REMARKS

ON

NORTHERN LITHOTHAMNIA

BY

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The limitation proposed in Norw. Lithoth.[1]) of the Norwegian unarticulated calcareous algæ, and in consequence of the majority of the boreal-arctic calcareous ones, was in part altered most recently in Rev. Syst. Surv. Melob.[2]). The fact is that several species, classified as independent ones, turned out to vary more than it appeared from the material I then possessed, and could not, therefore, be maintained as independent. Besides I had partly laid too great stress on the shape and the size of the conceptacles, as even these may vary more than then presumed. Be it said that by far the greater part of the material in hand consisted of sterile specimens or of specimens with conceptacles but slightly developed.

Shortly before composing the Rev. Syst. Surv. Melob. I had myself gathered new, large material along the northern coast of Norway, and besides I had received more material from other arctic or boreal areas. I had not then, however, as is evident only from the queries added to some of the species or forms l. c., the opportunity of a complete revision particularly of the species belonging to the genus *Lithothamnion* which form the bulk of the calcareous algæ here occurring. What principally prevented such a complete revision was the fact that I still wanted sufficient material from the south-western and the southern parts of the coast of Norway. Such material, however, has been collected of late years, which has to a great extent contributed to the understanding of not only several of the arctic or subarctic Lithothamnia, but also of some boreal ones.

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[1]) M. Foslie. The Norwegian Forms of Lithothamnion. — Det Kgl. norske Videnskabers Selskabs Skrifter 1894. Trondhjem 1895.

[2]) M. Foslie. Revised Systematical Survey of the Melobesieæ. — Det Kgl. norske Videnskabers Selskabs Skrifter 1900 no. 5. Trondhjem 1900.

I consider it superfluous to enter more fully upon the reasons which have induced me to reducing the species so considerably as done below. My motives will in part appear from the remarks made concerning each single species. I had so to speak to choose between two ways — either to establish a still larger number of feebly differentiated boreal-arctic species, than already done, or to reduce as below, and at the same time found some new forms. As I have indicated, I choose the latter way. It may, however, seem as if I have gone too far in this reduction. But as I have been unable to draw sure lines, I think the reduction must be considered compulsory, even if some species are to be taken in a rather wide sense. This reduction also corresponds with the view of recent authors concerning the mutual relationship of other algæ, e. g. the species of *Fucus;* for in these too a strong reduction has urged itself, the great variation of these algæ being really conditioned only by certain hydrographic circumstances. This is particularly the case with *Fucus inflatus.* The Laminariæ may also be instanced, which in the boreal-arctic areas show an extreme power of variation. If we have in hand a reduced form of e. g. *Laminaria digitata* from the interior of one of the larger fjords on the coast of Norway and another extreme form of the same species from certain localities on the open shore, we should believe, if we had not seen the intermediate forms, that we had in hand species rather widely different[1]). In the Lithothamnia is found a similar power of variation, which is scarcely greater in any other place than in these very areas. It is, however, to be observed that in several cases this variation is not conditioned by the same hydrographic circumstances as in the algæ mentioned above. As to the Lithothamnia, besides, other circumstances can play important parts.

1) A form peculiar in this respect, or rather biologically, is *Pelvetia canaliculata* f. *radicans* Fosl. New or crit. Norw. Alg. pl. 1, fig. 2. The lower part of the frond is somewhat creeping, provided with rhizoids more or less numerous, connecting the particular individuals to one another, and penetrating about 1 cm. into the clay. It has only once been met with in pools of probably brackish water along the lower part of the river Rindelven at the inner part of the Trondhjem Fjord.

As I have earlier pointed out, these algæ require, in order to thrive, a firm, or fairly firm, bottom, but principally a fairly strong movement of the water, i. e. places where the tidal waters run rather strongly. Besides the bottom must be fairly even, to render the formation of banks possible. On the other hand, it may be of partly destructive effect if the tidals run too strongly, or if the plant appears in places with very strong currents. Particulars about this state of things will be found below.

In places where the Lithothamnia thrive and occur in some number, there is — as a general rule — also a rich fauna. Most calcareous algæ — as I have earlier often mentioned — are to a great extent attacked by lower animals, particularly small ones, or serve as the residence of a lot of such ones — in the first instance of worms, then of echinoderms, peculiarly smaller forms, e. g. ophiurida, of mollusks[1]), peculiarly boring-muscles (saxicava), partly also of echinida and crustacea. This is either wholly or partly destructive, or at any rate checks the normal development of the plant, and may often cause the rise of greatly varying forms of one and the same species. This concerns both crustlike and branching species[2]). By a repeated overgrown of new hypothallium so as to cover the extraneous objects, and on the whole by a more vivid vegetative activity, the alga endeavours to defend itself against this destructive influence. Thus even the cells — particularly the hypothallic cells — will often grow considerably longer than in normal conditions. The occurrence of overgrowing hypothallium, as a matter of course, can also be owing to the fact that germinating plants attach themselves to and are developed on older specimens of the same species. However, even a sparsely branching species freely developed at the bottom will occasionally develop crustlike formations, when the alga comes in contact with foreign bodies, or certain lower animals attach themselves to it[3]).

1) M. Foslie. (M. F.). Alger og Muslinger. — Naturen. Bergen 1892. Pag. 17.

2) M. Foslie. The Lithothamnia of the Maldives and Laccadives. — The Fauna and Geography of the Maldive and Laccadive Archipelagoes — Vol. I. Part 4. Cambridge 1902. Pag. 460.

3) A. Weber-van Bosse and M. Foslie. The Corallinaceae of the Siboga-Expedition. — Siboga-Expeditie LXI. Leyden 1904. Pag. 22. 28. 36, 41.

In the northern areas are often found lying loose on the bottom densely branching roundish knolls of Lithothamnia, which are more or less hollow. This is in most cases caused by attacks of animals, chiefly of boring muscles. They attack the interior of the alga, which is here gradually destroyed and crumbled, while the peripheric parts continue growing, and the specimen even sometimes may increase rather considerably in size. I have seen specimens of up to about 10 cm. in diameter which only formed a cover of coalescing branches, about 1 cm. thick, round a number of boring muscles which completely filled up the interior of the alga, or in other cases the interior of the alga formed a cavity with distinct scars from attacks of animals. In such specimens the branches at last become shorter and are more apt to coalesce than elsewhere. In most cases, however, an opening is gradually formed, which may be the direct consequence of the destructive action of the animals, or the breaking through of the comparatively thin peripheric portion is owing to mechanical causes. The opening is mostly formed in the turning down part of the plant. Then an inverted cup-shaped specimen is seen, which by continued destruction becomes inverted crateriform, or plate-shaped, or more or less concave-convex, with the part turning downwards showing worn, truncate and fastigiate ends of branches. Cp. Contrib. II, pl. 2. The latter form, as a rule, rises from specimens which earlier or more typically developed formed masses depressed globular or subhemispheric. In most cases the alga still continues growing. Under certain circumstances the turning down and worn part of such specimens will be partly (very seldom wholly) covered with a thin crust developed from the peripheric and live parts. From this crust new branches will grow out, when the specimen is lying on a hard bottom or on other calcareous algæ (e. g. in a bank) in such a way that it only in part touches the substratum and allows the light to penetrate below it. In similar condition of things the cavity can be almost filled up with recent ramification from the peripheric parts of an inverted goblet-shaped specimen without the incrustation mentioned. Such specimens then again approach their earlier depressed-globular shape. On the other hand, by continued

destruction an opening may be formed in the central parts of an inverted plate-shaped specimen, i. e. in the second half of the original one, and the specimen becomes more or less wreathlike. Cp. Norw. Lithoth. pl. 12, fig. 2, pl. 13, fig 3.

It seems probable that also bigger marine animals than those presumed above may contribute to the rise af greatly varying or reduced forms, particularly of rather densely branching Lithothamnia. Thus crabs or other bigger crustacea will cut off branches or systems of branches from the alga, in order to obtain coveted food among the smaller animals living in or between the branches of the alga. The branches cut off in this way no doubt often grow on, as is the case with branches broken off by the waves[1]) or by the use of different kinds of fishing tackle.[2]) The form *soluta* of *Lithothamnion fruticulosum* mentioned l. c. may perhaps have risen in such a way. Cp. l. c. p. 7, fig. 18—33.

Another enemy to Lithothamnia is the family of the boring algæ. Their destructive work sometimes matches with attacks of animals. Of the boring algæ occurring in the boreal-arctic areas particularly *Ostreobium Queketti* Born. et Flah. is found in Lithothamnia, chiefly in older specimens of such ones. It often occurs so numerously as to form something like a dense network in large parts of the host plant.

The calcareous algæ have also a third enemy, a purely mechanical one, friction. It exercises a destructive influence particularly on older specimens, when the alga, as mentioned above, is growing in places with strong currents, i. e. in narrow and shallow sounds or in places in a fjord where the tidals run very strongly. In this case the friction of the water effects that the upwards turning part or even the greater part of the knolls lying freely on the bottom gets specked with the friction or is partly torn away. Cp. Norw. Lithoth. pl. 4, fig. 1—2, pl. 6, fig. 2—3, pl. 10, fig. 5,

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1) M. Foslie. A Visit to Roundstone in April. — Irish Naturalist. Vol. VIII. Dublin 1899. Pag. 175.

2) M. Foslie. Die Lithothamnien des Adriatischen Meeres und Marokkos. Wissensch. Meeresuntersuchungen. Neue Folge. VII. Band. Abt. Helgoland. H. 1. Oldenburg i. Gr. 1904. Pag. 10.

pl. 13, fig. 2. The surface affected with the attrition often conveys the impression of crustlike formation or almost orbicular discs up to about 1 cm. in diameter, but this is only owing to the fact that the branches partly torn away have inwardly coalesced more than in the outward parts of the plant. Cp. Norw. Lithoth. l. c. Such portions of the alga oftener prove to be dead; but under certain circumstances new layers of tissue extend themselves from the adjacent parts still live over parts of the dead portions, forming a thin crust over the latter. From this crust are then developed short verruciform branches or somewhat elongated ones, often, however, only from the edge of the said discs. These branches are more or less diverging from the normal ramification of the species. In some localities a great deal of specimens will appear with bigger or smaller specks caused by friction. This state of things bears to a certain degree a considerable resemblance to the state of the alga, when affected by the attacks of lower animals.[1])

There is every probability that the currents also play the most important part when some branching species are often forming compressed globular masses, whereas the typically developed ones are spherical. The same is, most likely, the case with the flabellate forms or with such ones whose systems of branches often spread like fans almost in one plane. A great deal of the branching Lithothamnia exhibit forms of that kind. There are species of which, in certain localities, almost only such forms are developed, e. g. *Lithothamnion calcareum* f. *compressa* in Dalkey Sound near Dublin, the first place where this form was collected by M'Calla. Besides, I have even seen densely branched and attached specimens of up to ten cm. in diameter with branches more or less compressed, all the branch systems being fairly much bent in one and the same direction. In this case there can be no doubt that the current has

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[1]) Also mollusks are specked by friction, when occurring in places with strong currents. Thus Mr. Nordgaard says of a kind of muscle *(Modiola modiolus)*: „Some shells were even thoroughly torn so that the mantle-leaf (kappebladet) was quite laid bare." Cp. O. Nordgaard. Bidrag til Oskjællets Biologi. Norsk Fiskeritidende. Bergen 1901. Pag. 545.

predominantly gone in one direction so as to determine the emphatically unilateral bend of the branch-systems.

A similar state of things is found with varying forms of several crustlike species, which are partly growing in shallower water than the branching ones. If the habitat is much exposed, the motion of the waves will exercise a considerable influence on the development of the alga, in some measure corresponding to the influence of the current in places where the tidal waters run strongly. Thus, by way of example, *Lithothamnion Sonderi* generally occurs in the upper part of the sublitoral region in a depth of 3—10 fathoms. Here it develops excrescences densely verruciform, or at any rate shows an uneven surface. On the other hand, when the species occasionally is growing in the litoral region in much exposed places at the open sea, it may become quite smooth and slightly shining. It then assumes so diverging an appearance that even in a fertile state, if it is not closely examined, it may be confounded with *Lithothamnion læve* otherwise rather different. A similar state of things is seen in *Phymatolithon polymorphum* and in other species.

In the tropics, where not only crustlike, but also branching calcareous algæ seem to occur in a larger number in the litoral region than in the northern areas, these algæ are in exposed places often water-worn. If at the same time they are much encumbered by extraneous bodies, rise is given to forms much stunted and almost unrecognizable. In such places other algæ, or even Corallinaceæ only a little incrusted with carbonate of lime, will assume the form of roundish masses densely heaped together and much diverging from specimens typically developed, e. g. *Mastophora macrocarpa*. Cp. Web. and Fosl. Corall. Siboga-Exp. p. 71, fig. 27. A similar state of things also occurs in exposed localities in the northern areas, where e. g. *Corallina officinalis* may assume a form nearly corresponding, f. *hemisphærica* Fosl.

It is evident from what has been stated above that the great variation of the Lithothamnia is often in essential points owing to extrinsic conditions. By the coincidence of certain circumstances they will — as is mentioned — assume the most peculiar forms,

which greatly impedes the limitation of the species. Therefore, several of such forms are rather to be considered as occasional and accidental variations than as true varieties in the usual sense. Another fact contributing to the difficulty of limitation is the great mutual uniformity of anatomical structure prevailing particularly in the species of the genera belonging to the group of the *Lithothamnioneæ*. This is less the case in the group of the Melobesieæ, e. g. *Lithophyllum*, which is chiefly represented in the tropical or subtropical areas. Besides, the forms belonging to the former group are most richly fructiferous at a rather young stage, whereas old specimens, especially of branching species, are almost always sterile, though still continuing their vegetative development.

It is, however, possible that there are forms of some species which are to be properly looked upon as relics from a period when the glacial formation had a greater extent to the south than in our days. This may perhaps be the case with e. g. *Lithothamnion glaciale* f. *Granii*, such as this form occurs peculiarly in the Christianiafjord, in the Cattegat, and even farther to the south at the coasts of Denmark. On the other hand, the development and rather numerous occurrence of this form in the said areas seem to tell against such a view. The occurrence of the species at the coast of Ireland seems more to favour the notion of a relic. It is, however, as yet difficult to decide this, as the species, in unfavourable local conditions, often assumes similar forms even in the arctic and subarctic areas, and the continuity of the distribution and of the development of the forms is still too little known. There are also other arctic or subarctic species, with smaller area of distribution, which occur to the south in forms which may be looked upon as relics.

In the sequel I will give a survey of the species occurring at the coast of Norway, and of their geographical distribution with the limitation which will be in all essentials my final view of the mutual relations of these species. I will, however, deal with all the forms hitherto described of the species, even if they are not all found within the said area. All the species or forms will be

figured at a later occasion. Then I also hope to be able to illustrate more fully the state of things above mentioned.

Abbreviation.

The exclamation point, — besides being employed in its general sense after the name of an author or of a collector —, indicates, after denominations of species or after an area of distribution, that I have in hand or have seen a specimen or specimens. The same mark in parenthesis indicates that I have collected the alga in the area concerned.

Lithothamnioneæ Fosl.

Den bot. saml. 1902 (1903).

Lithothamnion Phil.

Wiegm. Arch. Jahrg. 3, Bd. 1 (1837), p. 387; Fosl. Syst. Surv. Lithoth. (1898). p. 3, Rev. Syst. Surv. Melob. (1900), p. 10; char. mut.

Subgen. Eulithothamnion Fosl.

Norw. Lithoth. (1895), p. 12; Syst. Surv. Lithoth. (1898), p. 4; Rev. Syst. Surv. Melob. (1900), p. 11; char. mut.

a. Crustacea.

1. *Lithothamnion Lenormandi* (Aresch.) Fosl.[1])

Norw. Lithoth. (1895), p. 150; Melobesia Lenormandi Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 514.

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[1]) In Lithoth. Helgol. (1900) p. 78 Mr. Heydrich tries to show that I ought not to be considered as the first author who referred this species to the genus *Lithothamnion*, but that this was properly done by him in the pamphlet quoted. I have earlier pointed out the peculiarity of this wrong statement, and there has been given no consideration to it by De Toni in Syll. Alg. IV, p. 1756. Cp. Foslie. Bieten die Heydrich'schen Melobesien-Arbeiten eine sichere Grundlage? Det kgl. norske Videnskabers Selskabs Skrifter. Trondhjem 1901. Pag. 9.

When, on the other hand, De Toni in Syll. Alg. l. c. p. 1751 considers Mr. Heydrich as the first author who referred *L. lichenoides* to the genus *Lithothamnion*, I cannot acknowledge his statement to be right. In Corall. insb. Melob. (Ber. der Deutsch. Bot. Gesellsch. 1897) p. 48 Mr. Heydrich admitted the said species under the name of *Lithophyllum lichenoides*, but in Melob. l. c. p. 412 he refers the species to *Lithothamnion*. In referring to this fact De Toni observes l. c.: „(Foslie) nomen in Norw. Lithoth. passim." In Norw. Lithoth. (1895) I have mentioned the species both in the exordium and under *Lithoth. investiens* pag. 130. Besides I admitted it as a species accidentally mentioned in the index l. c. p. 178 under the denomination of „*Lithothamnion lichenoides* (Ell. & Sol.) Fosl.". This seems to me sufficiently justifying my claim to precedence. Therefore,

f. *sublævis* Fosl.

Lithothamnion Lenormandi f. sublævis Fosl. Norw. Lithoth. l. c.

f. *typica.*

Lithothamnion Lenormandi f. typica Fosl. l. c.; Lithophyllum Lenormandi Rosan. Rech. Melob. (1866), p. 85, pl. V, fig. 16—17, pl. VI, fig. 1—3.

f. *squamulosa* Fosl.

Lithothamnion squamulosum Fosl. Norw. Lithoth. (1895), p. 155, pl. 19, fig. 24—26.

Syn: Melobesia Lenormandi Le Jol. Liste Alg. Cherb. (1863), p. 151! Crn. Fl. Finist. (1867), p. 150; Kleen, Nordl. Alg. (1874), p. 11; Aresch. Obs. Phyc. III (1875), p. 1! Farl. New Engl. Alg. (1881), p. 181, partim! Traill, Alg. Mar. Orkney (1890), p. 36.

Lithophyllum Lenormandi Solms, Corall. Monogr. (1881), p. 15; Kjellm. N. Ish. Algfl. (1883), p. 136; Hauck, Meeresalg. (1885), p. 267, fig. 110, t. III, fig. 4! Reinke, Algenfl. westl. Ostsee (1889), p. 32; Fosl. Contrib. I (1890), p. 9, partim. Non Gobi, Algenfl. Weiss. Meer.!

Lithothamnion Lenormandi Debr. Cat. Alg. Maroc. etc. (1897), p. 72! Fosl. List of Lithoth. (1898), p. 6, Rev. Syst. Surv. Melob. (1900), p. 15; Heydr. Lithoth. Helgol. (1900), p. 78, t. II, fig. 23—25; Jönss. Mar. Alg. Icel. I (1901), p. 154! Börg. Mar. Alg. Færöes (1902), p. 401! Batt. Cat. Brit. Mar. Alg. (1902), p. 97! Fosl. Lithoth. Adr. Meer etc. (1904), p. 19, 34; De Toni, Syll. Alg. IV (1905), p. 1756 (excl. f. *australis*).[1])

The form *squamulosa* perhaps represents only old specimens of f. *typica* growing on uneven substrata in sheltered places or encumbered with foreign bodies. The frond is 4—8 mm. thick, and more or less irregular. It is, however, nearly always loosely squamulose-imbricate, in a vertical section frequently showing a more or less porous appearance. This is not the case in the typical form, which is thinner, more firmly adherent and more clo-

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I admitted it in the List of Lithoth. (1898) p. 7 and in Rev. Syst. Surv. Melob. (1900) p. 14 under the designation of author quoted. However, the species was also in 1897 admitted under the same denomination. Cp. F. Debray Catalogue des Algues du Maroc, d'Algérie et de Tunisie. Alger 1897. Pag. 72. This fact De Toni at any rate has been unaware of, to judge from the designation of author which he employs. The Lithothamnia admitted by Debray were determined by me, and he followed my denomination.

1) In the statement of synonyms here and in the sequel, I set aside such ones as are stated by the author concerned, because in several cases they do not agree with the quoted ones.

sely imbricate. On the other hand, it is much differing from a marked f. *sublævis,* which may be as good as quite even.

