobywanie się ich na powierzchnię owocnika przedstawiono u niektórych gatunków rodzaju *Lecanora*. Prawdopodobnie glony, wydostające się na powierzchnię owocnika, zostają oplątane przez strzępki grzyba z kielkujących zarodników, wydobywających się równocześnie z worków i dają początek nowej plesze. W ten sposób zachodzi synteza obu komponentów. Glony u rodzaju *Lecanora* tworzą często autospory i wówczas są podobne do „mikrogonidiów” opisanych przez Stahla (5) u niektórych rodzajów z grupy *Pyrenocarpeae*.

РЕЗЮМЕ

В работе описывается переход у водорослей некоторых видов родов *Lecanora* из слоевищного края через собственный край, гипотечий до гимения и выход их на поверхность апотеция. Возможно, что водоросли, выходящие на поверхность апотеция, опутываются гифами гриба из произрастающих спор, которые одновременно выходят из сумок, и дают начало новому таллосу. Таким образом происходит синтез обоих компонентов. Водоросли рода *Lecanora* создают часто аутоспоры и в это время похожи на „микрогонии” некоторых родов из группы *Pyrenocarpeae* описанные Сталом (5).

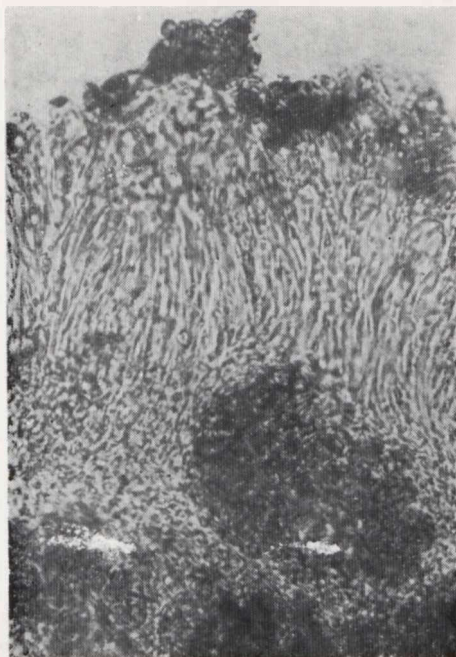


Fig. 4. A cluster of algae in the thallic excipulum and hypothecium, a small cluster of algae is also visible on the epithecium. Magn. ca. 300 \times

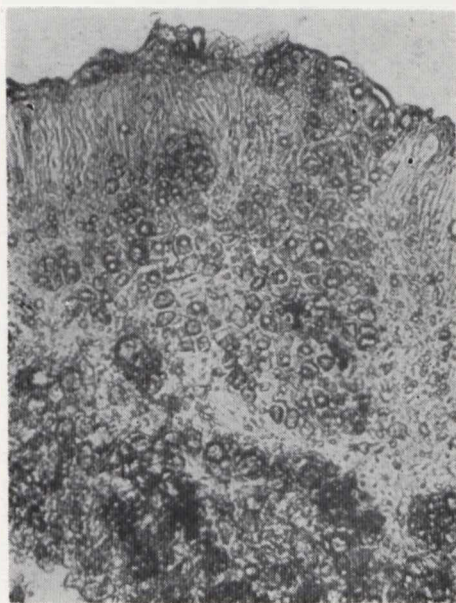


Fig. 5. Single algae in the hypothecium and hymenium. Magn. ca. 300 \times

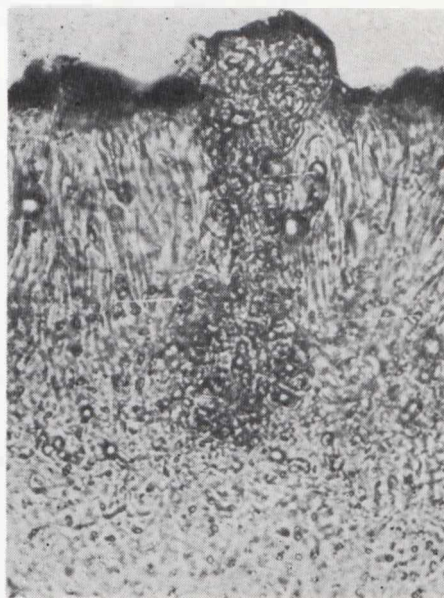


Fig. 6. Cells of algae with autospores. Magn. ca. 300 ×

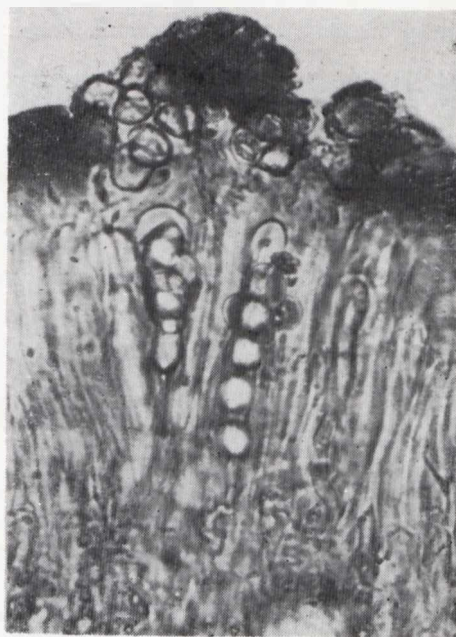


Fig. 7. A cluster of algae which are being released through a disrupted epithecium.
Magn. ca. 600 ×.

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