As far as I know, there has not earlier been stated any measure of the size of the cells in this species. A vertical radial section of a part of a crust freely growing or loosely superposed in the main resembles pl. VI fig. 3 by Rosanoff l. c., but a vertical section of a crust firmly adherent more resembles that of *Lithoth. læve,* often with a hypothallium [1]) rather feebly developed, the convergence of the lower anticlines being feeble or wanting, and the rows of the cells running upwards in rather large curves. Cp. Rosenv. Grönl. Havalg. fig. 7. The length of the hypothallic cells is double or three times the breadth, now and then even more, the length being 12—25 or up to 32 μ, the breadth being 7—11 μ. The perithallium is sometimes rather vigorously developed, and the cells of this layer partly squarish, 6—9 μ in diameter, partly vertically elongated and up to 12, or now and then 16 μ long.[2])

The conceptacles of sporangia in f. *typica* are densely crowded over the whole frond, except a part of the peripherical portion, often so densely that the roofs become angular, now and then even two or three quite confluent. They are subprominent, depressed-hemispherical or often at length disc-shaped or nearly so, 250 (200)—350 μ in diameter. In southern areas they are often a little smaller than usual in northern ones. Towards maturity the central portion of the roof, which is intersected with 25—35 muciferous canals, often becomes slightly concave. Before or after the conceptacles are emptied the central portion of the roof is gradually dissolved, the greater part of it still almost always leaving a narrow prominent border. The borders contribute to the uneveness of the frond, causing that the shallow or rather deep scars after the conceptacles get irregularly effaced by local

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[1]) As to the terms of the layers of tissue cf. Siboga Exp. LXI, p. 11.

[2]) As remarked at an earlier occasion, the measures of the cells stated by me in Norw. Lithoth. and in New or crit. calc. Alg. are from decalcified sections, whereas in pamphlets afterwards published as well as in this one the measures are from undecalcified, ground sections, which often makes a considerable difference.

formations of tissue. However, the conceptacles occasionally are almost immersed and the roof is not dissolved. In such cases the conceptacles consequently become overgrown. The sporangia are four-parted, about 60—80 μ long and 20—35 μ broad. In f. *squamulosa* the conceptacles resemble those of the typical form, though they are frequently less crowded. This form is often sterile. In f. *sublævis* the said conceptacles are generally more depressed and a little larger than in the forms mentioned, 300—400 μ in diameter. The conceptacles of cystocarps in this species often appear in the same individual as those of sporangia, but either frequently in greater number They are hemispheric-conical or subconical and of about the same size as those of sporangia. The conceptacles of antheridia are of the same shape as those of cystocarps, but only 150—200 μ in diameter.[1])

This characteristic and well known species is found attached to rocks and stones, or to shells of mollusks, exceptionally to other calcareous algæ. It occurs in the lowest part of the litoral region, where for the most part it is partly sheltered by other algæ, e. g. *Fucus,* and besides it is found in large numbers in the sublitoral region. The alga here descends to the depth of 8, or, towards its southern limit of distribution, sometimes even 16 fathoms. It shows, on the whole, a remarkable power of accommodating itself to the circumstances. Thus it occurs both on the open shore, often even in localities much exposed, and in sheltered places in the fjords. At the isle of Bornholm in the Baltic, where the sea is but slightly saliferous, Dr. Rosenvinge has found it in rather considerable number in a single place at the lowest water-mark. The specimens were almost typically developed, but somewhat encumbered by other algæ, and they were sterile, when being collected in the former half of July. In the Mediterranean and in the Adriatic it now and then occurs in grottoes above the highest water-mark. But it is here never well developed and seldom bears

1) Here and in the sequel unless it is otherwise observed, the shape and the size of the conceptacles are concerned, as seen from the surface of the plant.

reproductive organs. Cp. Solms, Corall. Monogr. p. 15 and Foslie, Lithoth. Adr. Meer. etc. p. 19.

The species in question is frequently abundant from Nordland in Norway southward at least as far as Finistère, but apparently less numerous in the Mediterranean and the Adriatic. In the most northern part of Norway it is rather commonly dispersed, but not occurring in any great number. It seems to be rare on the south coast of Iceland and scarce at the Færoe islands. This alga is nearly always richly provided with reproductive organs, and such ones have been found all the year.

Area: Norway: From Berlevaag[1]) in East Finmarken to Tromsö(!), Nordland (Kleen) and southward(!); Sweden, west coast (Areschoug and others!); Denmark (Rosenvinge!); the Baltic: Bornholm (Rosenvinge!); Western Baltic (Reinke); Helgoland (Sonder, Kuckuck!); S. W. Iceland: Reykjavik (Jönsson!); the Færöes (Börgesen!); the Orkneys (Traill); the British Isles! The Atlantic coast of France! The Mediterranean! The Adriatic (Hauck, Kuckuck!); the Black Sea (Deckenbach!); the Azores (Sauvageau!); the Atlantic coast of North America: Isles of Shoals, Mass. (Farlow!), Cape Rosier, Me. (Collins!), Point Pleasant, Halifax, N. S. (Mackay!)[2])

2. *Lithothamnion læve* (Strömf.) Fosl.

List of Lithoth. (1898), p. 7, Rev. Syst. Surv. Melob. (1900), p. 15; Lithophyllum læve Strömf. Algveg. Isl. (1886), p. 21, t. I, fig. 11—12; Fosl. Contrib. I (1890), p. 10.

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1) The species probably occurs farther to the east, but as it has formerly been in part confounded with *Lithoth. læve,* I only record it from the most eastern locality from where I now possers specimens.

2) A specimen from the Pacific Beach near San Diego on the coast of California, collected by Mrs. Snyder and communicated to me by Mr. Collins, much resembles *L. Lenormandi* f. *squamulosa* in habit. The cells, however, are often a little coarser than frequently seen in this species, but a few conceptacles occurring resemble those in South-European specimens. On the other hand the specimen somewhat approaches *L. squamuliforme* from Australia. Therefore, as only a solitary specimen and apparently a not well developed one has been examined, I do not venture to record the species in question from the said area.

Syn. Melobesia Lenormandi Farl. New Engl. Alg. (1881), p. 181, partim!

Lithophyllum Lenormandi Gobi, Algenfl. Weiss. Meer. (1878), p. 21, saltem pro parte! Fosl. Contrib. I (1890), p. 9, partim.

Lithophyllum Lenormandi f. lævis Fosl. Contrib. II (1891), p. 10.

Lithothamnion tenue Rosenv. Grönl. Havalg. (1893), p. 778! Non Kjellm. Beringh. Algfl. (1889), p. 22, t. I, fig. 6—10?

Lithothamnion Strömfeltii Fosl. f. macrocarpa, f. tenuissima Fosl. Norw. Lithoth. (1895), p. 145, t. 22, fig. 12.

Lithothamnion læve Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 14! Börg. Alg. Mar. Færöes (1902), p. 401! Jönss. Alg. Mar. Icel. I (1901), p. 153! Jönss. Alg. Mar. East. Greenl. (1904), p. 6! De Toni Syll. Alg. IV (1905), p. 1757. Non Saund. Alg. Harr. Alaska Exp. (1901), p. 442! Nec. Setch. and Gardn. Alg. Northw. Amer. (1903), p. 358![1])

In List of Lithoth. p. 7 I admitted *Lithophyllum tenue* Kjellm. from the Behring's Sea as an independent species under the genus *Lithothamnion*. But in Rev. Syst. Surv. Melob. I subsumed it as a form of *Lithoth. læve*. The specimens I have seen of the said alga are in all essentials consistent with *Lithoth. læve* both in habit and in structure. The conceptacles of sporangia are depressed hemispherical or almost disc-shaped, sometimes two or three confluent, 350—650 μ in diameter. They are in so far diverging from typical *Lithoth. læve,* as they are a little less prominent than usual in this species. But they seem to have been faintly developed and are decaying. The fact is, however, hardly decidable from a few specimens from a single locality. I, therefore, think it most correct at present to maintain the species as an independent one till by a larger material from the said area not only its relation to *Lithoth. læve,* but also to the near *Lithoth. californicum,* apparently much varying, can be realized. The last mentioned species and *Lithoth. læve* can hardly be identical.

On the other hand it is questionable, whether *Lithoth. læve* in fact is something more than a form of *Lithoth. flavescens*. It is,

[1]) I have once had for determination samples of two of the specimens from Alaska which are admitted by Saunders l. c. under *Litholh. læve*. I much regret that they were referred to this species. By a more searching inquiry of fragments of these specimens, I now find that they ought to be referred to the near *Litholh. californicum*. It is sometimes difficult or almost impossible to draw the line between these two species. They appear to be in the same correlations as *Ph. loculosum* and *Ph. compactum*.

however, considerably thinner, the conceptacles frequently larger, more superficial and never becoming overgrown as in the said species.

I omit the two forms of this species (f. *macrospora* and f. *tenuissima)* formerly admitted, as a fair line cannot be drawn. The thickness of the crust and the size of the conceptacles, indeed, prove much varying even in one and the same species.

The shape and the size of the cells in the species in question have not earlier been stated. The structure, otherwise, shows the same uniformity as in several other species, and considerable mutual resemblance to that of several northern ones. Nor can I state a sure average measure, having in this respect only examined a couple of young specimens. The hypothallic layer mostly seems to be rather faintly developed. The length of the cells is double or thrice, now and then even four times the breadth, the length being 15—35 μ and the breadth being 6—11 μ. The perithallic layer is composed of cells which are squarish, abouth 7 μ in diameter, or vertically elongated and up to 12 μ long and 11 μ broad. In crusts proportionally thick this layer shows an indistinct stratification. Cp. Rosenv. Grönl. Havalg. l. c. fig. 4—6.

The conceptacles of sporangia are depressed hemispherical or almost disc-shaped, most frequently superficial or nearly so, 0.5 (0.4) – 1 mm. in diameter, frequently 0.6—0.8 mm., and the roof is intersected with 80—120 muciferous canals. The said conceptacles are generally numerous and rather crowded, some of them here and there so densely crowded that the roofs become angular. The sporangia are four-parted, 200—600 μ long and 100—200 μ broad. But the alga sometimes also seems to bear two-parted sporangia. Cp. Strömfelt l. c., Rosenvinge l. c., Norw. Lithoth. p. 146 and below under *L. tophiforme*. The conceptacles of cystocarps are conical, frequently 600—800 μ, and those of antheridia of the same shape and about 350 μ in diameter.

The species occurs rather numerously almost in all the areas where it is dispersed. It is found only on hard ground and occurs in preference in localities where the tidals run rather strongly, but also both on the open shore and in sheltered places. The alga is

found partly solitary, partly associated with other calcareous algæ and is attached to rocks or particularly to small stones or to shells of mollusks. It is sometimes met with in the lower part of the litoral region, but has its most frequent occurrence in the sublitoral region in a depth of 5—15 or 20 fathoms, exceptionally deeper. Thus the Danish Ingolf Expedition in 1896 brought home specimens of this species picked up even from a depth of 44 fathoms at Stat. 127 on Lat. 66° 33′, Long 20° 05′ W. The alga has been collected with reproductive organs from the month of May till the month of October.

Area: Norway: From the north-eastern boundary to Haugesund(!); N. and E. Iceland (Strömfelt, Jönsson!); the Færöes (Börgesen!)[1]); the Atlantic coast of North America: Wood's Holl, Mass.[2]); Gloucester, Mass. (Farlow!), Eagle Island, Jaddleback Island, Me. (Collins!), Eastport, Me. (Farlow!); Newfoundland (Waghorne!); Ellesmereland, southere coast: Havnefjord, Exkrementbugten, Gaasefjord, Hvalrosfjord, Jammerbugten (Baumann, Bay, Simmons!); Ellesmereland, east coast: Rice strait (Simmons!); West Greenland (Hartz, Holm, Rosenvinge!); East Greenland: Stenö (Kruuse sec. Jönsson!), Danmarks island at Heklahavn (Hartz sec. Rosenvinge!); Spitzbergen: between Norsköerne and Amsterdamöen (Nils Johnsen!); Lat. 80° 31′, Long. 18°o (Malmgreen!)[3]); the White Sea (Gobi!).

3. *Lithothamnion flavescens* Kjellm.

N. Ish. Algfl (1883), p. 129, t. 6, fig. 1—7! Fosl. Contrib. I (1890), p. 8; Fosl. Norw. Lithoth. (1895), p. 110; Jönss. Mar. Alg. Icel. I (1901), p. 153! De Toni, Syll. Alg. IV (1905), p. 1739.

In a vertical section of this species the hypothallic layer is developed mainly as in *Litholh. læve.* The cells are 14—40 μ

[1]) It seems very likely that this species also occurs at the northern coast of Scotland. But I have not yet seen sure specimens from that place. Specimens recorded from the British Isles under the name *L. Strömfeltii (L. læve)* have turned out to be *L. Sonderi.*

[2]) Specimens seen from this place are sterile and consequently uncertain.

[3]) According to specimens in the Riksmuseum at Stockholm, collected in 1861 „in 10 fathoms wather, 3—5 miles (geogr.?) from nearest land."

long and 7—14 μ broad, their length being twice to four times, usually twice to three times their breadth. The perithallic cells are squarish, 8—11 μ in diameter, or vertically elongated, up to 15 μ long and 12 or exceptionally 14 μ broad.

The conceptacles of sporangia are depressed-hemispherical, sometimes almost disc-shaped, 400—800 μ in diameter, frequently 500—650 μ, and the roof intersected with 80—110 muciferous canals. The sporangia are four-parted, 190 - 300 μ long and 50—120 μ broad. The said conceptacles finally become overgrown in specimens typically developed and not too young, but in others the roof falls into decay as in *Lithoth. læve,* and the scar is effaced by new formed tissue. The conceptacles of cystocarps are conical, 500—600 or up to 800 μ, and those of antheridia 250—350 μ in diameter.

As remarked above under *L. læve,* it is rather uncertain whether that species and *L. flavescens* are specifically distinct. Young and even fertile specimens seem almost undistinguishable, apart from the substratum. However, in *L. flavescens* the crust becomes thicker than ever seen in *L. læve,* the structure seems to be slightly coarser in the former, the conceptacles of sporangia frequently are a little smaller and finally become overgrown. On the other hand the species in question approaches in habit young specimens of *Phymatolithon investiens,* by which in certain localities it becomes partly covered.

This species occurs in the sublitoral region and descends to a depth of about 20 fathoms. It is attached to other calcareous algæ, particularly *Lithoth. glaciale* and *L. tophiforme,* and sometimes also to shells of Balanidæ.[1]) Some specimens mentioned in Norw. Lithoth. l. c. as attached to stones can not be referred to this species, although they are thicker than usual in *L. læve.* The alga seems to prefer sheltered places. It appears rather scattered and in small number of individuals. It has been found fructiferous from June to the middle of September.

[1]) The form growing on shells of Balanidæ with smaller conceptacles than usual, I have denominated f. *balanicola* Fosl. herb.; but I do not admit it here, as it seems to be too little differentiated.

Area: Norway: From the north-eastern boundary (Magerö and Karlsö, Kjellmann!) as far south as Balstad in Lofoten(!); N. and E. Iceland (Jönsson!); Spitzbergen, west coast: Between Norsköerne and Amsterdamöen (Nils Johnsen!); Novaia Zembla, west coast: Karmakulbay (Kjellmann!).

4. *Lithothamnion foecundum* Kjellm.

N. Ish. Algfl. (1883), p. 131, t. 5, fig. 11—19! Fosl. Norw. Lithoth. (1895), p. 109; Rev. Syst. Surv. Melob. (1900), p. 12; Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 12! Jönss. Mar. Alg. Icel. I (1901), p. 153! De Toni, Syll. Alg. IV (1905), p. 1739.

Syn: Lithothamnion polymorphum Kjellm. Kariska Hafv. Algveg. (1877), p. 15.

As to the structure of this species I will only add to the description given by Prof. Kjellman that I have found the hypothallic cells in a vertical section being of a length of up to about four times the breadth, or 15—25 or up to 35 μ long and 7—12 μ broad. The perithallic cells are squarish, 7—11 μ in diameter, or vertically elongated and up to 15 μ long, frequently however shorter. Thus the alga in all essentials corresponds with *Lithoth. læve* in structure; but new crusts are often developed above others, so as to form at last rather thick crustlayers. Besides the conceptacles of the species in question become gradually overgrown; which is never the case with *Lithoth. læve,* which therefore, shows a more regular anatomic structure.

The conceptacles of sporangia are densely crowded over the whole frond except a narrow peripherical portion, 400 (300)—600 μ in diameter, frequently about 500 μ. They are immersed to subimmersed, at first convex or nearly hemispherical, however by and by decorticated in the central part of the roof. Here they finally become concave or sometimes much impressed, with a border rather strongly elevated, which in fact represents the peripherical portion of the roof. The said central part is traversed by 40—60 muciferous canals. The sporangia are four-parted, 120—185 μ long and 45—90 μ broad. Sometimes the sporangia seem to be two-parted, but such ones perhaps represent organs not fully developed. Besides I have seen very few conceptacles of cysto-

carps and apparently also of antheridia in a specimen from East-Greenland. They are convex or subhemispheric conical, 300—450 and 200—250 μ in diameter, occurring in the central part of a thin crust richly furnished with conceptacles of sporangia.

This species is characteristic and easily recognizable, when bearing conceptacles of sporangia fully developed. Otherwise it may be confounded principally with *Lithoth. læve,* but also with other species. Even specimens with young conceptacles may be hardly distinguishable from a *Lithoth. læve* faintly developed, the more so because both species are for the most part growing gregariously and often sharing substratum and coalescing or one sometimes growing over the other. Old specimens of the species with an uneven surface or specimens growing on an uneven substratum may even be confounded with stunted forms of *Lithoth. glaciale* which have not developed branches, but only show a surface more or less uneven or finely rugged. This is, by way of example, the case at Heklahavn on the east coast of Greenland, where *L. foecundum, L. læve,* and such a stunted form of *L. glaciale* are growing gregariously. The same sometimes seems to be the case on the coast of Iceland. Sterile specimens will besides bear a considerable resemblance to young *Ph. investiens* or somewhat faded forms of *Ph. polymorphum* f. *sublævis,* or of *Ph. lævigatum* which bear the peculiar sterile conceptacles mentioned under these species.

There is a possibility that *L. foecundum* is referable to the genus *Phymatolithon,* but this can not at present be decided.

The alga occurs within the sublitoral region in a depth of 5—20 fathoms both on the open coast and in sheltered places where the tidal waters run rather strongly. It grows sporadically in small numbers of individuals together with other calcareous algæ, often sharing substratum with *Lithoth. læve.* It has been found furnished with sporangia in June, July, August and October.

Area: Norway: Near Tamsö in Porsanger Fjord and at Berg near Tromsö (!)[1]) N. and E. Iceland (Jönsson!); Newfound-

[1]) Specimens from other localities on the northern coast of Norway are uncertain. Therefore, I do not record them here, but only such ones of which

land (Waghorne!)?[1]) Ellesmereland, southern coast: Havnefjord (Baumann, Bay, Simmons!); Ellesmereland, east coast: Rice Strait (Simmons!), West Greenland: Upernivik, Pröven (Rosenvinge!) East-Greenland: Heklahavn (Hartz. sec. Rosenvinge!) Spitzbergen: Between Norsköerne and Amsterdamöen (Nils Johnsen!); the Kara Sea (Kjellman!).

b. Subramosa.

5. *Lithothamnion Sonderi* Hauck.

Meeresalg. (1885), p. 273, t. III, fig. 5! Fosl. Norw. Lithoth. (1895), p. 127; Johns. and Hensm. Irish. Corall. (1899), p. 29, partim![2]) Fosl. Rev. Syst. Surv. Melob. (1900), p. 14; Heydr. Lithoth. Helgol. (1900), p. 77, t. II, fig. 20—22; Batt. Cat. Brit. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1747.

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at present I possess certain specimens. It is however probable that the alga occurs scattered from Tromsö to the north-eastern boundary, not unlikely even farther to the south than Tromsö.

[1]) A solitary specimen seen from Newfoundland resembling a young *L. foecundum* bears only a few young conceptacles of sporangia which are a little prominent, one of them being indistinctly concave in the central part. They are, however, only 300—350 μ in diameter. Thus the said organs are smaller than usual in *L. foecundum* or in *L. lœve*. In this respect the specimens stands nearest to *L. Sonderi* although the roof of the conceptacles seems to be thicker than in this species. Besides it is not probable that the last named species occurs at Newfoundland. On the other hand the specimen approaches a little *Ph. lævigatum*. But the conceptacles being too prominent, and the colour being different, the said specimen most probably belongs either to *L. lœve* or to *L. foecundum*, most likely to the latter.

Nor have I seen any certain specimen from more southern parts of North America. A few sterile ones from Wood's Holl, Mass., Eastport, Me. (Farlow!) and Newport, R. I. (Collins!) I once considered perhaps referable to *L. foecundum*, but they have proved to be too uncertain, partly also approaching *L. lœve* or even *Ph. lævigatum*.

[2]) I once had for determination the greater part of the calcareous algæ admitted in this pamphlet under the genus *Lithothamnion*. Then, however, many species and their limitation were not yet sufficiently known to me, and most of the specimens were, besides, sterile and bleached. I, therefore, designated several species as uncertain. On that account I here only admit the species from Ireland where I have now sure proofs of the accuracy of the determination.

f. *typica.*

Descr. Lithoth. Sonderi Hauck l. c.

f. *sublævigata* Fosl. mscr.

Frond even or subeven and feebly shining; conceptacles of sporangia 250—400 μ in diameter.

f. *pacifica* Fosl.

New Sp. or Forms of Melob. (1902), p. 4; Setch. and Gardn. Alg. Northw. Amer. (1903), p. 358!

The form *sublævigata* is distinguished for its even or almost even frond, which is feebly shining. Besides, the conceptacles of sporangia are frequently a little smaller than in the typical form. It is perhaps only a local form, once found in the litoral region in a much exposed locality at Rövær near Haugesund. I have seen specimens also from the British Isles which are almost even, but they are dull and the conceptacles a little larger. Specimens from there, growing on dead *Lithoth. calcareum,* sometimes are feebly shining and rather resembling the form in question, but they are young and stunted. However, the specimen from Finistère mentioned below seems to stand near to this form and is perhaps identic.

As to the form *pacifica* I am still unable to draw any certain line between this form and f. *typica.* The excrescences are more regular than usually seen in European specimens, but in this respect no limit is to be drawn. I have even seen specimens of this form approaching f. *sublævigata* in habit. The conceptacles of sporangia also agree with typical *L. Sonderi* except that the roof frequently is a little thicker. The sporangia too are of about the same size. However, as remarked l. c., antheridia and cystocarps are not yet known in f. *pacifica.* Therefore, its relation to the species in question in fact depends on these organs.

In structure this species stands near to or almost coincides with closely adherent forms of *Lithoth. Lenormandi.* However, the hypothallium in the latter species is nearly always vigorously developed, in a vertical section often occupying the greater part of the thickness of the crust, whereas in *L. Sonderi* the said layer is rather feebly developed. The cells are frequently 14—25 μ long

and 7—11 μ broad. On the other hand, the perithallium in *L. Sonderi* is nearly always more vigorously developed than in any form of *L. Lenormandi,* but new crusts are often developed upon others. The cells of the latter layer are squarish, 6—10 μ in diameter, or elongated vertically and about 12 μ long.

The conceptacles of sporangia in the typical form are subprominent, rather crowded, often two or three confluent, circular or nearly circular in circumference, convex or nearly disc-shaped, 300—500, frequently 350—400 μ in diameter. In f. *sublævigata,* as above remarked, they are a little smaller. The roof is intersected with 50—100 muciferous canals. It finally falls into decay, and overgrown conceptacles do not occur. The sporangia are four-parted, 100—150 μ long and 35—60 μ broad. The conceptacles of cystocarps, occasionally occurring in the same specimens as those of sporangia, are conical or subconical, 300—450 μ in diameter. Some smaller ones together with the latter are likely to be those of antheridia, about 200 μ in diameter.

This species on one side approaches stunted forms of *Lithoth. læve,* and on the other hand it is nearly related to old and uneven specimens of *Lithoth. Lenormandi,* particularly f. *sublævis.* The latter species and *L. Sonderi* are sometimes hardly distinguishable, particularly when the specimens are stunted or bleached. In habit the species also approaches stunted forms of *Lithoth. glaciale,* or occasionally reminds of *Phymatolithon polymorphum.*

L. Sonderi grows on rocks or stones, sometimes on shells of mollusks or other calcareous algæ. It frequently occurs in the sublitoral region, descending to a depth of about 15 fathoms, mostly, however, appearing in 4—10 fathoms. Once it has been found in the lower part of the litoral region in an exposed locality (f. *sublævigata).* The plant bears reproductive organs, mostly sporangia, in January, March, May to August, and October.

Area: Norway, south-west — south coast: Rövær, f. *typica,* f. *sublævigata* (!), Haugesund (!), Mandal (Wille!,!), Fredriksværn (!), Hvalöerne (!); Sweden: Gullmarsfjord (Lagerheim, Arwidsson!); Denmark (Rosenvinge!); Helgoland (Sonder, Kuckuck!); Scotland, south-west coast: Bute (Mrs. Robertson!), Cumbrae

(Batters!); Ireland: Larne, Co. Antrim (Hanna!), Dalkey Sound near Dublin (Johnson!,!); France: Finistère (Debray!)[1]; Pacific coast of North America (f. *pacifica):* Channel Rocks, Wash. (Setchell and Gardner!); Pacific Grove, Cal. (Setchell!).

c. Ramosa.

6. *Lithothamnion glaciale* Kjellm.

N. Ish. Algfl. (1883), p. 123, t. 2—3!

f. *typica.*

The basal crust usually vigorous, sometimes disappearing (being attacked by animals), sending forth coarse lobes; branches subsimple or irregularly divided, frequently with wartlike processes or short side-branches and often forming irregular bundles.

f. *botrytoides* Fosl. mscr.

Lithothamnion botrytoides Fosl. in Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 10; Rev. Syst Surv. Melob. (1900), p. 11; De Toni, Syll. Alg. IV (1905), p. 1733; Lithothamnion intermedium Rosenv. Grönl. Havalg. (1893), p. 774! Lithothamnion delapsum f. conglutinata Fosl. Norw. Lithoth. (1895), p. 50, t. 14, fig. 4.

The basal crust vigorous, sending forth lobes with very short, approximate branches, forming small bundles more or less distant.

f. *subfastigiata* Fosl. mscr.

Lithothamnion glaciale f. verrucosa Fosl. Rev. Syst. Surv. Melob. (1900), p. 11.

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[1] A bleached specimen from that place (Debray, no. 67) seems to me to belong to *L. Sonderi,* although on the other hand it much approaches *L. Lenormandi.* The frond, however, is coarser than in the latter, and the cystocarpic conceptacles are more acute, or almost conical. On the contrary, the conceptacles of sporangia are smaller than frequently in typical *L. Sonderi,* 300—350 μ in diameter. In this respect as well as in habit the specimen apparently stands nearest to f. *sublævigata.*

Three other specimens bleached and rather stunted from the same place, which I formerly with some doubt referred to *L. Sonderi,* are too uncertain to be recorded under this species. They are likely to belong to another species.

Some years ago I referred to *L. Sonderi* a few bleached specimens from Guethary (Basses Pyrenees), collected by C. Sauvageau (no. 6). They partly share substratum with *Lithoph. subtenellum.* After a renewed examination of these specimens I now consider them to represent a rather coarse form of *Litholh. Lenormandi.* I found some cystocarpic conceptacles, which are too low to be identic with those in *L. Sonderi.*

Frond spherical or irregular, the crust rather feeble or finally disappearing (being attacked by animals), the lobes small and the branches frequently delicate, short, approximate, often with wart-like processes, or forming bundles rather approximate and subfastigiate.

f. *subsimplex* Fosl. mscr.

The crust rather feeble or often vigorous, not or indistinctly lobed, with branches simple or subsimple, frequently conical or subcylindrical, erect.

Syn: Lithothamnion calcareum Kleen, Nordl. Alg. (1874), p. 11; Kjellm. Vinteralg. (1875), p. 64.

Lithothamnion fasciculatum Dickie, Alg. Sutherl. I, (1852), p. 142? Aresch. Obs. Phyc. 3 (1875) p. 5, partim! Kjellm. Spetsb. Thall. I (1875), p. 3! Algveg. Murm. Meer. (1877), p. 7; Gobi, Algenfl. Weiss. Meer. (1878), p. 22!

Lithothamnion glaciale Strömf. Algv. Isl. (1886), p. 18; Fosl. Contrib. I (1890), p. 7; Rosenv. Grönl. Havalg. (1893), p. 773! Fosl. Norw. Lithoth. (1895), p. 13 (excl. f. torosa); Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 9! Fosl. Rev. Syst. Surv. Melob. (1900), p. 11; Saund. Alg. Harr. Alaska Exp. (1901), p. 442? Batt. Cat. Brit. Alg. (1902), p. 97! Jönss. Mar. Alg. Icel. I (1901), p. 153! Börg. Mar. Alg. Färoes (1902), p. 400! Setch. Alg. Northw. Amer. (1903), p. 358? Jönss. Mar. Alg. Jan Mayen (1904), p. 305! De Toni, Syll. Alg. (1905), p. 1730 (excl. f. *flabellata*).

Lithothamnion colliculosum Fosl. Contrib. II (1891), p. 8, partim, Norw. Lithoth. (1895), p. 75, partim, in Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 11.

Lithothamnion varians Fosl. Norw. Lithoth. (1895), p. 8, partim, in Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 11.

Lithothamnion Ungeri f. intermedia Heydr. Mus. Lithoth. Paris. (1900), p. 540!

Lithothamnion boreale Fosl. Contrib. II (1891), p. 2, t. 1, partim, Norw. Lithoth. (1895), p. 12, partim; De Toni, Syll. Alg. IV (1905), p. 1731, partim.[1])

[1]) There is known only a solitary specimen of *Lithoth. boreale*, which is figured l. c. I now think this specimen likely to represent a coarse form of *Lithoth. glaciale*, covered with *Phymatolithon investiens* except a small portion of the basal parts. The branches are rather elongated, but this has probably taken place during the encompassing of the alga, and the uppermost part of the branches seems to have been thoroughly formed by *Ph. investiens*. It is difficult to fix the limit between both species, as *Ph. investiens* clings closely to *L. glaciale*. Cp. below under the species first-named. Also in a section the limit is often hardly discoverable, as a new crust over older ones of *L. glaciale* is sometimes scarcely distinguishable from a closely covering crust of *Ph. investiens*. Also the cells, particularly the hypothallic ones, are often much resembling each other.

There are some branching species along the coast of Norway, most of them, however, more widely dispersed, which nearly run into each other. They are frequently easily recognizable when vigorously and typically developed, but as soon as they are attacked by animals or grow in places not favourable to their development, they become more or less varying or stunted. Sometimes a species will even assume forms which rather resemble specimens almost typically developed of another species, or, more often of course, run into forms of the same species more or less stunted. Cp. the introductory remarks. One of these species is *L. glaciale.* It is extremety varying and difficult of limitation. After a renewed and careful examination of a large material from a number of localities, and after succeeding in getting some curious specimens of one of the forms nearly allied from the south coast of Norway and the Bahusian coast of Sweden, I now find it necessary to take *L. glaciale* in a more restricted sense than formerly. Even then, however, it includes forms sometimes much diverging from each other.

Thus I have found it almost impossible to draw any line between *L. Granii,* admitted below, and *L. glaciale.* But still I think the former ought to be considered as an independent species also closely connected with *L. tophiforme.* The same is the case of *L. colliculosum,* which I must also look upon as an independent species, though with a circumscription somewhat different from the earlier one. Particulars are found under the species mentioned.

As to the forms admitted above of the species in question, I consider f. *typica* as the coarsest one and as the form which reaches its most vigorous development within the arctic zone. Cp. Kjellman l. c. t. 2. To this form is affined f. *botrytoides,* which I originally looked upon as an independent species. In this form the branches are considerably shorter and more delicate, developing small bundles. It, therefore, often has an appearance greatly diverging and corresponds to f. *glomerata* of *L. intermedium.* This form sometimes is to be found coalesced with *L. fornicatum.* Young specimens of f. *botryoides,* or, strictly speaking, a form intermediate between the said form and f. *subsimplex* (partly also f. *subfastigiata)* is hardly distinguishable from *L. tophiforme* and *L. Granii.* The

form *subsimplex* is a form less independent, which is on one side approaching f. *typica,* but the crust forms no lobes or but indistinct and small ones, and the branches form no bundles. It may be partly vigorously developed, forming a thick crust with shorter or longer branches, partly forming a thin crust with branches feebly developed. In certain stunted forms of *L. glaciale* the crust is about 3 mm. thick with a surface but indistinctly verrucate or almost even, approaching *Phym. compactum* or *Lithoth. foecundum* in habit. Cp. under the latter species.

The form *subfastigiata* is also varying and often rather diverging. It frequently encompasses pebbles forming smaller or larger nodules, or is attached to rocks. *Lithoth. glaciale,* like several other species, has a tendency to detaching itself from the substratum, particularly when it is small, or when the basal crust is attacked by animals, which is of frequent occurence particularly in f. *subfastigiata,* sometimes also in f. *typica,* and which is perhaps to be regarded as the chief cause of the loosening. When attached to rocks, the crust is often detaching itself at a rather early stage of development, and at the same time small lobes are formed, the ramification becomes denser, the branches more or less fastigiate and rather coalescing, with wartlike processes. At last the alga is completely detached from the substratum, and under favourable circumstances the part turning downwards is covered with a new crust, mostly a quite thin one, from which short branches are emitted. When the form is encompassing pebbles, the crust is often but faintly developed, and branches are emitted at an early stage such as in some other species which are normally attached to hard objects.[1]) Also in this case small lobes are formed, but even these are partly dissolved by boring mussels, the branching grows dense, and the branches short, subfastigiate, usually forming small bundles, more or less approximate. It is often not distinguishable from certain forms of *L. intermedium* but for the partition of sporangia, and sometimes it bears a con-

[1]) Cp. M. Foslie. Die Lithothamnien des Adriatischen Meeres und Marokkos. Wissensch. Meeresuntersuchungen. Neue Folge. VII Band. Abt. Helgoland. Heft. 1. 1904. Pag. 8.

siderable resemblance to small forms of *L. fornicatum*. On the other hand, particularly the form of f. *subfastigiata* which is attached to rocks now and then approaches certain branching forms of *Phym. polymorphum* in habit. Cp. under the latter species Sometimes the form develops coarse branches and then approaches coarse forms of *L. tophiforme* f. *sphærica*, and as the inner branches of the latter form are sometimes fairly coalescing, the resemblance will be considerable, though the branches of *L. glaciale* are mostly more irregular with more wartlike processes. Definite charachters, however, by which such specimens can be distinguished, are scarcely statable. The same is the case of young specimens attached of *L. tophiforme* and *L. Granii*.

As to reproductive organs, the conceptacles of sporangia partly appear in the crust, partly and most frequently in the upper part of the branches. They are now but very little prominent, now subprominent. In the latter case the roof sometimes falls into decay, and the conceptacles are not gradually overgrown, but the scars are effaced by new-formed tissue. This I have seen even in specimens typical and vigorously developed. They are frequently rather crowded, 300 (250)—400 or up to 500 μ in diameter and intersected with 50—70 muciferous canals. The sporangia are two-parted, 80—180 μ long and 40—80 μ broad. The cystocarpic conceptacles are conical and of about the same size as those of sporangia. A few smaller ones seen among the latter about 200 μ in diameter, are likely to be those of antheridia.

This species occurs in the sublitoral region at the depth of 3—20 or 30, particularly 8—20 fathoms. A specimen is said to have been dredged up in a depth of 80 fathoms near Grimsey, Iceland. Cp. Jönsson, Alg. Icel. I, p. 153. The alga thrives best on the open coast, but is also found in larger fjords. It appears now sporadically, now gregariously in great numbers. Cp. Kjellman l. c. Specimens with reproductive organs have been taken from the month of March to the month of December.

As to the geographical distribution of this species I want to remark that I got a specimen from Professor Farlow (herb. no. XXII), labelled Bermuda, leg. I. C. Hill. This specimen represents

a typical *Lithoth. glaciale* well developed, which seems to have come from an arctic area. On my question Professor Farlow kindly communicated to me as follows: „In regard to the *L. glaciale* supposed to have come from Bermuda, I can only say that it was a part of the collection belonging to the Agassiz Museum, which was given to me by Mr. Agassiz, and the label stated that it came from Bermuda. As I did not collect the specimen myself, I cannot of course be sure that the label was correct, but I have to assume that the labels were correct." — I will add that the specimen bears a considerable resemblance to specimens in the same collection from Labrador. This seems to suggest that there is some mistake or other as to the statement of place of collection, and that the specimen actually has come from arctic North America. Besides it is quite improbable that a typical *L. glaciale* should occur at Bermuda.

Lithoth. glaciale is stated also to have been found at Fuegia. Cp. Heydrich, Lithoth. Mus. Paris in Engler's cot. Jahrb. 1901, p. 540. The specimen on which this statement is based is sterile. It is, however, likely belonging to *L. glaciale* and must be supposed to have come from an arctic area. Cp. Foslie, Melob. Arb. Heydr. (1901) p. 27. There is certainly a mistake due to a confusion of labels.[1])

I do not venture at present to consider any of the three specimens I have seen from the northwest coast of America as surely

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[1]) In this connection I will mention another case in which labels are likely to have been confounded. In the pamphlet quoted Mr. Heydrich describes p. 538 a new sterile species under the name of *Lithothamnion labradorense* Heydr. from Labrador. I think it quite unquestionable that this uncertain species is not from an arctic area. It must have risen almost as far from Labrador as, I except, Mr. Heydrich himself. The alga does not resemble *Litholh. fornicatum*, as Mr. Heydrich remarks. On the contrary, its habit as well as structure go to show decidedly that it is tropical or subtropical. Nor does it seem to be referable to the genus *Lithothamnion*. It might be an obvious conclusion that owing to a confusion of labels the alga has been mistaken for the *Litholh. glaciale* mentioned above, which is stated to be from Fuegia; but even this I think not very probable. In the material treated by Mr. Heydrich l. c. also other mistakes as to the labels are conceivable than the two mentioned ones.

belonging to *L. glaciale.* Cp. Saunders l. c., Setchell and Gardner l. c. The specimens, besides, seem to be young and are fragmentary, particularly those collected by Dr. Saunders which I have earlier indicated as uncertain. The specimen from Whidbey Island, Wash. (Setchell and Gardner) bears a striking resemblance to young *L. glaciale* f. *subsimplex,* but also recals young *L. colliculosum.* It bears a few conceptacles of sporangia, which are convex, but little prominent, 300—400 μ in diameter. The sporangia are two-parted. In many places, however, even species rather widely different are — as is pointed out above — under certain circumstances almost running into each other. As it has recently been proved how e. g. *Phymatolithon compactum* on the north and northwest coast of America runs into *Ph. loculosum* so that it seems almost impossible to draw a line between them, while specimens typically developed are widely different, there may also be left an opening for the supposition that the specimens referred to *L. glaciale* may belong to another species, e. g. *L. japonicum.* This can not be decided from so inconsiderable a material as that which I possess at present. I have already in the description of *L. japonicum* (New or crit. calc Alg. p. 6) stated that it very nearly approaches *L. glaciale.* But of the former there is only a single specimen without sporangia, and a possible identity does not at present seem to be probable.

As to the distribution of each individual form is to be observed that f. *typica* and f. *subsimplex* occurs most frequently within the arctic zone; f. *botrytoides* is known from Ikamuit and Egedesminde on the west coast of Greenland, from Mestervik in Malangen near Tromsö (Norway), from Loppen and Altenfjord, in the two places last mentioned, however, are only found young specimens; f. *subfastigiata* particularly occurs in the southern part of the area of distribution.

Area: Norway: From the north-eastern boundary to the Trondhjem-Fjord (Kleen, Kjellman!,!)[1]); Iceland (Strömfelt,

[1]) The specimens from the Trondhjem Fjord are much attacked by boring mussels, the crust dissolved and the branches rather coalescing, but probably belonging to f. *subfastigiata* of this species.

Jönsson!); The Färoes (Börgesen!)[1]); Scotland: Bute at Port Bannatyne (Holmes, Robertson!)[2]); (Bermuda, leg. J. C. Hill?)[3]); Atlantic coast of North America: Massachusetts—Maine (Collins, Farlow!); Nova Scotia (Ruggles, Mackay, Howe!), Newfoundland (Waghorne, Holden, Howe!), Labrador (Carpenter!); Ellesmereland, southern coast: Havnefjord, Exkrementbugten, Jammerbugten (Baumann, Bay, Simmons!); West-Greenland (Rosenvinge!); East-Greenland: Heklahavn (Rosenvinge!); Jan Mayen (Jönsson!), Spitzbergen (Kjellman!); the Murman coast and the White Sea (Gobi!); Nova Zembla, west coast (Kjellman); the North west coast of America (Saunders, Setchell and Gardner!)?[3])

Subfossil: *Lithoth. glaciale* has also been found subfossil in several places. Thus at Tamsö in Finmark I have taken it under the green turf a few meter above the level of the sea, at Korsnes in the Altenfjord too. Besides, it is probably in part this species which has been met with in several other places, from Vadsö in East-Finmark and southward as far as the mouth of the Trondhjemfjord, sometimes even up to 50 meter above the level of the sea. The subfossil specimens pictured in Norw. Lithoth. pl. 23 perhaps also in part belong to this species. The main part of the material of subfossil Norwegian Lithothamnia, a number of which also are kept at the Geological Institution at Christiania, has not yet been closely examined.

Interesting subfossil finds of the species in question have also

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1) The specimens seen from that place are young and, therefore, the determination may admit of doubt. One of them approaches young *L. colliculosum* in habit.

Cp. C. Wyville Thomson. The Depths of the Sea. London 1874. Pag. 60: „On the 15th and 16th (August) we dredged over the Färoe Banks at a depth of from 200 to 50 fathoms, the bottom gravel and nullipore, and the temperature from 8° to 10 C.“ It would be of great interest, if it could be ascertained whether the said nullipores were actually Lithothamnia, in that case not unlikely *L. glaciale*.

2) I possess a few specimens with two-parted sporangia from that place, which in my opinion must be referred to *Lithoth. glaciale* f. *subfastigiata*. Cp. below under *L. tophiforme*.

3) Cp. above under remarks on the distribution of the species.

been made in Ellesmereland and N. Kent during the Fram-Expedition led by Mr. Sverdrup 1898—1902, namely in the following places: Ödedalerne in the Havnefjord in a river-bed in gravel mixed with clay, together with large numbers of mussels, e. g. *Mya truncata, Saxicava rugosa, Astarte elliptica,* etc., about 5 meter above the level of the sea (Simmons!); the Neve Bay (Nevebugten) in a river-bed together with mussels (Simmons!); the Reindeer Bay (Renbugten) in a river-bed (Isachsen!); N. Kent, bay on the south-side in a layer of clay about 3 meter above the level of the sea together with *Mya, Saxicava, Balanus, Serpula,* etc. (Simmons!).

7. *Lithothamnion colliculosum* Fosl.[1])

Contrib. II (1891), p. 8, partim, Norw. Lithoth. (1895, p. 75, partim, Rev. Syst. Surv. Melob. (1900), p. 11.

f. *typica.*

Frond at first saxicolous, crustlike, with wart-like excrescences which arise into erect, subcylindrical, short branches 2—3,5 mm. in diameter, either simple or bifid, often with wartlike processes and frequently crowded; afterwards the crust sometimes disappears (being attacked by animals) and the branches become more elongated, repeatedly subdichotomously divided, subcylindrical or subcompressed, with rounded ends, the frond finally lying loose at the bottom, almost inverted plate-shaped and up to about 12 cm. in

1) On the urgency of Dr. F. Börgesen to give him a list of the boreal-arctic Lithothamnia and their distribution, I submitted them to a revision somewhat hurried, and I was not able to go through the whole material thoroughly. I am sorry to state that in consequence the number and the limitation of the species in the pamphlet present are to some extent disagreeing with the survey I sent to Dr. Börgesen last spring. Cp. Jönsson and Börgesen. The Distribution of the Marine Algæ of the arctic Sea and of the northermost part of the Atlantic. — Botany of the Færöes. Appendix (Copenhagen 1905). The number of Norwegian species has now become larger. Besides a few new species, indeed some forms of species of the said list have been here admitted as species independent, viz. *L. colliculosum, L. intermedium, L. breviaxe, L. soriferum, L. nodulosum* and *L. Granii.* I much regret the alteration, which, however, will hardly disturb, in a degree worth mentioning, the understanding of the survey of the geographical distribution of the algæ given by Messrs. Jönsson and Börgesen.

diameter, by a thickness of about 5 cm. Conceptacles of sporangia convex, but little prominent, often crowded in the upper part of the branches, 300 (250)—400 μ or up to 500 μ in diameter; sporangia bisporic, 140—220 μ long, by 60—100 μ broad; conceptacles of cystocarps conical, 300—400 μ in diameter.

f. *pusilla* Fosl. mscr.

Frond 1—2 cm. in diameter, branches crowded, subsimple, shorter and sometimes thinner than in the typical form.

Syn: Lithothamnion colliculosum Batt. in Grevillea vol. 21 (1892), p. 23, partim! Batt. Cat. Brit. Alg. (1902), p. 97, partim! De Toni, Syll. Alg. IV (1895), p. 1732, partim. Non Fosl. in Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 11.

Lithothamnion roseum Batt. in Grevillea, vol. 22 (1893), p. 20, saltem pro parte!

Lithothamnion fasciculatum Aresch. Obs. Phyc. 3, (1875) p. 5, partim!

This species — as it was formerly circumscribed — included partly young or stunted specimens of the species in the sense here taken, partly young *L. glaciale*. The essential part of the material I have hitherto seen of this alga consists of such young specimens, often hardly distinguishable from certain forms of *L. glaciale* and *L. Granii*. I have, however, lately received specimens which, I think, are representing an old form of the species in the sense taken above. This form even approaches *L. fornicatum* in habit.

At first the species is hard attached to the substratum, rocks or stones. It often forms a crust widely spread, but mostly attaining to no conciderable thickness. In the lower part of the litoral region or in the upper part of the sublitoral region the crust mostly develops only simple or bifid branches, which are frequently rather crowded and straight, 2—3,5 mm. thick with rounded ends. If the crust is attacked by animals, the alga is gradually detached from the substratum and becomes more densely branching. Farther down in the sublitoral region, it becomes — under favourable circumstances — much larger and more branching. The crust disappears little by little, being attacked by animals, and the branches are repeatedly divided, but still rather straight. Finally the alga will become almost inverted-plate-shaped and then resembles certain forms of *L. fornicatum*.

The form *pusilla* seems most likely to have to be regarded as a stunted form of the species, corresponding to *L. Granii* f. *reducta*. The branches, however, are often comparatively shorter, thinner and more coalescing than in the typical form. Sometimes it is hardly distinguishable from young specimens of *L. Granii*.

As to conceptacles, the species comes near to *L. Granii*. Those of sporangia partly are gradually overgrown, partly and more frequently they are not so.

L. colliculosum occurs in the lower part of the litoral region, sometimes in pools, but particularly in the upper part of the sublitoral region and descends to a depth of about 10 fathoms. The alga occurs both in exposed places and in sheltered ones where the tides run rather strongly. It is fructiferous in January—March, and June—September.

Area: Norway: Skorpen in Tromsö amt, f. *pusilla* (!), the Trondhjemsfjord, f. *typica*, f. *pusilla* (!), Haugesund f. *typica* (Norum!,!), Kragerö, f. *typica*! Dröbak in the Christianiafjord, f. *pusilla* (Gran!,!); Sweden: Fiskebäckskil, young f. *typica* (Areschoug!), Väderö Storö, young f *typica* (Lagerheim!), off Gullmarfjord, f. *typica*, f. *pusilla* (Arwidsson!); Denmark: Limfjord, young f. *typica* (Rosenvinge!); Scotland: Berwick, Cumbrae, young f. *typica* (Batters!).[1])

8. *Lithothamnion intermedium* Kjellm.

N. Ish. Algfl. (1883), p. 127; Strömf. Algveg. Isl. (1886), p. 19; Fosl. Contrib. I (1891), p. 7, partim; Lithothamnion fruticulosum f. intermedia Fosl. Norw. Lithoth. (1895), p. 18; (non Kütz.); L. Ungeri Fosl. Rev. Syst. Surv. Melob. (1900), p. 11, partim; De Toni, Syll. Alg. IV (1905) p. 1734, partim.

f. *subdistans* Fosl. mscr.

Lithothamnion intermedium Kjellm. l. c. t. 4, fig. 2!

The basal crust sending forth simple or subsimple, subdistant branches.

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[1]) The specimens from the Atlantic coast of North America which in Norw. Lithoth. p. 75 were referred to this species I now consider as representing young forms of *L. glaciale*, although they are in part scarcely distinguishable from young specimens of *L. colliculosum*.

f. *glomerata* Fosl.

Lithothamnion fruticulosum f. glomerata Fosl. Norw. Lithoth. (1895), p. 18, pl. 4, fig. 3.

In Norw. Lithoth. l. c. I united *L. intermedium* and *L. Ungeri* Kjellm., founding my statement on old specimens particularly of the latter alga, much attacked by animals and partly worn by friction of the water. Now, however, I take *L. Ungeri* in another sense than Prof. Kjellman did l. c., and I did in Norw. Lithoth. Cp. below. I also take *L. intermedium* in a sense more limited than originally taken by Prof. Kjellman. Thus I do not refer to this species specimens branching from the centre of the frond, or attached to stones, developing a very feeble basal crust not producing lobes. This is the case with specimens in my collection from Finmark, which Prof. Kjellman once referred to *L. intermedium,* and which I formerly considered as a form of this alga. Such specimens I now think to belong to *L. fornicatum.* The same may also be the case with the specimen pictured by Prof. Kjellman l. c. t. 4, fig. 1, which I have not seen.

With this limitation I refer to *L. intermedium* only forms with a basal crust as a general rule well developed, or a solid central mass producing clumsy lobes, more or less distinct, simple or divided, carrying branches subsimple or repeatedly divided, which often form dense bundles. The circumscription and the identification of the species, however, also in this sense is impeded by the assiduous occurrence of animals destroying the older parts and bringing about a greater fusion of the younger parts of the alga. Certainly this species is much less exposed to being destroyed than several other species, e. g. *L. fornicatum,* probably on account of its more solid basal or central parts. But on the other hand, hardly any older specimen is found which is not to some extent attacked by animals or does not serve as the residence of such ones.

When typically developed, *L. intermedium* bears in habit a considerable resemblance to delicate forms of *L. glaciale.* The form *subdistans* corresponds to f. *subsimplex,* partly also to f. *typica* of *L. glaciale,* and the form *glomerata* corresponds to f.

botrytoides of the same species. They are often only distinguishable by the parting of sporangia.

The conceptacles of sporangia are usually spread over the whole of the frond, seldom crowded as in several other species. They are convex, but little prominent, sometimes indistinctly marked, 250 (200)—400 μ in diameter, and are gradually overgrown. The roof is intersected with 30—60 muciferous canals. The sporangia are four-parted, 100—150 μ long and 30—50 μ broad. The cystocarpic conceptacles are conical, sometimes low, and of about the same diameter as those of sporangia.

The species — as far as is hitherto known — occurs sporadically, often together with other species in a depth of 3—15 fathoms. However, I only met with a small number of specimens. It occurs both on the open coast and in places fairly sheltered, and is fructiferous in the months of June—September.

Area: Norway: From the north-eastern boundary to Tromsö (!) (Karlsö, Kjellman); Iceland, the Eskifjördur (Strömfelt).[1])

9. *Lithothamnion fornicatum* Fosl.

Contrib. II (1891), p. 3, pl. 1—2, Norw. Lithoth. (1895), p. 36, Rev. Syst. Surv. Melob. (1900), p. 12; De Toni, Syll. Alg. IV (1905), p. 1734; Lithothamnion dehiscens Fosl. Norw. Lithoth. (1895), p. 45.

f. *subsphærica* Fosl. mscr.

Lithothamnion fornicatum f. sphærica Fosl. Rev. Syst. Surv. Melob. (1900), p. 12 (Norw. Lithoth. pl. 12, fig. 1).

Frond spherical or depressed-spherical, repeatedly subdichotomously branching from the centre, branches erect, straight and fastigiate.

f. *dimorpha* Fosl. mscr.

Lithothamnion dimorphum Fosl. Norw. Lithoth. (1895), p. 40, pl. 10; Rev. Syst. Surv. Melob. (1900), p. 12; De Toni, Syll. Alg. IV (1905), p. 1735; Lithothamnion fruticulosum f. fastigiata Fosl. Norw. Lithoth. (1895), p. 18, t. 5.

f. *apiculata* Fosl. mscr.

Lithothamnion apiculatum Fosl. f. typica, f. parvicocca Fosl. Norw. Lithoth.

[1]) I have not seen any specimen of *L. intermedium* in the sense above taken from Iceland, nor did the species occur among numerous Lithothamnia collected by Mr. Jönsson in several places on that coast. On the other hand it seems probable that the alga should occur there.

(1895), p. 54, pl. 15, fig. 1—8 (excl. f. connata, f. patula); De Toni, Syll. Alg. IV (1905), p. 1735.

f. *obcrateriformis* Fosl. mscr.

Lithothamnion fornicatum f. typica Fosl. l. c.; Lithothamnion dehiscens f. typica Fosl. l. c. pl. 11, pl. 12, fig. 2.

Frond finally convex-concave or sometimes subhemispherical.

f. *tuberculata* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 12; Lithothamnion dehiscens f. grandifrons Fosl. Norw. Lithoth. p. 45, pl. 13.

f. *robusta* Fosl.

Lithothamnion fornicatum f. robusta Fosl. Norw. Lithoth. p. 36, pl. 9.

Syn: Apora polymorpha Gunn. in Act. Nidros. IV (1768), p. 71, partim, t. XV, fig. 1.

Lithothamnion fasciculatum Aresch. Obs. Phyc. 3 (1875), p. 5, partim!

Lithothamnion delapsum f. abbrevita Fosl. Norw. Lithoth. p. 50? De Toni, Syll. Alg. IV (1905), p. 1733?

As I observed, in treating of *L. intermedium* Kjellm., I separate from this species a form which was originally referred to it both by the author who described the species and by myself in Norw. Lithoth. The said form, repeatedly branching from the centre of the frond or sometimes attached to small pebbles, developing a very feeble crust, is to be transferred to *L. fornicatum*. It very nearly approaches *L. Ungeri* f. *fastigiata*, which, therefore, also has to be transferred to the species in question. With the limitation stated above, *L. fornicatum* represents a species much varying in habit and hardly distinguishable from several other species. This is particularly due to attacks of animals. Thus scarcely any other boreal-arctic calcareous alga is found more attached by boring mussels than this one.

The form *subsphærica* seems to be the typical form of the species. It is partly spherical, partly, and more frequently compressed-spherical, which seems always to be the case in places where the tidal waters run strongly. The form is branching from the centre, the branches repeatedly subdichotomously divided, erect, fastigiate and straight, either terete or subcylindrical or subcompressed, towards the apex often carrying small wart-like processes, rather anastomosing, with the ends rounded or obtuse. Cp. Norw.

Lithoth. pl. 12, fig. 1. It is in general freely developed at the bottom, seldom attached to pebbles or shells of mussels and then at first developing a thin crust. Of this form there are found a more delicate and more southern one, and a coarser and more northern one, the latter of which runs into f. *robusta*. On the other hand f. *subsphærica* imperceptibly runs into f. *dimorpha*, of which also a coarser form (*L. dimorphum*, Norw. Lithoth. pl. 10) and a somewhat more delicate form (*L. Ungeri* f. *fastigiata*, Norw. Lithoth. pl. 5) are found. The latter is met with chiefly in shallow sounds where the current is strong. It is distinguished for very short and rather coalescing branches. The form sometimes encompasses small pebbles, but always develops only a very feeble crust with crowded branches proceeding from it, or occasionally attaches itself to or encompasses stones in a stage of development somewhat advanced. The central parts of this form nearly always are gradually attacked and dissolved by boring mussels, and finally an opening is formed. It is a rather stunted form of the species and never attains to any considerable size. The form *apiculata* is perhaps also a stunted or but a young form of the species. This form partly runs into the preceeding one, partly also approaching f. *tuberculata* as to ramification, in the latter case with the branches of the central parts rather coalescing, giving the impression of small lobes, and those of the last order forming small bundles.

The form *obcrateriformis* is developed from f. *subsphærica*, which is mostly only found in places peculiarly favourable to the development of the alga. Also f. *subsphærica* is much attacked particularly by boring mussels, which first destroy the central parts of the alga and continue their destructive work outward towards the peripheric parts, which are often only forming as it were a thin cover round the said animals. At the same time, however, the alga often grows considerably in size, the peripheric parts uninterruptedly continuing their growth, developing short branches more coalescing, while the interior of the alga is filled with boring mussels continually carrying on their destructive work. At last there is frequently formed an opening in the part turning downwards. Then we have in hand a specimen inverted cup-shaped,

which is then, by continued destruction, becoming more or less convex-concave. Such a specimen represents f. *obcrateriformis,* which is properly a forma *subsphærica* changed by attacks of animals. Cp. Norw. Lithoth. pl. 11. The part turning downwards shows truncate, worn ends of branches more or less coalescing. Cp Contrib. II, pl. 2. The form may also become wreathlike. Cp. Norw. Lithoth. pl. 12, fig. 2. Under certain circumstances the f. *obcrateriformis* may again almost assume its original shape. Cp. above pag. 6—7. Also of f. *obcrateriformis* there are found a southern form with thinner branches *(L. dehiscens* in Norw. Lithoth.) and a northern one with thicker branches *(L. fornicatum* l. c.).

The form *tuberculata* seems partly to represent an old f. *obcrateriformis,* whose upper branches have been in part worn away by the friction of the water, whereupon shorter and thinner branches have been developed over or round the worn surfaces, forming short branches with wartlike processes or small bundles. In places where the tidals are running very strongly, the bundles are crowded and are often also gradually worn or partly torn away, sometimes even getting an almost truncate appearance. Cp. above p. 7—8 and Norw. Lithoth. p. 46, pl. 13. If new branches are developed in the part turning downwards, they often do not form bundles, but are, however, thinner than in specimens typically developed.

The conceptacles of sporangia in this species are convex, but little prominent or subprominent, 300 (250)—450 μ in diameter, often crowded below the apex of the branches. The roof is intersected with 40—70 muciferous canals. The sporangia are tetrasporic, 100—180 μ long and 40—80 μ broad. The conceptacles of cystocarps are conical or subconical, of about the same size as those of sporangia, and those of antheridia are also concial and 200 - 250 μ in diameter. Old specimens, or specimens much attacked by animals, are almost always sterile. Overgrown conceptacles are now and then found in the peripheric parts of a branch.

As to the synonomy, it is to be observed that *L. delapsum* f. *conglutinata* probably belongs to f. *obcrateriformis,* though I have not found ripe sporangia in it.

As to the relation of the species to other ones, it may partly be difficult to distinguish the form *apiculata* from a faintly developed *L. nodulosum* f. *typica*. On the other hand, f. *dimorpha* in certain localities will in habit approach old specimens not typically developed of *L. colliculosum*, and is distinguishable only by the parting of the sporangia. The species also approaches *L. nodulosum* f. *congregata*, and in habit also *L. grande*, the following species. It is, however, most nearly akin to *L. tophiforme* and *L. soriferum*, from which it is very difficult or almost impossible to distinguish young nodules or slightly developed spherical ones. In such specimens of *L. fornicatum*, however, the branches are mostly thinner and more densely crowded than in the said species, and the branch-systems are not distinctly inverted pyramidshaped. On the other hand, small nodules are considerably approaching a *L. vardöense* densely branching, which, however, is mostly carrying smaller conceptacles, and the sporangia are two-parted as in *L. tophiforme*.

L. fornicatum occurs in the upper part of the sublitoral region from the lowest water mark to a depth of about 8 fathoms. It prefers places sheltered, but generally only occurs where the tidal waters are strongly running. In favourable localities f. *obcrateriformis* will attain a size of up to 0,5 m. in diameter, and a weight of up to about 6 kilogrammes. The species almost always appears gregariously in large numbers, partly associated with other Lithothamnia, and often forms considerable banks. It occurs in larger numbers than any other species on the coast of Norway. The alga has been found with reproductive organs in January and in June—September, but always only a few specimens among a great lot of collected ones. In some places it has only been found sterile.

Area: Norway: From the north-eastern boundary to the Trondhjem Fjord(!), Tusteren near Kristiansund N.(!)[1]), Vestnes in Romsdal (Gran!), and in the neighbourhood of Bergen (Palibin!)[2])

[1]) All the specimens gathered in this place are sterile and somewhat approaching *L. colliculosum* so as to make the determination uncertain.

[2]) Two specimens I have seen from this place are feebly developed, 3—4 cm. in diameter, but seem to have to be referred to this species.

10. *Lithothamnion grande* Fosl. mscr.

Frond freely developed at the bottom, subspherical or hemispherical, repeatedly subdichotomously branching, the branches erect, but curved, fastigiate, 1,5—2,5 mm. in diameter; conceptacles of sporangia convex, but little prominent, 300—400 μ in diameter; sporangia two-parted, 100—140 μ long and 50—70 μ broad.

This species forms spherical masses of 10—15 cm. in diameter, or subhemispherical ones of up to about 35 cm. in diameter by a thickness of about 14 cm., and of up to about 5 kilogrammes in weight. The branches are 1—1,5 or up to 2 cm. long, curved, those of the last order sometimes rather straight, often carrying wart-like processes and more or less anastomosing.

In structure the alga coincides in the main with *L. fornicatum*. So it does also as to the conceptacles, which are more or less crowded in the upper part of the branches. Grown in organs of that kind occur sparingly in the peripherical portion of a branch.

L. grande approaches *L. fornicatum* in habit, but is distinguished by its curved branches as contrasted with the straight branches of *L. fornicatum*. On the other hand, it coincides in ramification with *L. Ungeri* and *L. breviaxe*, particularly coarse specimens of the former species, but differs by its two-parted sporangia, and from the latter by its longer branches and as it seems frequently less prominent conceptacles. Besides it sometimes approaches old specimens of *L. colliculosum*, but the branches of the latter are mostly thicker and straight, and this species never grows as large as *L. grande*.

Of the occurrence and frequency of the species little is known. A solitary live specimen has been taken in the Langesundfjord, a few dead specimens at Mandal and in the Sandsund at Rövær. A single specimen not certainly belonging to this species, has been picked up from a depth of 15 fathoms in the Hardanger Fjord. The other specimens in hand few, but well developed, have come from localities unknown on the west coast of Norway.

Area: Norway: the west coast (sent in to the Bergens Museum from localities now unknown); Sandsund at Rövær (brought

up by excavators, comm. Norum!); Östensjö in Hardanger (Norum!)[1]; at Mandal (Wille!,!), Langesundsfjord!

11. *Lithothamnion Ungeri* Kjellm.

N. Ish. Algfl. (1883) p. 120! Non L. byssoides Unger.

f. *typica.*

Lithothamnion fruticulosum f. typica Fosl. Norw. Lithoth. (1895), p. 18, pl. 3 et 4, fig. 1—2, non Kütz; Lithothamnion Ungeri f. typica Fosl. Rev. Syst. Surv. Melob. (1900), p. 11.

Frond freely developed at the bottom, very seldom attached, repeatedly branching from the centre, branches erecto-patent, short, curved, feebly attenuating or not so, with ends rounded or sometimes spherically thickened, fastigiate or subfastigiate, 1,5—2 mm. thick, often provided with wartlike processes or short side-branches, finally rather crowded and coalescing; conceptacles of sporangia frequently crowded in the upper part of the branches, subprominent, 300—400 or up to 500 μ in diameter; sporangia tetrasporic, 100—150 by 35—50 μ, conceptacles of cystocarps conical, of about the same diameter as those of sporangia.

f. *flexuosa* Fosl.

Lithothamnion fruticulosum f. flexuosa Fosl. Norw. Lithoth. l. c., pl. 6—8; Lithothamnion Ungeri f. flexuosa Fosl. Rev. Syst. Surv. Melob. p. 11.

Branches usually less crowded than in the typical form, up to 2,5 mm. thick.

Syn: Lithothamnion Ungeri Fosl. Contrib. I (1890), p. 8; Jönss. Mar. Alg. Icel. I (1901), p. 153; De Toni, Syll. Alg. IV (1905), p. 1734, partim.

As I observed above, in treating of *L. intermedium,* I take *L. Ungeri* a little otherwise circumscribed than I formerly did. Kjellman l. c. states that „it differs distinctly (from *L. soriferum)* by its strongly developed, crustaceous hypothallus, by its denser ramification, with shorter, much finer, and less compound branches". In Norw. Lithoth. l. c. I admitted the species in the same sense. But I have afterwards made sure that, strictly speaking, it never

[1] The specimen from this place is inverted cup-shaped, with the upper branches rather coalescing, and in habit almost coinciding with *L. fornicatum* f. *obcrateriformis.* I have not found sporangia, and the determination is not certain.

develops any crustaceous hypothallus. Among a large number of specimens I have only seen a single one attached to the substratum with a small crust very faintly developed, while elsewhere the alga is lying freely on the bottom. The apparent hypothallus which is now and then seen in old specimens are only remnants of parts of the alga which have fallen to decay, partly on account of attacks of animals, partly because of the friction of the water. Such lingering remnants are often covered with crusts of the same species faintly developed, from which new branches are developed — in part and particularly with crusts of other species, e. g. *L. flavescens*. Cp. Norw. Lithoth., pl. 8, fig. 1.

In N. Ish. Algfl. l. c. Professor Kjellman identifies *L. Ungeri* with *L. byssoides* Unger, Leithakalk p. 19—20, t. V, fig. 1—8, the latter from a specimen collected in the neighbourhood of Bergen. I have formerly pointed out that they are scarcely identical, but that *L. byssoides* must be referred to *L. nodulosum*. Cp. Norw. Lithoth. p. 29 and 61.

The alga in question is generally attacked by boring mussels at an early stage of development, and in certain localities it is at the same time worn by friction of the water. Accordingly the central parts of the alga, which have partly fallen to decay, often convey the impression of forming rather coarse lobes such as are mentioned in Norw. Lithoth. But this is only due to a fusion of branches which has taken place at an earlier stage. The alga will finally get hollow, the outer branches more coalescing than usual, and at the same time large surfaces of friction being formed. From such parts worn are often developed a number of wartlike processes or short branches. Cp. Norw. Lithoth. pl. 4, fig. 1—2.

The form *corymbiformis* l. c. pl. 6 represents such old specimens of the species, much dissolved and worn, but partly emitting new bundles of branches. I, therefore, do not maintain it as an independent form. If the interior of the alga is attacked by animals, and the outer parts are not at the same time worn by friction, the branches become here still more approximate, less curved and more coalescing than elsewhere. In such cases, the plant is hardly distinguishable from *L. fornicatum* f. *subphærica*

or *dimorpha* whose central parts are dissolved by boring mussels. When forming small bundles, it will also approach f. *tuberculata* of the species mentioned.

The conceptacles of sporangia on one side approach those of *L. fornicatum* so as to make it difficult to draw any limit in this respect. On the other hand, they come near to those of *L. soriferum,* and also here a limit is scarcely to be drawn, although they are often less prominent than fully developed ones in the said species. The roof, which is traversed by about 50 muciferous canals, usually falls to decay, leaving a cupshaped scar, which is gradually effaced by new-formed tissue. However, overgrown conceptacles now and then occur in the peripherical portion of a branch.

I have thought it questionable whether *L. Ungeri* together with *L. nodulosum,* admitted below, should not be considered as a form of *L. norvegicum,* as they belong to the same series of forms. But I have afterwards found this less probable, although a definite line can hardly be drawn. In the limitation here taken, it also approaches other species. Thus I have above mentioned that it will approach *L. fornicatum,* and particularly coarse, sterile specimens seem to be hardly distinguishable from *L. grande.* On the other hand, coarse specimens of f. *flexuosa* will so nearly approach *L. soriferum* f. *squarrosa* that it is difficult to draw the line. It is distinguished from the latter mainly by its branches generally more curved. Specimens of this form with more delicate branches very nearly approach *L. nodulosum.* This is the case e. g. with the form of the species occurring on the coast of Iceland. I refer this form to f. *flexuosa,* though it is more delicate than usual. I have seen specimens well developed from Bildudalur, about 10 cm. in diameter.[1])

This species occurs in a depth of 3—15 fathoms and prefers places sheltered, where the tidals are running strongly. In such places it appears, as a general rule, in shallow water, often forming considerable banks, while in places somewhat exposed it descends

1) In this form from Iceland I found four-parted as well as two-parted sporangia, the latter, however, in small number, but apparently ripe.

deeper into the sublitoral region. It is often covered by *Phymatolithon investiens*. At Galten in West-Finmarken and inside Tamsö in the Porsangerfjord I have seen large masses of sterile specimens probably of the species in question quite overgrown with the said species. It was in these places coarser and less typical than it is, when growing freely. Cp. under the said species. The alga is fructiferous in the months of May—September.

Area: Norway: From Porsangerfjord as far as Tromsö(!); Iceland (Jönsson!).

12. *Lithothamnion breviaxe* Fosl.

Norw. Lithoth. (1895), p. 16, partim, pl. 2.

Syn: Lithothamnion fruticulosum Fosl. in Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898) p. 10?

Frond resembling *Lithoth. Ungeri* in habit and in structure; conceptacles of sporangia convex, but little prominent, or subprominent, 300—450 μ in diameter; sporangia bisporic, 120—160 μ long and 40—60 μ broad; conceptacles of cystocarps conical, rather low, 400 - 500 μ in diameter.

As remarked l. c. p. 17, I found only a few sporangia, when I described this species. They were found in a small fragmentary specimen, which was in habit resembling those pictured l. c. I have, however, afterwards succeeded in finding sporangia in a part of the specimen pictured l. c., fig. 2. These sporangia are two-parted. I, therefore, still concider this alga as an independent species, but with a limitation different from that stated l. c., i. e. bearing the same relation to *L. Ungeri* as *L. tophiforme* is bearing to *L. soriferum*.

In old specimens of this species, or particularly in such ones which are attacked by boring mussels, the branches of the last order — like the case of *L. Ungeri* — will become rather straight and coalescing, though always short.

L. breviaxe has hitherto been found in a depth of 3—5 fathoms in places fairly sheltered. It bears sporangia in the months of June—August.

As to the geographical distribution of the species, I want to

observe that the specimens from Greenland recorded below are those mentioned by Dr. Rosenvinge l. c. I referred them to a form identic with *L. Ungeri.* There are only two specimens known. One is from Sukkertoppen, having been about 10 cm. in diameter and hollow owing to the attacks of animals, the peripherical portion left being only about 1 cm. thick, the branches being fastigiate and but slightly curved and rather coalescing. It resembles old and hollowed Norwegian specimens of *L. Ungeri* and *L. breviaxe.* As remarked above under the former species, such specimens also much approach *L. fornicatum* in the sense now taken, or certain forms of *L. tophiforme,* but are more consistent with specimens of *L. Ungeri* and *L. breviaxe* having been attacked by animals. I have never seen *L. tophiforme* hollowed. The said specimen bears conceptacles of sporangia 300—400 μ in diameter, but I have not succeeded in finding any sporangia. I refer it to *L. breviaxe,* as the other branching Lithothamnia known from Greenland bear two-parted sporangia and not four-parted ones as in *L. Ungeri* in the sense now taken. — The specimen from Julianehaab was fragmentary, when collected, and the branches are less fastigiate than those of the other specimen. It bears scars from the conceptacles emptied, and probably belongs to the same species. — From Labrador only one specimen is in hand. It is compressed-spherical, about 10 by 6 cm. in diameter. It is not hollow, though it is in the central parts partly dissolved by boring mussels, and the branches are rather coalescing, but somewhat curved. I, therefore, refer it to *L. breviaxe.* It is provided with rather numerous conceptacles of sporangia. But also here I have not succeeded in finding sporangia. Accordingly the determination of these specimens is not quite certain.

Area: Norway: Kjelmö in Sydvaranger and Skarsvaag near the North Cape(!); North America: „Some point on the coast of Labrador within the province of Quebec, on the coast of the Gulf of Saint Lawrence, within the islands of Cape Breton and Newfoundland" (A. K. Mackay!)[1]); West-Greenland: Sukkertoppen, Julianehaab (Rosenvinge!)[1]).

[1]) Cp. the remarks on the distribution of the species.

13. *Lithothamnion soriferum* Kjellm.

N. Ish. Algfl. (1883), p. 117, partim!

f. *globosa* Fosl.

Lithothamnion soriferum f. globosa Contrib. II (1891), p. 6, pl. 3, fig. 3; Kjellm. l. c. t. 1, fig. 1—5; Lithothamnion tophiforme f. globosa Fosl. Norw. Lithoth (1885), p. 119, partim.

f. *squarrosa* Fosl.

Norw. Lithoth. l. c. t. 21, fig. 8—9.

f. *alcicornis* (Kjellm.) Fosl.

Contrib. II (1891), p. 6, pl. 3, fig. 4; Lithothamnion alcicorne Kjellm. l. c. p. 121, t. 5, fig. 1—8; Lithothamnion tophiforme f. alcicornis Fosl. Norw. Lithoth. p. 119.

Syn: Millepora polymorpha Mohr, Isl. Naturhist. (1786), p. 141, 148, partim t. 6, fig. b?

Lithothamnion fasciculatum Kleen, Nordl. Alg. (1874), p. 11, partim?

Lithothamnion soriferum Strömf. Algveg. Isl. (1886), p. 18 (partim?); Fosl. Contrib. I (1890), p. 6, partim.

Lithothamnion tophiforme Fosl. Norw. Lithoth. l. c. partim; Jönss. Mar. Alg. Icel. I (1901), p. 153, partim! De Toni, Syll. Alg. IV (1905), p. 1740, partim.

This species and *L. tophiforme* I formerly considered as identical. Also Prof. Kjellman l. c. referred specimens of both to one and the same species. They resemble each other in habit and in structure. But one of them bears four-parted sporangia, the other bears two-parted ones. Cp. below under the latter.

I omit here the f. *typica* admitted in Norw. Lithoth. Cp. l. c. pl. 21, fig. 7 and 10. It is a form intermediate between f. *globosa* and f. *squarrosa,* and little independent. The former seems more likely to be the typical form of the species, and the specimens pictured by Prof. Kjellman l. c. are most nearly connected with this form. I also leave out the f. *affinis* admitted in Rev. Syst. Surv. Melob. p. 13. It is a very delicate form of f. *squarrosa.* In habit it even approaches young *L. nodulosum* or certain forms of *L. norvegicum,* but particularly a delicate *L. Granii.* There occurs a form corresponding of *L. tophiforme.* The form has risen in some localities from the use of a peculiar kind of fishing nets, by which coarse specimens of the alga have been crushed, and delicate fragments of them have continued growing. Cp. Lithoth. Adr. Meer. etc. p. 10. Thus it represents — at any rate partly

— only an occasional variation, and is no true variety in the usual sense.

The species, as a general rule, is developed freely on the bottom. But in certain circumstances it will, like several other species, develop crust-like formations or attach itself to hard objects. In the latter case, it even develops a feeble crust, which is, however, sometimes fairly extended, and which, at an early stage of development, sends forth branches at first rather spreading, but gradually growing approximate. This seems, however, to occur much more rarely than in *L. tophiforme.*

The conceptacles of sporangia in this species are partly scattered, partly — and more frequently — densely crowded, particularly in the upper part of the branches, often so densely crowded as to make the roofs angular. They are convex, partly but little prominent, partly — and most frequently — subprominent, finally almost superficial, 300—500 μ in diameter. The roof is intersected with 50—80 muciferous canals. The sporangia are tetrasporic, 100—180 μ long and 50—80 μ broad. The cystocarpic conceptacles, which generally occur in other individuals than those of sporangia, appear scattered and are conical, 400 - 600 μ in diameter. Those of antheridia are of the same shape as the latter, and of about half the size in diameter. I have not seen overgrown conceptacles of sporangia in this species, but the scars after conceptacles emptied and but little prominent are sometimes effaced by local formations of tissue, and are visible in a section.

Like most other species, also *L. soriferum* prefers places where the tidals are running strongly. It is found in a depth of 5—20, and particularly 10—15 fathoms. In some localities it is wholly or partly covered by *Phymatolithon investiens* and *Lithothamnion flavescens.* It bears reproductive organs in the months of June—September.

The area of distribution is rather limited. In this respect the alga stands in the same relation to *L. tophiforme* as *L. intermedium* does to *L. glaciale.* Nor does it occur in large numbers, though here and there it is forming small banks. Of the forms recorded f. *squarrosa* appears to be the most frequent one, whereas

f. *globosa* and f. *alcicornis* are of rather rare occurrence, the former only known from Magerö and Altenfjord, and the latter from Tromsö.

Area: Norway: From the north-eastern boundary (Maasö and Karlsö, Kjellman) as far as Tromsö(!), and Nordland (Kleen)? Iceland (Jönsson!).[1])

14. *Lithothamnion tophiforme* Unger.

Leithakalk (1858), p. 21, t. V, fig. 14.

Frond resembling L. soriferum in habit and in structure, but the sporangia bisporic.

f. *sphærica* Fosl. mscr.

Frond 4—7 cm. in diameter, spherical or subspherical, branches erect, straight and fastigiate.

f. *divergens* Fosl. mscr.

Lithothamnion divergens Fosl. Norw. Lithoth. (1895), p. 68, t. 16, fig. 43—50.

f. *flabellata* (Rosenv.) Fosl. mscr.

Lithothamnion flabellatum Rosenv. Grönl. Havalg. (1893), p. 772, fig. 1—2! Lithothamnion flabellatum f. Rosenvingii Fosl. Norw. Lithoth. (1895), p. 70, Lithothamnion glaciale f.? flabellata Fosl. Rev. Syst. Surv. Melob. (1900), p. 11; De Toni, Syll. Alg. IV (1905), p. 1730.

Syn: Lithothamnion fasciculatum Kleen, Nordl. Alg. (1874), p. 11, partim? Gobi, Algenfl. Weiss. Meer. (1878), p. 22, partim?

Lithothamnion soriferum Kjellm. N. Ish. Algfl. (1883), p. 117, partim! Strömf. Algveg. Isl. (1886), p. 18, partim? Rosenv. Grönl. Havalg. (1893), p. 772!

Lithothamnion flabellatum Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 13! Jönss. Mar. Alg. East-Greenl. (1904), p. 6!

Lithothamnion tophiforme Fosl. Norw. Lithoth. (1895), p. 119, partim; Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 13! Jönss. Mar. Alg. Icel. I (1901), p. 153, partim! De Toni, Syll. Alg. IV (1905), p. 1740, partim.

When in Norw. Lithoth. l. c. I admitted *L. tophiforme (L. soriferum* Rosenv.) from Greenland as being identical with *L. soriferum* Kjellm., I wrote on the footing that the form admitted by Dr. Rosenvinge in Grönl. Havalg. l. c. with the denomination last mentioned bore sporangia four-parted. However, by the kindness of Dr. Rosenvinge, I then had got all the material of Li-

1) Certain specimens are known from Eyafjord (no. 182) and Hvalfjord, but the species most probably also occurs at other places.

thothamnia from Greenland for examination. I separated l. c. from the said species a form which I referred to *L. flabellatum* f. *Granii*, and which bore sporangia two-parted. The other specimens, which were in habit quite like forms of *L. soriferum* Kjellm., were partly sterile, and partly they were not closer examined. They were referred to *L. tophiforme*, in the sense then taken, though much approaching f. *Granii*. Be it said that in Norw. Lithoth. I presumed that, in forms with sporangia partly two-parted, partly four-parted, apparently belonging to the same species, the former were not fully developed. Cp. *L. norvegicum* f. *saxatilis* and other species l. c. It is, however, sometimes difficult to decide whether a specimen bears two-parted sporangia or in fact four-parted ones, as in the latter case the middle wall may seem to be fully, or almost fully, developed before the other two walls are founded or visible. Cp. Norw. Lithoth. p. 6. Having anew gone over a part of the said material from Greenland, I have not succeeded in finding any specimen with sporangia four-parted, but several specimens with only two-parted ones. At the same time, I have also, among the considerable material more recently collected at the coast of Norway, found a form bearing sporangia two-parted which resembles *L. soriferum*, viz. *L. tophiforme* in the sense here taken. It even appears to be much more widely distributed than *L. soriferum*.

On the other hand, it is still rather doubtful to me what importance ought to be attached to the parting of the sporangia, or whether the said parting is on the whole to be looked upon as a character of species. *L. tophiforme* and *L. soriferum* are not growing gregariously in the same locality. In one locality I have only found one species, and in another place only the other, i. e. specimens with sporangia two-parted or specimens with sporangia four-parted, respectively. In one case, however, I have found both four-parted ones and two-parted ones apparently fully developed even in one and the same specimen, in a place where coarse forms of these species were growing together with *L. glaciale*. Cp. below.

I mentioned above, in treating of *Lithoth. Ungeri,* that in a couple of specimens of this species from Iceland I have found both four-parted sporangia and two-parted ones, also the latter apparently fully developed, but in small numbers. In *L. læve,* which normally bears sporangia four-parted, I have often seen two-parted ones, sometimes even only two-parted ones, particularly in the northern part of the arctic zone. But having found in other specimens, partly from the same places, both two-parted and four-parted ones, sometimes even in one and the same conceptacle, I think it fair to presume that the two-parted ones have not been fully, or normally, developed. *L. foecundum,* which is of rather rare occurrence, shows nearly the same condition of things. *L. Lenormandi* exceptionally bears two-parted sporangia according to Thuret (in herb.). In *L. flavescens,* which usually also bears four-parted sporangia, I have seen two-parted ones only in a singh case, viz. in a specimen from Spitzbergen. In *Lithophyllum incrustans* usually occur four-parted sporangia, but now and then also two-parted ones. Cp. Fosl. Norw. Lithoth. p. 97 as to such organs in specimens from France. Besides, in *Phymatolithon loculosum* I have seen, in young specimens from the Kurile Islands approaching *Ph. compactum* in habit, both four-parted and apparently mature two-parted sporangia even in one and the same conceptacle. On the other hand, the sporangia of *Ph. compactum* are normally bisporic, but sometimes four-parted ones are met with, particularly in fjords in the southern part of its area of distribution, or exceptionally irregularly three- or four-parted ones. Cp. *L. testaceum* Fosl. Norw. Lithoth. p. 107, and Rosenv. l. c. p. 776, 781. Also in *Lithophyllum (Dermatol.) macrocarpum* the sporangia are usually bisporic. But now and then are found four-parted ones in the southern area of its distribution. Still in *Melobesia Lejolisii* I have seen two-parted sporangia apparently fully developed and four-parted ones in the same conceptacle, the latter, which are the usual ones in this species, being in great majority. Evidently it is only in the areas boreal-arctic and antarctic that the Lithothamnia are liable to developing

— partly or exclusively — two-parted sporangia, whereas elsewhere they always develop four-parted ones.[1])

The most southern boreal area where sporangia two-parted are developed is in the Mediterranean and the Adriatic. Here is found a form of the epiphytic *Lithoph. macrocarpum*. Within the cold boreal area and the arctic one, the distribution of almost all species with sporangia four-parted proves to be more circumscribed than that of species with two-parted ones. They occur particularly in the southern part of these areas, while in the northern part species with sporangia two-parted occur in great majority. On the other hand, from the tropics, as far as I am aware, there is as yet found no calcareous alga of the section in question with sporangia two-parted. This difference of development is probably owing to certain biological conditions, and particularly to the unfavourable states of light in which these algæ are growing in the arctic and antarctic areas. Still these algæ occur in large numbers, at any rate in the arctic area and in the cold boreal one, being often very vigorously developed and attaining to a considerable size. On the other hand, reproductive organs, as I have mentioned above, are comparatively rarely developed, especially by the species branching, but this seems frequently to be the case also in warm areas.

It seems to be necessary to set aside the irregularities mentioned as to the parting of sporangia in certain species, and to give it the value of character of species in others. Otherwise, we might have to unite species, which, when vegetatively typically developed, do not seem to belong to the same series of forms, but which are, in their extreme forms, undistinguishable except by the parting of sporangia. On the other hand, we shall in this way have species stated which vegetatively show the same development and are in most cases quite like each other except as to the parting of sporangia, e. g. *L. soriferum* and *L. tophiforme* in the sense here taken. The latter species, indeed, is comprehended in the *L.*

1) Antarctic Lithothamnia are, as yet, but little known, but as a matter of fact, *Litholh. coulmanicum* Fosl. from Coulman Island near South Victoria Land bears only two-parted sporangia.

soriferum originally stated, the specimens from Honningsvaag mentioned by Prof. Kjellman l. c. only bearing sporangia two-parted.[1])

The conceptacles of sporangia in *L. tophiforme,* as observed, are like those of *L. soriferum.* They are partly scattered, partly densely crowded in the upper part of the branches, convex, but little prominent, or subprominent, finally almost superficial, 300—500 μ in diameter. The roof is intersected with 50—80 muciferous canals. The bisporic sporangia are 90—160 μ long and 40—80 μ broad. The conceptacles of cystocarps and antheridia are conical, the former 400—600 μ in diameter, and the latter of about half the size. In certain specimens of this species, the conceptacles of sporangia are less prominent than usual, and are gradually overgrown. Particularly in specimens from Greenland, I have sometimes seen rather numerous grown-in organs of that kind in the peripheric portions of a branch, though more frequently the scars from conceptacles emptied are effaced by local formations of tissue and visible in a section. In most cases, however, the conceptacles, when emptied, fall utterly to decay, and the said formations are not to be seen in a section.

I take each of the forms admitted above in a rather wide sense, in the main corresponding to the forms of *L. soriferum,* though more varying. Thus f. *sphærica* is in part quite like f. *globosa* of *L. soriferum.* It is partly coarse, partly rather delicate and more densely branching than usual, in the latter case greatly approaching *L. fornicatum* or a coarse *L. vardöense.* Sometimes the form also approaches *L. Ungeri* in habit. On the other hand, this form even approaches *L. glaciale.* This is the case particularly

[1]) I have not earlier had the opportunity of undertaking the extremely time-wasting labour of going over each specimen, particularly of branching Lithothamnia collected, for the purpose of searching for conceptacles and sporangia, the less so because peculiarly older specimens are often sterile, or fructiferous ones are only sporadically occurring, even among a large number of collected specimens. In part I have also thought it uncalled for, when the specimens in habit were quite like a species definite and apparently well-known. It has, however, turned out that some of these specimens bear sporangia two-parted, others four-parted ones.

on the northern coast of Norway in places where the species grows in company with the said species. Here it frequently encompasses small pebbles, and develops a rather feeble crust with coarse branches, 2—3 mm. thick, sparely divided, subdistant or approximate, sometimes, peculiarly when the alga is attacked by animals, fairly coalescing towards the centre. It is often wholly accrete with small specimens of *L. glaciale,* or one species partly encompasses the other so as to make it almost impossible to draw the line between them. In this form I have found the sporangia two-parted and four-parted, mentioned above, in the same specimen. I never saw the form so diverging, when growing alone, and it is not improbable that the specimens in question should be looked upon as a hybrid. I have seen young specimens from Iceland of a form similarly diverging. Also from Scotland (Port Bannatyne) there are a couple of specimens which resemble this form, and which are likely to be referred to *L. tophiforme.* They occurred together with *L. glaciale,* encompassing small pebbles, developing a feeble crust and branches like those of the specimens from northern Norway mentioned above. But on the other hand they are considerably approaching certain forms of *L. glaciale.*

The form *divergens* includes *L. divergens* in Norw. Lithoth. As is stated l. c., I have not earlier found conceptacles fully developed. But in looking over the material anew, I found bisporic sporangia. It is a delicate form, hardly distinguishable form *L. Granii,* though the branches are mostly more elongated than in the latter. It also includes a coarser form, which is in habit resembling a coarse *L. soriferum* f. *squarrosa.* Also f. *divergens* is generally freely developed on the bottom. Sometimes, however, it is attached to hard objects and will develop a crust which, though feeble, is fairly extended. Such specimens are hardly distinguishable from a *Lithoth. glaciale* feebly developed, and particularly from *L. Granii.*

With some doubt I consider f. *flabellata* as belonging to this species. The type specimen, as a matter of fact, shows a crust faintly developed and comparatively long branches, as in attached specimens of f. *divergens.* Therefore, I now refer it to the spe-

cies in question. Be it said that I have also seen specimens with thicker crusts, a state of things pointed out also by Dr. Rosenvinge l. c. Besides I have seen specimens of *L. glaciale* which have partly developed almost similar, though shorter, branches.

Lithoth. tophiforme occurs under the same conditions as *L. soriferum,* frequently forming small banks, now alone, now associated with other species. Like *L. soriferum,* it is apt to be covered with *Lithoth. flavescens* and *Phym. investiens.* The alga is fructiferous in the months of March and of June—September.

As to the geographical distribution of the species is to be observed that the occurrence in the White Sea, stated in Norw. Lithoth. p. 126, is likely to concern the species in question in the sense now taken. I have seen no sporangia. Some specimens have been collected in the Bay of Founday, Nova Scotia (by Ruggles, comm. Mackay, no. 12) which have no doubt to be referred to *L. tophiforme.* They were collected together with *L. glaciale* (Mackay, no. 9 and 10) and bear the same relation to the latter as the specimens from northern Norway and from Scotland mentioned above. One of these specimens bears a few conceptacles, which are 400—500 μ in diameter and contain bisporic sporangia. Besides, I have some specimens from Eastport, Maine, dredged by Mr. Lyman and kindly communicated to me by Professor Farlow (no. 5). I formerly considered these specimens as extreme forms of *L. glaciale.* Unfortunately they are sterile, but they now seem to me to have to be referred to *L. tophiforme.* One of them is most nearly connected with f. *sphærica,* but the branches are shorter and more coalescing than in typical specimens of this form. The others are more connected with Greenland specimens of f. *divergens,* though with shorter branches than usual.

As to the distribution of each form, is to be observed that f. *shpærica* occurs in several places at the northern coast of Norway. A single specimen, probably belonging to this form, is known from Julianehaab on the west coast of Greenland[1]), and besides

[1]) This specimen is that mentioned by Dr. Rosenvinge l. c. under *L. soriferum* f. *globosa* (no. 423 b). Once I thought it referable to *L. Ungeri*

the specimen, mentioned above, from Eastport, Maine. The form *divergens* is the most frequent one, and is found almost in all areas where the species is distributed. The form *flabellata*, on the contrary, is of rare occurrence. A few specimens have been taken at Pröven on the West coast of Greenland and at Heklahavn on the East coast. A specimen from Kjelmö in Sydvaranger (Norway) shows in part flabellate branches and perhaps belongs to f. *flabellata,* but it is rather coarse and in part also resembling the coarse form, above mentioned, approaching *L. glaciale.* It is partly covered with *Phymatolithon investiens.* Another, and a young, specimen from Bodö with short and compressed branches recalls young f. *flabellata,* but the crust is rather coarse, and, therefore, the specimen is likely to represent a form of *L. glaciale.* At Korsnes i Altenfjord I have collected specimens freely developed at the bottom and likely referable to f. *flabellata.* They are sterile, in habit almost coinciding with typical *L. soriferum* f. *alcicornis,* but occurred together with fructiferous specimens of *L. tophiforme* f. *divergens.*

Area:[1]) From the north-eastern boundary as far as Tromsö(!), and Nordland (Kleen)? Iceland (Jönsson!)[2]); Scotland: Port Bannatyne (Holmes, Mrs. Robertson!)?[3]) Atlantic coast of North America: Eastport, Me. (Lyman, Farlow!)[4]), Bay of Founday in Digby county, Nova Scotia (Ruggles, Mackay!)[4]); West Greenland: Pröven, Sukkertoppen, Unartok Fjord, Julianehaab (Petersen, Ryberg, Rosenvinge!); East Greenland: Heklahavn (Hartz, Rosenvinge!); the White Sea (Gobi!)?[4])

(*L. fruticulosom* l. c.), but it is likely to represent *L. tophiforme* f. *sphærica,* although the branches are shorter and more coalescing than usual in this form. The ends of some of the branches are a little worn by friction.

1) In Syll. Alg. IV (1905), p. 1740, De Toni records this species „in calcarea Leith (Unger)." However, the specimen described by Unger l. c. is from Greenland, and he does not mention the alga as occurring in the „Leithakalk".

2) Specimens bearing bisporic sporangia are known from the following places: Arnarnes (no. 219), Vattarnes (no. 412), Hesteyrefjord, and Hvalfjord. From the latter place is in hand a coarse form resembling the above mentioned one of f. *sphærica,* and in part probably belonging to *L. glaciale.*

3) Cp. above under remarks on f. *sphærica.*

4) Cp. above under remarks on the geographical distribution of the species.

15. *Lithothamnion Granii* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 11; Lithothamnion flabellatum f. Granii Fosl. Norw. Lithoth. (1895), p. 70, t. 17, fig. 1—7, t. 22, fig. 1 (excl. f. Rosenvingii); De Toni, Syll. Alg. IV (1905), p. 1731.

f. *typica.*

Descr. Lithoth. flabellatum f. Granii Fosl. Norw. Lithoth. l. c.

f. *reducta* Fosl. mscr.

Frond 1—3 cm. in diameter, branches spreading or crowded, shorter and often thinner than in the typical form.

Syn: Lithothamnion Battersii Fosl. New or crit. Lithoth. (1895), p. 1? Batt. Cat. Brit. Mar. Alg. (1902), p. 97? De Toni, Syll. Alg. IV (1905), p. 1733?

In Norw. Lithoth. I described *L. Granii* as a form of *L. flabellatum* Rosenv., whereas in Rev. Syst. Surv. Melob. I, with some doubt, admitted the former as an independent species. However, I have formerly felt a doubt whether *L. Granii* should not be regarded as a form of *L. glaciale.* I have above p. 10 suggested that it might be looked upon as a relict form of the species last named, but on the other hand found this hypothesis less probable. It is most likely to be regarded as an independent species, partly resembling young and delicate forms of *L. glaciale,* partly closely connected with *L. tophiforme* f. *divergens.* There are several specimens particularly of the latter species — not only young ones, but even rather old ones — which are quite like each other in almost every respect, but that the specimens of one species shows a somewhat greater tendency in one direction and the other in a different one. Thus the branches in *L. Granii* are as a rule thinner, shorter and provided with more numerous short lateral branches than in *L. tophiforme* f. *divergens.* Besides, it nearly always at first forms a thin crust developing branches more or less crowded, whereas *L. tophiforme* is in general freely developed at the bottom, and the conceptacles are mostly a little smaller than in the latter.

The form *reducta* is in fact only a stunted form of the species, but it is frequently so peculiar and diverging that it ought to be looked upon as a particular form. It is found attached to small pebbles from which it is often detached so as to lie freely

on the bottom. Sterile specimens are almost undistinguishable in habit from certain forms of *L. nodulosum* and *L. norvegicum*.

The conceptacles of sporangia in *L. Granii* particularly occur in the upper part of the branches. They are convex, partly but little prominent, partly subprominent, 300 (250)—400 μ in diameter, and often as crowded as in *L. tophiforme*. The roof is traversed by 30—60 muciferous canals. The sporangia are bisporic, 100—180 μ long, 40—60 μ broad. The conceptacles are partly gradually overgrown, partly and more frequently falling to decay, and the scars are effaced by new-formed tissue. Those of cystocarps are conical and of about the same diameter as those of sporangia.

It seems as if *Lithoth. Battersii* is a stunted form of this species, partly attached to fragments of other calcareous algæ. I have only seen the specimens pictured l. c. which are also approaching stunted forms of *L. colliculosum*. It is, therefore, not sure to which of these species it is referable, but at any rate it can hardly be considered as independent.

The species in question grows in the sublitoral region in a depth of 3—15 fathoms. It occurs particularly in fjords or in places fairly sheltered, where the tidals are running more or less strongly. It has been found with reproductive organs in January, April till September, and in December.

Area: Norway: Skorpen in Tromsö Amt (!), the Trondhjem Fjord (!), the Puddefjord at Bergen (!), Haugesund (!), Fredriksværn (!), the Christiania Fjord (Gran, Schreiner!,!), Hvalöerne (!); Sweden: the Gullmarfjord (Arwidsson!), Skelderviken (Lönnberg!); Denmark (Rosenvinge!); Scotland: Cumbrae (Batters!); Ireland: Larne, co. Antrim (Hanna!); Dalkey Sound near Dublin (Johnson!,!).[1])

16. *Lithothamnion vardöense* Fosl.

Vidensk. Selsk. Skr. 1905, No. 2.

[1]) The specimens from Scotland and Ireland are young, and it is difficult to distinguish them from young specimens of *L. colliculosum*, so that the determination may admit of doubt.

This species is very nearly related to *L. tophiforme* f. *globosa,* and it seems doubtful whether the alga ought to be considered as an independent species. However, it is distinguished by its branches being of almost equal thickness throughout, whereas in the said species they are usually thicker or more coalescing in the central parts. Besides, the conceptacles, particularly those of cystocarps, are usually smaller. In specimens typically developed the branches are 1,5—2 mm. thick, partly rather crowded, partly more or less distant, in the latter case generally with numereous short lateral branches as in similar specimens of *L. tophiforme,* or forming almost obpyramidate branch-systems, but less distinct than in f. *sphærica* of the said species. Other specimens with branches about 2,5 mm. thick are in habit hardly distinguishable from the form last named. Sometimes the branches form rather irregular bundles and then approach certain forms of *L. nodulosum* in habit. Moreover, there are specimens with the branches densely crowded and almost destitute of lateral-branches. Such specimens, which partly occur in other localities than the former ones, are in habit almost fully resembling small nodules of *L. fornicatum* f. *sphærica* and partly even f. *dimorpha.*

The conceptacles of sporangia are scattered or crowded in the outer branches, finally subprominent, 300—400 μ in diameter; the sporangia are bisporic, 90—140, by 40—60 μ. Also the cystocarpic conceptacles are 300—400 μ in diameter, conical and resembling those of *L. tophiforme,* but usually smaller. I have not seen conceptacles overgrown in a number of specimens examined.

The species appears in a depth of 1—15 fathoms in places sheltered with tides strongly running. It bears reproductive organs in the months of July—September.

Area: Norway: Vardö[1]), Mjaanes in Altenfjord(!), Svolvær and Balstad in Lofoten(!), Froöerne and Fröien(!)[2])

[1]) Only dead specimens in company with other species brought up by excavators in the harbour.

[2]) Among a number of specimens from these two places only a single one bears a few conceptacles of sporangia. They are coarser than specimens typically developed and perhaps belong to *L. tophiforme*, though as to ramification more agreeing with the species in question.

17. *Lithothamnion nodulosum* Fosl.

Norw. Lithoth. (1895), p. 116.

f. *typica.*

Lithothamnion nodulosum Fosl. l. c. pl. 21, fig. 1—6, Rev. Syst. Surv. Melob. (1900), p. 13.

f. *gracilescens* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13; Lithothamnion gracilescens Fosl. Norw. Lithoth. (1895), p. 59, pl. 15, fig. 20—27.

f. *congregata* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13; Lithothamnion congregatum Fosl. Norw. Lithoth. p. 114, pl. 20.

f. *saxatilis* Fosl. mscr.

Frond attached to small stones, afterwards often detached, branches very short, more or less coalescing, about 1,5 mm. thick, frequently forming small bundles rather approximate.

Syn: Lithothamnion byssoides Unger, Leithakalk, p. 19, t. V, fig. 1—8. Lithothamnion nodulosum De Toni, Syll. Alg. IV (1905), p. 1743.

This species is developed in the same way as *L. Ungeri,* and resembles the latter, but is more delicate. It is branching from the centre of the frond, sometimes, attached to pebbles, developing a feeble crust. The branching is at first not very dense, and the alga then bears in habit a striking resemblance to *L. norvegicum.* When growing older, it becomes more densely branching, and the branches, 1—1,5 mm. in diameter, develop a larger or smaller number of wartlike processes or short side-branches forming bundles more or less dense. This is particularly the case in localities where the alga is attacked by boring mussels dissolving the central parts. Cp. Norw. Lithoth. pl. 21, fig. 1—6. Gradually the form is developed which I have denominated f. *congregata.* Cp. l. c. pl. 20. Especially in this form the outer branches are frequently more straight than elsewhere, such as is the case with certain forms of *L. Ungeri.* Like corresponding forms of other species, it has risen from the alga being attacked by animals, and, therefore, strictly speaking is no form independently developed, though often very peculiar. Of the specimens figured l. c. pl. 20, fig. 4 represents the part turning downwards of a specimen having originally been subspherical or depressed-spherical, then hollowed

by boring mussels, and finally becoming convex-concave, such as in *L. fornicatum* f. *obcrateriformis,* with the lower ends of the branches truncate. A similar specimen is represented fig. 5, but here new crustlike formations partly cover the worn lower ends of branches, here and there with new branches being in development. Fig. 6 shows a similar specimen with a lot of branches new-developed, resembling those of the parts turning upwards of the specimen, though often being more delicate than the latter. Cp. fig. 1—3. In certain localities the peripheric parts of the alga will be worn by friction in the same way as in *L. Ungeri* and in several other species branching. I have seen specimens of f. *typica* in which a large part of the alga has been thus torn away, only leaving the central parts consisting, as it were, of a network coalescing, branching parties more or less incise or flattened.

The form *gracilescens* on one side resembles small specimens of f. *typica*, and on the other hand it runs into specimens of f. *saxatilis* loosened from the substratum.

The form *saxatilis* first forms a crust faintly developed, from which very short branches are emitted, partly somewhat spreading, partly and more frequently approximate, with wartlike processes or side-branches more or less coalescing and forming small bundles. It is often detached from the substratum and lies freely on the bottom. This form partly embraces *L. norvegicum* f. *saxatilis,* Norw. Lithoth. pl. 16, fig. 12—23 and Rev. Syst. Surv. Melob. p. 13, i. e. specimens with tetrasporic sporangia.

The conceptacles of sporangia in this species are usually crowded in the upper part of the branches, convex, but little prominent, or subprominent, finally often flattened, 300 (250)—400 μ in diameter. The roof is finally very thin and easily falling to decay, traversed by about 50 muciferous canals. The sporangia are four-parted, 110—180 μ long and 40—80 μ broad. In f. *saxatilis* the said conceptacles occasionally are gradually overgrown. Those of cystocarps are conical, rather low, and about 500 μ in diameter.

As to the synonymy, I still think it most likely that *L. byssoides* Unger from the neighbourhood of Bergen belongs to *L.*

nodulosum. Cp. above under *L. Ungeri*. Fig. 1 l. c. resembles specimens of *L nodulosum*, which I recently got from the surroundings of Bergen where the species seems to be of frequent occurrence.

Also this species approaches several other ones. In treating of *L. Ungeri*, I pointed out that a definite line between the latter species, *L. nodulosum*, and *L. norvegicum*, can hardly be drawn. They no doubt belong to the same series of forms together with *L soriferum*. However, it is particularly *L. nodulosum* and *L. norvegicum* which most nearly approach one the other. As mentioned above, young specimens of f. *typica* are almost quite like *L. norvegicum* f. *pusilla* or f. *uncinata*, while the older ones become more densely branching and develop numerous side-branches. — On the other hand, the latter specimens of this form sometimes very nearly approach *L. fornicatum* f. *apiculata* and f. *congregata* comes near to specimens of *L. fornicatum* f. *obcrateriformis* with delicate branches. The form *gracilescens* is often hardly distinguishable from *L. norvegicum*. This is sometimes also the case as to f. *saxatilis*, which, on the other hand, now and then is quite consistent with *L. Granii* f. *reducta* in habit, and only distinguished by the parting of sporangia.

L. nodulosum occurs in the sublitoral region in a depth of 2—10 fathoms. It prefers places sheltered, where the tidals are running rather strongly. The alga has been found sparely fructiferous in the months of June, July and August.

Area[1]: Norway: The Trondhjem Fjord, all the forms(!), Hiteren, Puddefjorden at Bergen, f. *saxatilis*(!); the neighbourhood of Bergen, f. *typica* (Palibin!); Dröbak in the Christiania Fjord (Gran!)[2])

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[1]) In Syll. Alg. IV (1905), p. 1731, De Toni records under *Lithoth. Ungeri* Kjellm. (as considered identic with *L. byssoides* Unger) „f. in Leithakalk (sec. Unger)". However, Unger do not mentions his *L. byssoides* from the „Leithakalk", but from „der Küste Bergens". Cp. above, and Unger l. c. p. 19 and 24.

[2]) A few specimens from that place, about 3—4 cm. in diameter, seem to belong to the species in question and most nearly connected with f. *gra-*

18. *Lithothamnion tusterense* Fosl. mscr.

Frond freely developed at the bottom, subspherical, 4—6 cm. in diameter, repeatedly subdichotomously branching; branches being issued in all directions from the centre, terete, about 1,5 mm. thick, more or less curved and subfastigiate, often with numereous wartlike, lateral processes or short lateral branches; conceptacles of sporangia subprominent, 300 (250)—400 μ in diameter; sporangia bisporic, 90—300 μ long, by 40—60 μ.

This species resembles in habit and in structure small specimens of *L. nodulosum,* and is distinguished only for the partition of the sporangia. Cp. Norw. Lithoth. pl. 21, fig. 3—6. A number of specimens from the Altenfjord and from Lofoten on one side rather resemble delicate forms of *L. tophiforme* f. *divergens* and are very nearly approaching certain forms of *L. Granii,* or even *L. norvegicum,* and on the other hand coincide in habit with young forms sparely branching of *L. nodulosum* and *L. tusterense.* They are furnished with bisporic sporangia and, therefore, most nearly connected with the latter species. However, as I have not in these places seen true transitions to old and typical *L. tusterense,* I do not venture at present to refer the said specimens to this species. Specimens typically developed have hitherto been found in small number in a single place fairly sheltered, here appearing in a depth of 3—4 fathoms. The alga is sparingly furnished with sporangia in the month of August.

Area: Norway: Tusteren north of Kristiansund, N.(!).

19. *Lithothamnion norvegicum* (Aresch.) Kjellm.

N. Ish. Algfl. (1883), p. 122, pl. 5, fig. 9—10! Lithothamnion calcareum var. norvegicum Aresch. Obs. Phyc. 3, p. 4!

f. *pusilla* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13; Lithothamnion coralloides f. norvegica Fosl. Norw. Lithoth. (1895), p. 62, pl. 16, fig. 1—11.

cilescens. However, they have partly been worn by friction and not typically developed. Therefore, the determination may admit of doubt.

Besides a few specimens from Denmark (Aarhus Bugt), about 1—2 cm. in diameter, considerably remind of a stunted *L. nodulosum.* But as they occur together with typical *L. norvegicum,* they are likely to represent a form of the latter species.

f. *uncinata* Fosl.

Rev. Syst. Surv. Melob. p. 13; Lithothamnion uncinatum Fosl. Norw. Lithoth. (1895), p. 126, t. 19, fig. 11—14.

f. *similis* Fosl. mscr.

Frond simple or subsimple, curved, 1—1,5 mm. thick.

Syn: Lithothamnion norvegicum Fosl. List of Lithoth. (1898), p. 6, Rev. Syst. Surv. Melob. p. 13; De Toni, Syll. Alg. IV (1905), p. 1742.

This species is almost always freely developed on the bottom, sometimes, however, attached to pebbles, and then developing a feeble crust, but afterwards frequently detached. The form *pusilla* is perhaps the typical form of the species. It mostly varies between 1 and 3 cm. in diameter, the branches are partly crowded, partly sparingly divided, and more or less diverging. It runs into f. *uncinata,* which is a little coarser and becomes up to 6 cm. in diameter. The specimen of f. *uncinata* pictured l. c. is not a typical one, as it has partly — and peculiarly in the lower part — been worn by friction. The parts worn have then been partly covered with a thin crust, here and there growing over and covering up small extraneous objects. These parts, therefore, are thicker, and the branches in consequence are more attenuating than usual in this form. Besides the specimen bears more lateral branches than specimens typically developed, though the form is frequently more densely branching than the said specimen. The form *similis* is in habit wholly resembling *L. calcareum* f. *subsimplex,* but is more delicate. It runs into f. *pusilla.* All the three forms, however, are little independent, as numerous transitions are found. Still there is a considerable difference between a f. *uncinata* vigorously developed and a delicate f. *pusilla* or particularly a simple f. *similis.* Therefore I think that they ought to be admitted as denominated forms.

The conceptacles of sporangia resemble those of *L. nodulosum.* They are scattered or crowded in the upper part of the branches, 300—400 μ in diameter. The sporangia are tetrasporic, 90—130 μ long and 25—45 μ broad. The said conceptacles, when emptied, are usually quite dissolved. The cystocarpic ones are conical and of about the same diameter as those of sporangia.

The species is nearly related to *L. nodulosum,* particularly f. *gracilescens* and f. *saxatilis.* It occurs in places sheltered, in fjords or sounds, in a depth of 3—12 fathoms. It often forms small banks, but it is nearly always sterile or sparely fructiferous, at least along the coast of Norway. Specimens provided with reproductive organs have been taken in the months of March—August and December.

As to the geographical distribution, the specimens I have seen from Denmark partly resemble typical f. *pusilla,* partly approach stunted forms of *L. nodulosum* f. *gracilescens.* Cp. under the latter species. It does not seem to occur in any great number on that coast, being known from six places, whereas it is abundant in several places along the coast of Norway, in most cases forming small banks. The form occurring on the coast of Scotland partly resembles typical f. *pusilla,* but is mostly only 1—2 cm. in diameter, partly approaches a stunted and delicate *L. nodulosum* f. *gracilescens,* i. e. it is provided with lateral wartlike processes or short branches, like the above mentioned ones from Denmark, and showing a tendency to form small bundles.

Area: Norway: Lödingen and Korsnes in Nordland, f. *pusilla* (!), the Trondhjem Fjord, f. *pusilla* (!), Moldøen, f. *pusilla,* f. *similis* (Östergren!), Espevær, f. *pusilla* (Gran!), Haugesund, f. *pusilla* (Wittrock, Areschoug, Norum!), Mandal, f. *uncinata,* f. *pusilla* (Wille!,!), Kragerö, f. *uncinata*!, the Christiania Fjord, f. *pusilla* (Schreiner!), Denmark, f. *pusilla* (Rosenvinge!); Scotland: Port Bannatyne of Bute, Cumbrae, Arran, f. *pusilla,* f. *similis* (Holmes, Batters, Robertson!)[1]; Atlantic coast of North America: Penobscot Bay, Me., f. *pusilla?* (Collins!)[2]

20. *Lithothamnion calcareum* (Pall.) Aresch.

In J. Ag. Spec. Alg. 2 (1852), p. 523; Millepora calcarea Pall. Elench. (1766), p. 265, partim (non Ell. et Sol.?).

[1] The species perhaps also occurs on the coast of the Orkneys. Cp. under *L. calcareum.*

[2] A few specimens examined from that place seem to be referable to this species. They have been picked up from a depth of 10 fathoms and resemble a small f. *pusilla* in habit and in structure, but, unfortunately, they are sterile.

f. *squarrulosa* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13, Lithoth. Adriat. Meer. etc. (1904), p. 9, 13, 32, t. 2, fig. 1—14.

f. *coralloides* (Crn.) Fosl. mscr.

Lithothamnion coralloides Crn. Fl. Finist. (1867), p. 151, t. 20, gen. 133, fig. 8—9, Spongites coralloides Crn. Alg. Mar. Finist. no. 242! L. coralloides f. australis Fosl. Norw. Lithoth. (1895), p. 62, partim, pl. 16, fig. 24—25, 27—31; L. coralloides Fosl. Some new or crit. Lithoth. (1898), p. 7 (excl. f. *minuta*); De Toni, Syll. Alg. IV (1905), p. 1744.

f. *compressa* (M'Calla) Fosl.

On some Lithoth. (1897), p. 9, Lithoth. Adriat. Meer. etc. (1904), p. 32, t. II, fig. 15—23; Melobesia compressa M'Calla sec. Harv. Man. 2 (1849), p. 108; Lithothamnion coralloides f. flabelligera Fosl. Norw. Lithoth. (1895), p. 62, pl. 16, fig. 32—37.

f. *palmatifida* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13; L. squarrulosum f. palmatifida Fosl. Some new or crit. Lithoth. (1898), p. 6.

f. *subsimplex* (Batt.) Fosl.

Rev. Syst. Surv. Melob. (1900), p. 13; Lithothamnion coralloides f. subsimplex Batt. in Journ. Bot. (1892), p. 8, Fosl. Norw. Lithoth. (1895), p. 62, pl. 16, fig. 38—42.

Syn: Corallium pumilum Ellis, Corall. (1767), p. 83, t. 27, fig. C.
Millepora polymorpha Ell. et Sol. Zooph. (1786), p. 130.
Millepora informis Lam. Anim. s. vertebr. 2 (1836), p. 311?
Nullipora calcarea Jonst. Brit. Spong. and Lithoph. (1842), p. 240, pl. XXIV, fig. 4.
Melobesia calcarea Harv. Phyc. Brit. (1846—51), pl. 291.
Spongites calcarea Kütz. Spec. Alg. (1849), p. 699.
Lithothamnion ramulosum Solms Corall. Monogr. (1881), p. 19, partim.
„ coralloides Born. Alg. Schousb. (1892), p. 349.
„ squarrulosum Fosl. Some new or crit. Lithoth. (1898), p. 6.
„ calcareum Traill, Mar. Alg. Orkney Isl. (1890), p. 36; Debr. Cat. Alg. Maroc. etc. (1897), p. 72! Johnst. and Hensm. Irish Corall. (1899), p. 28! Batt. Cat. Brit. Mar. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1745; Chalon, Liste Alg. Mar. (1905), p. 206, partim!

As the author of this species I quote Mr. Pallas, as the *Millepora calcarea,* described by him l. c., at any rate partly, is identic with *„Corallium pumilum album"* Esper, and the latter must now be considered as an unquestionable *L. calcareum.* On the contrary, the *Millepora calcarea* from the Mediterranean, de-

scribed by Ellis et Solander, Zooph. p. 129, t. 23, fig. 13 and quoted by Areschoug l. c., seems to me more likely to represent a coral, whereas the *Millepora polymorpha* Ell. et Sol. described l. c. p. 130 is an unquestionable *L. calcareum.*

In Lithoth. Adriat. Meer. etc. p. 11 and p. 33 I suggested that *L. coralloides* seems in fact only to be a form of *L. calcareum.* After succeeding in finding conceptacles in specimens of both which I presumed to be typical ones, I must now subsume the former under the latter.

As to the forms of the species is to be observed that f. *squarrulosa* is the bigger form and mostly the coarser one. It includes f. *valida,* which I do not now admit as an independent form, because it in the main only represents a coarse or partly monstrous variety of the said f. *squarrulosa.* The form *coralloides* is smaller, often with branches comparatively shorter, but otherwise no real line can be drawn between them. It runs into f. *compressa.* The latter form is flabellate, the branch-systems spreading like a fan in all directions from the centre of the frond almost in one plane. Sometimes it forms rather thick and compressed fronds. A form nearly approaching and faintly differentiated is f. *palmatifida,* with branches more distant and palmate, but otherwise resembling the former. Cp. Lithoth. adriat. Meer. etc. t. 2, fig. 22. I admit it as an independent form, because it seems to proceed from f. *squarrulosa,* while f. *compressa* has risen from f. *coralloides.* Cp. Lithoth. Adriat. Meer. etc. t. II, fig. 22, which represents a form intermediate between typical f. *palmatifida* and f. *compressa.* The form *subsimplex* is but a simple or feebly branching f. *squarrulosa.* The f. *minuta,* admitted l. c , on the contrary, has proved not to belong to the species in question, but to be a delicate form of *Lithoth. fruticulosum,* and is perhaps identical with f. *soluta* described in Lithoth. Adriat. Meer. etc. p. 7. Cp. l. c. t. 1, fig. 18—33.

The conceptacles of sporangia in this species are partly scattered, partly somewhat crowded, 250—400 μ in diameter, immersed or subimmersed, at first convex, but by and by decorticated in the central part of the roof, where at last they become concave or

rather impressed, with an annular border somewhat elevated, representing the peripherical portion of the roof. The central part is traversed by about 30—40 muciferous canals. All the conceptacles of sporangia examined have been attacked by animals and are destitute of sporangia. The said conceptacles are rather resembling those of *L. foecundum* as well as those of *Ph. polymorphum,* and are finally overgrown. Those of cystocarps are not yet known, and, therefore, it is as yet questionable how to place the species systematically.

As to the synonymy is to be observed that *Millepora informis* Lam. is more likely to belong to the species in question than to *Phym. polymorphum,* to which it is referred in Syll. Alg. p. 1724. By the kindness of Dr. Chalon, I have had the opportunity of examining specimens of *L. calcareum* f. *mamillosa,* determined by Mr. Heydrich, and admitted by Dr. Chalon in Liste Alg. l. c. These specimens represent a stunted form of *L. fruticulosum,* recalling stunted forms of *L. calcareum* f. *coralloides—compressa* worn by friction. They are, however, provided with conceptacles consistently with those in *L. fruticulosum.* It seems as if f. *mamillosa* is considered by Mr. Heydrich as being identic· with *L. mamillosum* Hauck (*Goniolithon mamillosum* Fosl.), a species quite different from both the mentioned ones. These specimens are in part covered with crusts of *Lithoth. Sonderi* and *Phym. polymorphum.*

L. calcareum is easily recognized, when provided with well developed conceptacles of sporangia; but specimens stunted or faintly developed are easily confounded with *L. fruticulosum.* On the coast of France and in the Mediterranean it sometimes grows gregariously with the said species, or is even found coalescing with it so as to make it sometimes difficult to draw the limit. Cp. Lithoth. Adriat. Meer. etc., p. 32 and pl. II, fig. 24—26. Monstrous specimens sometimes even approach certain forms of *L. glaciale.* Cp. l. c. pl. III, fig. 1—7. On the other hand, the alga often resembles *L. norvegicum* in habit, particularly delicate forms of f. *squarrulosa* approach f. *pusilla,* and f. *subsimplex* may be hardly distinguishable from a coarse f. *similis* of the said species.

On the coast of Scotland the two forms last mentioned seem occasionally to grow gregariously.

The species occurs in a depth of 3—18 fathoms. In the Gulf of Naples it is said to have been picked up from a depth of 30 fathoms. It prefers places sheltered, but also appears in exposed ones. Cp. Lithoth. Adriat. Meer. etc. p. 9, and A Visit to Roundstone (The Irish Naturalist, Vol. VIII, 1899), p. 176. It has been found with conceptacles of sporangia in small numbers in the months of April—August, but without sporangia.

As to the occurrence and the geographical distribution of the species, the form met with on the south west and south coast of Norway represents a delicate form of f. *squarrulosa* with transitions to f. *palmatifida*. It is, however, very scarce. Besides, dead specimens of a coarse f. *squarrulosa* have been found in two places (Rövær and Mandal). Similar forms of the species have been found on the coasts of Denmark, here, however, also transitions to f. *coralloides* and f. *compressa* as well as f. *subsimplex*. Here the alga seems to occur in larger number than on the coast of Norway. On the coasts of the British Isles the species is common and in many places abundant, and all the forms have been found there. So also on the Atlantic coast of France, where particularly f. *coralloides* and f. *compressa* seem to be common in many places, but also f. *squarrulosa* occurs rather numerously. Besides, all the forms seem to occur in part rather abundantly in certain places in the Mediterranean. But only a delicate form of f. *squarrulosa* occurs in the Adriatic, and apparently very scarcely. Cp. Lithoth. Adriat. Meer. l. c.

Area: Norway: Espevær (Gran!), Haugesund (Wittrock, Areschoug, Norum!)[1]), Röver, dead specimens (Norum!), Mandal, dead specimens (Wille!,!); Denmark (Rosenvinge!),

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[1]) *L. calcareum* is, in fact, included in *L. norvegicum* Aresch. Obs. Phyc. 3, p. 4. Among a number of authentic specimens of the latter I found a few ones belonging to the former species. It seems to occur very scarcely in the periphery or in the neighbourhood of the bank where *L. norvegicum* was first collected by Professor Wittrock, described by Professor Areschoug, viz. Vipransund near Haugesund.

the Orkneys (White! Traill)[1]); the British Isles! The Atlantic coast of France! The coast of Portugal![2]). Morokko: Tanger (Schousboe, Bornet, Kuckuck!); Alger (Debray!); the Gulf of Naples (Solms Laubach, Zool. Station!); the Adriatic: the Brionic Islands (Kuckuck!).

Subgen. **Epilithon** (Heydr.) Fosl.

List of Lithoth. (1898), p. 7; *Epilithon* Heydr. Melobesiæ (1897), p. 408.[3])

21. *Lithothamnion membranaceum* (Esper) Fosl.

List of Lithoth. (1898), p. 7, Corallina membranacea Esper, Pflanzenth. (1786) t. 12, fig. 1—4.

Descr. *Melobesia membranacea* Rosan. Melob. (1866), p. 66, pl. II, fig. 6—9, 13—16, pl. III, fig. 1.

Syn: Melobesia membranacea Lamour. Polyp. flex. (1816), p. 315! Aresch. Phyc. Scand. (1846), p. 289 et in J. Ag. Spec. Alg. 2. (1852), p. 512, partim; Le Jol. Liste Alg. Cherb. (1863), p. 150 partim, non Alg. mar. Cherb. no. 194! Aresch. Obs. Phyc. 3 (1875), p. 3! Solms, Corall. Monogr. (1881), p. 10; Hauck, Meeresalg. (1885), p. 265, fig. 104; Reinke, Algenfl. westl. Ostsee (1889), p. 31; Born. Alg. Schousb. (1892), p. 188; Debr. Cat. Alg. Maroc. etc. (1897), p. 71!

Hapalidium roseolum Kütz. Phyc. gener. (1843), p. 385; Spec. Alg. (1849), p. 695; Tab. Phyc. XIX (1869), p. 33, t. 92[4]); Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 509 (sub nom. H. roseum).

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[1]) The species is mentioned by Mr. Traill l. c. from that place as „common on sandy bottom, 4 to 15 fathoms". I have not seen specimens collected by Mr. Traill which may perhaps also include *L. norvegicum*. But a sterile specimen kept in the British Museum, collected by the Rev. Mr. White, no doubt belongs to this species.

[2]) According to specimens in the British Museum without fixed locality.

[3]) This subgenus has been based as a genus by Mr. Heydrich (Melobesiæ in Ber. d. Deutsch. Bot. Gesellsch. 1897 p. 408), as to the vegetative part on the same characters as then characterized the genus *Melobesiæ*, the type being *Lithoth. membranaceum*. However, in this species the frond is composed of two or more layers of cells, with the exception of the very youngest parts. I, therefore, base the subgenus on the hypothallium being one-layered, as corresponding to the subgenus *Carpolithon* of *Lithophyllum* and as contrasted with the hypothallium of *Eulithothamnion* having several layers. There are, however, perhaps species which are monostromatic and which should also perhaps be referred to the same subgenus.

[4]) The alga is not found by this name in Kützing's herbarium.

Melobesia corticiformis Kütz. Spec. Alg. (1849), p. 696; Tab. Phyc. XIX (1869), p. 34, t. 94! Aresch. in J, Ag. Spec. Alg. 2 (1852), p. 518; Rosan. Melob. (1866), p. 76, pl. I, fig. 14—16! Solms, Corall. Monogr. (1881), p. 11; Born. Alg. Schousb. (1892), p. 188.

Melobesia verrucata Harv. Phyc. Brit. (1846—51), pl. 347 C.?

Melobesia rosea Rosan. Melob. (1866), p. 77! (Tab. II, fig. 1—2?)

Hapalidium Hildenbrandtioides Crn., Alg. Finist. (1867), p. 149!

Lithothamnion membranaceum Batt. Cat. Brit. Alg. (1902), p. 97? (cfr. *M. Lejolisii*); De Toni, Syll. Alg. IV (1905), p. 1758.

Lithothamnion corticiforme Fosl. List of Lithoth. (1898), p. 7; Debr. Cat. Alg. Maroc etc. (1897), p. 72! Batt. Cat. Brit. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1759.

In List of Lithoth. l. c., in Rev. Syst. Surv. p. 15 and in Lithoth. Adr. Meer. etc. p. 20 I admitted *L. membranaceum* and *L. corticiforme* as distinct species, following in this respect Mr. Rosanoff and some recent authors. I had then not yet had the opportunity of studying more closely the mutual relation of these species, nor had I seen authentic specimens of any of them. But now, by the kind liberality of Mr. O. Lignier, Professor at Caen, and of Madame A. Weber—van Bosse, I have had the opportunity of examining the type-specimens of *M. membranacea* Lamour. and of *M. corticiformis* Kütz. and found these two algæ to be identical. Also the form referred by Mr. Rosanoff to the latter species belongs to *L. membranaceum*. The same is the case with *M. rosea* Rosan. and most likely also with *Hapalidium roseolum* Kütz. Be it said that *L. membranaceum* seems to have been taken in a rather wide sense by Mr. Rosanoff. Thus I have seen a specimen distributed by Mr. Le Jolis, which according to his label Mr. Rosanoff had partly referred to the said species *(M. membranacea)*, while as a matter of fact it only embraces *M. Lejolisii*. Some recent writers also seem to have referred specimens of *M. Lejolisii* to *L. membranaceum*, but I shall not here enter upon that question. I will in this respect only observe, as being of phytogeographical interest, that — as is mentioned below under *M. Lejolisii* — I think it reasonable, at any rate for the present, to assume that *M. membranacea* Kleen belongs to the said species and not to the species in question.

Lithoth. membranaceum, as a general rule, is easily recognizable. It forms filmy patches on the fronds of other algæ, particularly Florideæ, the colour of the host plant showing through the species in question. The crust is frequently at first orbicular, then many crusts becoming confluent, indefinite in outline. It adheres very closely to the substratum, becomes wrinkled as the latter contracts in drying, but does not crumble and fall from it, as some other epiphytic calcareous algæ do, being but little incrusted with carbonate of lime. Sometimes a new crust is here and there developed over the primary one, then the former becomes a little brittle, and if only provided with cystocarpic conceptacles the species may be confounded with *Melobesia Lejolisii* which now and then covers *L. membranaceum.*

The frond is frequently composed of two to five layers of cells. Only the youngest parts of the frond are in part monostromatic. In these parts the cells are elongated in the direction of the radius, 9—18 μ long and 6—8 μ broad. In vertical section the basal cells are somewhat varying. Thus when the alga grows e. g. on *Furcellaria* they have generally their largest length vertically, 10—18 μ long and 7—14 μ broad, but when growing on *Rhodymenia* the cells are partly squarish, about 11 μ in diameter, partly vertically or horizontally elongated, in both the latter cases of about the same size as on *Furcellaria.*

The conceptacles of sporangia are convex or subhemispherical, frequently crowded and not sharply defined, 160—300 μ in diameter. The central part of the roof is either not incrusted with carbonate of lime or but scarcely so and semi-transparent, intersected with 20—30 muciferous canals. This part becomes somewhat settled towards maturity, and the dark coloured sporangia are often visible through the thin cell-walls of the roof. Therefore, to the naked eye the conceptacles (or properly the central part of them) look like so many dark specks on the surface of the frond. The sporangia are four-parted, 60—90 μ long and 40—60 μ broad. The conceptacles of cystocarps are subhemispheric-conical and of about the same diameter as those of sporangia. A small part around the orifice is either not incrusted with carbonate of lime

or but scarcely so and settles a little towards maturity, then, or particularly when being on the state of decomposition, to the naked eye rather resembling the conceptacles of sporangia. Those of antheridia are of about the same shape as the conceptacles of cystocarps, but only 80—110 μ in diameter.

As to host plant, the species particularly occurs on different Florideæ, e. g. *Furcellaria, Phyllophora, Rhodymenia, Chondrus, Gigartina, Rytiphlea* and some others. It is now and then met with also on *Cladophora,* and as a rare exception it even occurs on the stem of *Laminaria digitata* (at Roundstone on the west coast of Ireland!). The species, on the other hand, seems never to occur on *Zostera.* The statement of some writers, that it is found on this plant, — as far as I have hitherto seen — is owing to confusion with *Melobesia Lejolisii.* It has its greatest occurrence in northern areas, — as far as is hitherto known, in the tract from southern Norway to Ireland. The alga is to be found on the said host plants partly in rock-pools in the lower part of the litoral region, partly and especially in the sublitoral region and here descending to a depth of about 8—10 fathoms. It is nearly always richly fructiferous.

Area: Norway: South-west and south coast (!). Sweden: West coast! Denmark! British Islands! Atlantic coast of France! The Mediterranean! The Adriatic! Cape of Good Hope (Harvey, Tyson!); Australia (according to Rosanoff).

Phymatolithon Fosl.

Syst. Surv. Lithoth. (1898), p. 4; De Toni, Syll. Alg. IV (1905), p. 1724; *Eleutherospora* Heydr. Lithoth. Helgol. (1900), p. 64.[1])

Subgen. **Euphymatolithon** Fosl. mscr.

1. *Phymatolithon polymorphum* (L.) Fosl.

Syst. Surv. Lithoth. (1898), p. 4; Millepora polymorpha L. Syst. Nat. ed. 12 (1758), p. 1285, partim.

[1]) I now place *Phymatolithon* after *Lithothamnion*, as it in reproductive organs somewhat approaches *Archæolithothamnion.* Cp. Siboga Exp. LXI, p. 10.

f. *sublævis* Fosl. mscr.

Lithothamnion polymorphum f. papillata Fosl. Norw. Lithoth. (1895), p. 87, pl. 17, fig. 22—23.

f. *tuberculata* Fosl.

Norw. Lithoth. p. 86, pl. 17, fig. 17—19.

f. *valida* Fosl.

Norw. Lithoth. p. 86, pl. 17, fig. 20—21.

Syn: Melobesia polymorpha Harv. Man. 2 (1849), p. 108, partim; non Phyc. Brit. pl. 345, nec. Ner. austr. p. 110.

Spongites polymorpha Kütz. Spec. Alg. (1849), p. 699, partim.

Spongites crustacea Kütz. Phyc. gener. (1843), p. 386; Spec. Alg. (1849), p. 689; Tab. Phyc. XIX, p. 34, t. 97! Aresch. in J. Ag. Spec. Alg. 2 (1859), p. 519.

Lithothamnion polymorphum Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 524, partim; Alg. Scand. exsicc. no. 302! Obs. Phyc. III (1875), p. 5, partim! Le Jol. Liste Alg. Cherb. (1863), p. 151, partim; Rosan. Rech. Melob. (1866), p. 99, partim; Crn. Fl. Finist. (1867), p. 151, partim; Kleen, Nordl. Alg. (1874), p. 11, partim; Kjellm. N. Ish. Algfl. (1883), p. 134, partim; Strömf. Algveg. Isl. (1886), p. 19; Traill. Alg. Mar. Orkney (1890), p. 36; Fosl. Contrib. I (1900), p, 9, partim, Norw. Lithoth. (1895), p. 87; Simm. Meeresalg. d. Færöer (1897), p. 269; Jönss. Mar. Alg. Icel. I (1901), p. 154! Börg. Mar. Alg. Færöes (1902), p. 400! Mar. Alg. Shetl. (1903), p. 7. Non Hauck. Meeresalg.

Lithothamnion purpureum Crn. Fl. Finist. (1867), p. 150!

Eleutherospora polymorpha Heydr. Lithoth. Helgol. (1900), p. 65!

Lithothamnion testaceum Heydr. l. c. p. 77! (Non Fosl.)

Phymatolithon polymorphum Fosl. Rev. Syst. Surv. Melob. (1900), p. 9; Batt. Cat. Brit. Alg. (1902), p. 98! Fosl. Lithoth. Adr. Meer. etc. (1904), p. 20, 35; De Toni, Syll. Alg. IV (1905), p. 1724.

As I already mentioned in Norw. Lithoth. l. c., the forms of this species admitted above are but feebly differentiated, and often run into each other. There is, however, a considerable difference between an almost even forma *sublævis* and a coarse f. *valida*, and the intermediate f. *tuberculata* is a rather characteristic form, which frequently occurs in exposed places, partly sheltered by other algæ. The species almost always grows on rocks (or in rock-pools). Sometimes it partly covers the hapters of *Laminaria* and *Alaria*, or the root of *Fucus* and, towards the southern limit of its distribution, occasionally also other calcareous algæ. Along the northern part of the coast of Norway it often grows in com-

pany with or coalesces with *Lithothamnion glaciale,* or one of these species even partly covers the other. Sometimes it also grows together with *Ph. compactum.* Once I even found all three species coalesced. The form *tuberculata* here sometimes assumes forms which in habit approach certain forms of *L. glaciale* so nearly that, when sterile, they cannot possible be defined. Nor does the structure always give a sure point of definition. This is particularly the case when both species are attacked by boring mussels and assume extreme forms. *Ph. polymorphum* will then even develop short branches irregularly parted. At the southern part of the British Isles or on the Atlantic coast of France the species in question now and then grows in company with *Lithophyllum incrustans,* or one species partly covers the other, and the species approach each other in habit. Occasionally the alga grows partly freely, or two crusts, which in growing come in contact, rise against each other, coalesce and continue growing freely, forming higher or lower ridges, which are undulate-lobate or crenate, all but like what is often seen in *Lithophyllum incrustans.*

As to structure the plant is not much varying, though its development is somewhat disturbed by the numerous overgrown conceptacles or by attacks of animals causing new formations of hypothallium, partly fairly regular, partly quite irregular. The hypothallium is formed by dichotome rows of cells, whose lower anticlines either but faintly converge towards the substratum, or not converging run upwards in large curves, — or the rows of cells, particularly in thick superposing crusts, form rather large curves upwards, running into or sending forth the perithallium, and smaller curves downwards towards the substratum. The hypothallic cells are 12—16 μ or up to 20 μ long and 7—12 μ broad. The perithallium is composed of cells which are partly squarish, 6—8 μ in diameter, often with a little rounded corners, partly vertically elongated, 7—10 μ or up to 12 μ long and 6—8 μ broad.

Typically developed conceptacles of sporangia are immersed, becoming cup-shaped or impressed-oblong, frequently with an

annular border, 150—300 μ in diameter. The roof is intersected with 30—70 muciferous canals. The sporangia are four-parted, 80—110 μ long and 25—45 μ broad. Along the northern part of the coast of Norway a form is rather frequent whose conceptacles are slightly elevated above the surface of the plant and resemble those mentioned below under *Ph. investiens* f. *torosa,* which I suppose are not normally developed. Besides there are sometimes found conceptacles with peculiar disc shaped local formations of tissue like those mentioned below under *Ph. lævigatum.* The conceptacles of cystocarps are at first convex, however frequently at length resembling those of sporangia and of about the same size with a single central pore. The conceptacles of antheridia resemble those of cystocarps in shape and are 100—120 μ in diameter. Overgrown conceptacles are frequently numerous in a section, but they are often wholly or in part filled with new-formed tissue.

Ph. polymorphum occurs most numerously in the lower part of the litoral zone and in the upper part of the sublitoral zone. According to Börgesen, it is found at the Færöes even above the highest water mark. On the other hand, it descends to a depth of 5—6, sometimes to a depth of about 10 fathoms, and on the northern coast of Norway (West Finmarken) I sometimes even found it at the depth of 15 fathoms. At Morocco and at a single place in the Adriatic it has been found very scantily at a depth of 8—17 fathoms. Particularly in the sublitoral region the alga forms the substratum of a large number of other algæ, e. g. *Alaria, Laminaria.* At the same time it is much attacked by boring algæ and peculiarly by lower animals, e. g. boring mussels, which often cause that the alga — chiefly when growing old — is wholly or partly detached from the substratum. The species develops reproductive organs at any time of the year in the areas from Finistère northward (except perhaps Finmarken), but on the other hand also sterile specimens are met with at the same times.

Area: Norway: From Havningberg near Vardö in East-Finmarken southwards(!); Sweden: West coast (Areschoug and

others!); Denmark (Rosenvinge!); Helgoland (Kuckuck!); S. Iceland (Strömfelt, Jönsson!); the Færöes (Simmons, Börgesen!); Shetland (Börgesen); the Orkneys (Traill); the Hebrides (Stanford!)[1] The British Isles! The Atlantic coast of France! Morocco: Tanger (Kuckuck!); the Adriatic: Brionic Islands (Kuckuck!)[2]

2. *Phymatolithon lævigatum* Fosl.

List of Lithoth. (1898), p. 8; Rev. Syst. Surv. Melob. (1900), p. 9; Lithothamnion lævigatum Fosl. Norw. Lithoth. (1895), p. 139, t. 19, fig. 21—23.

Syn: Lithothamnion lævigatum Heydr. Lithoth. Helgol. (1900), p. 76! Johns. and Hensm. Irish. Corall. (1899), p. 29?

„ emboloides Heydr. l. c. p. 74!

Phymatolithon lævigatum Börg. Mar. Alg. Færöes (1902), p. 400! Batt. Cat. Brit. Alg. (1902), p. 98! De Toni, Syll. Alg. IV (1905), p. 1725.

Phymatolithon? emboloides De Toni l. c. p. 1726.

This species is distinguished for its thin and smooth crust, which is often slightly shining, but particularly for its two-parted sporangia. It cannot, however, with certainty be considered as specifically distinct from *Ph. polymorphum,* which mostly shows a surface more or less uneven, and bears four-parted sporangia. The distinction depends on the stress to be laid on the partition of the sporangia. Particularly in the southern part of their area of distribution no line, as a general rule, can be drawn between these two species either as to habit or as to structure. Thus on the Atlantic coast of France, from where as yet *Ph. lævigatum* is not known, there occurs a form almost quite resembling the

[1] According to a specimen in the British Museum under the name of *Lithoth. colliculosum.*

[2] Among the specimens belonging to the group of *Ph. polymorphum — lævigatum* which I have seen from the Atlantic coast of North America, only a few belong to *Ph. lævigatum.* The rest are sterile and resemble in habit partly *Ph. lævigatum,* partly *Ph. polymorphum* f. *sublævis.* A sterile specimen from Magnolia (Herb. Farlow, II) attached to the hapters of *Laminaria digitata* recalls *Lithoth. læve* in habit, but seems most likely to represent a form of *Ph. polymorphum.* Besides, I have seen a couple of specimens from Greenland which resemble *Ph. polymorphum* in habit. They are, however, sterile, and on the other hand also approach *Lithoth. glaciale,* to which they are perhaps to be referred.

said species, only less smooth. It bears, however, four-parted sporangia and is, therefore, to be referred to *Ph. polymorphum*. Be it said that the alga never attains to the thickness of *Ph. polymorphum*, and the conceptacles are not to be found overgrown by new formed tissue.

As to structure the species in all essentials corresponds with *Ph. polymorphum*, though the hypothallium is generally more faintly developed than in the latter.

Also the reproductive organs are like those of the said species. In some places the conceptacles frequently bear peculiar local formations of tissue forming a disc-shaped layer over the roof (*L. emboloides* Heydr.). These formations, however, rather soon fall into decay and are sometimes found also in several other species.[1]) The two-parted sporangia are 120—150 μ long and 40—60 μ broad.

The species in question occurs on rocks, stones and shells of molluscs in the lower part of the litoral region and in the upper part of the sublitoral region, in the former one sometimes associated or even anastomosed with *Lithoth. Lenormandi*. Sometimes it also seems to occur attached to other calcareous algæ. The species descends to a depth of about 10 fathoms, and occurs in about the same conditions as *Ph. polymorphum*. It seems, however, to prefer more sheltered localities than the said species, having not yet been found in shallow water at the open coast. As far as is hitherto known, the alga is most frequent on the coasts of Denmark, where like *Ph. polymorphum* it has been found in many places. It seems also to be of common occurrence at Helgoland associated with the said species. Although it is rather widely dispersed, it is on the other hand known only in small numbers from the other areas recorded below. The alga develops reproductive organs at any season of the year; but sterile specimens are often met with analogously to the state of things in the case of the species preceding.

[1]) Cp. M. Foslie. Bieten die Heydrichschen Melobesien-Arbeiten eine sichere Grundlage? — Det Kgl. norske Videnskabers Selskabs Skrifter 1901. No. 2. Trondhjem 1901. Pag. 11.

Area: Norway: Haugesund(!)[1]); Fredriksværn(!), Dröbak (Gran!,!) and Nesodden in the Christiania Fjord (Schreiner!); Sweden?[2]) Denmark (Rosenvinge!); Helgoland (Kuckuck!); the Færöes (Jönsson, Börgesen!); Scotland: Berwick (Batters!); Ireland: West coast (Johnson)? Larne, Co. Antrim (Hanna!); Atlantic coast of North America: Newport, R. I. (Collins!), Kennebunkport, Me. (Collins!), Halifax Harbour, N. S. (Mackay, Howe!)[3]) Newfoundland (Waghorne!).[3])

3. *Phymatolithon investiens* Fosl. mscr.

Lithothamnion investiens Fosl. Norw. Lithoth. (1895), p. 129, t. 22, fig. 2—5; Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 11? Jönss. Mar. Alg. East-Greenl. (1904), p. 6? De Toni, Syll. Alg. IV (1905), p. 1731.

f. *torosa* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 11; Lithothamnion glaciale f. torosa Fosl. Norw. Lithoth. (1895), p. 13, t. 1.

f. *ocellata* Fosl. mscr.

Lithothamnion ocellatum Fosl. Norw. Lithoth. (1895), p. 112, t. 19, fig. 10. Phymatolithon ocellatum Fosl. List of Lithoth. (1898), p. 8; Rev. Syst. Surv. Melob. (1900), p. 9; De Toni, Syll. Alg. IV (1905), p. 1725.

Syn: Lithophyllum zonatum Fosl. Contrib. I (1890), p. 10.

This species covers or encompasses other calcareous algæ, particularly *Lithothamnion Ungeri, L. soriferum, L. tophiforme,* and *L. glaciale,* possibly also other hard objects. In specimens of *L. soriferum* or *L. tophiforme* lying freely on the bottom with the central branches rather crowded, but the outer ones divaricate, the former part of the alga is collectively loosely encompassed by *Ph. investiens,* but the outer branches individually. The encompassing crust of the latter species is 0,5—2 or up to 3 mm. thick.

1) I assume that some specimens bearing conceptacles in which sporangia have not been found belong to this species. They were picked up at Salhus near Haugesund from a depth of 8—10 fathoms in company with *Lithothamnion læve* and *L. Sonderi.*

2) From Gullmarfjord I have seen a very small and sterile crust together with *Litholh. Sonderi* which probably belongs to this species.

3) The specimens from Halifax and Newfoundland bear conceptacles, but I have not found sporangia. Therefore, it is uncertain whether they belong to *Ph. lævigatum* or perhaps to *Ph. polymorphum,* probably however to the former species.

The encompassing is generally so complete and coherent that such a specimen conveys the impression of being an alga thoroughly independently developed, now strongly branching, now slightly branching with the apparent branches up to 2 cm. long and about 0,5 cm. thick, mostly however shorter and frequently thicker. But the specimen thus, as a matter of fact, represents a crustformed, not branching alga, which is developed round a branching one. Even tubes of worms which have attached themselves to the host plant are often encompassed individually. Sometimes some branch or other of the host plant sticks out of the encompassing crust, but also such ones are soon completely covered by *Ph. investiens*. In host plants more densely branching, e. g. in *L. Ungeri*, the whole of the alga is encompassed in a lot, or some projecting branch or other individually. Younger specimens, e. g. of *L. glaciale*, which have attached themselves to a stone are sometimes almost wholly encompassed together with the stone. Also specimens of some of the said species which are attached to the bottom, or lying closely associated on the bottom, are often collectively covered as with a mantle by *Ph. investiens*.

A host plant thus encompassed is gradually attacked by animals, particularly boring mussels, by which it finally disappears. We have then only to deal with the encompassing alga, which now consequently represents a *Ph. investiens* apparently freely developed, more or less hollow or with an opening generally in the part turning downwards. As a general rule, however, this is only the case when *Ph. investiens* encompasses in a lot the whole bulk of a densely branching host plant, whereas in a sparsely branching one the outer branches encompassed for the most part remain undissolved. As a matter of fact, these branches are so closely encompassed by *Ph. investiens* that in a fracture the surface of the latter often conveys the impression of an almost parenchymatic mass or of a new thickening layer of the host plant.

Also *Ph. investiens* is attacked by the same animals that have caused the decay of the host plant, so that the original crust of the alga in question will frequently only form a tissue perforated by animals in every direction. But upon this crust are at the

same time developed a new overgrowing hypothallium and new thickening layers, forming a new crust upon the primary one. Even three or four crusts, one above the other, are to be met with. But the oldest of these crusts are mostly falling to decay or crumbling. Thus things are going on, animals and boring algæ carrying on their work of destruction and mostly from the inside or from the side turning downward of the alga, while on the other hand the latter is continually forming new layers of tissue and covering the parts attacked. In so doing the alga constantly increases in size, while the crust itself does not grow much thicker than mentioned above. There are found specimens of *Ph. investiens* which are up to 0,5 m. in diameter, but most frequently they are smaller, obverse-cup-shaped or flattened hemispherical, or irregular. Cp. Norw. Lithoth. pl. 1. In such coarse specimens of the species are often formed subhemispheric or wartlike processes 0,5—1 cm. in diameter or more. They are, however, more or less hollow and have only come out as the result of the growing over and the covering up extraneous objects, or of the attacks of animals with a consequent brisker formation of tissue. Sometimes the whole specimen is hollow with a small opening and very light of weight, while another is comparatively heavy, the encompassed object being undissolved or the specimen being filled with boring mussels. Thus I have seen specimens only 3—4 cm. in diameter filled with small boring mussels, which had nearly dissolved the encompassed calcareous alga and was about to begin its attack on *Ph. investiens* itself. It sometimes happens that *Ph. investiens,* when occurring in banks of *L. glaciale* and growing over the latter, is overgrown itself by the said species. But this seems only to occur in conditions particularly unfavourable to the development of *Ph. investiens.* In old specimens of the species in question which have become inverted cup-shaped or more or less convex-concave, also the inside or the part turning downward of the alga is often covered with new layers of tissue, or a new crust is formed. The same can be the case with specimens which have become water-worn in the part turning upwards. Such specimens will even increase considerably in thickness and finally

assume a more flattened form than usual. Cp. Norw. Lithoth. pl. 1, fig. 3. The same is also the case with *L. fornicatum* and other species, when the alga is so situated on a hard substratum that the light can penetrate below it.

The development of the alga, however, does not always proceed in the manner described above, but frequently more irregularly. Thus there may be formed complexes of indefinable shape, partly owing to the shape of the encompassed objects, partly to the degree and the direction of the attacks and the havoc of the animals and the boring algæ. Sometimes are also developed numerous semicircular, now and then lobed, or irregular prolifications which are growing more or less freely, often with concentric striæ particularly on the under side, or furrowed almost as in *Lithophyllum expansum* and other species. Cp. Norw. Lithoth. pl. 22, fig. 3—4.

The form of *Ph. investiens* here described represents f. *torosa*. As far as I have seen, it never forms real branches. It is possible that it sometimes develops small wartlike excrescences. But in the cases I have examined, even such ones have been formed by growing over and covering up extraneous objects, or new layers of tissue have been heaped up round the surface opening of passages made by worms, or caused by other animals. Larger excrescences or short branchlike formations may be solid in the uppermost part and convey the impression of real branching, apart from similar ones encompassing branches of a host plant as mentioned above. But being more closely examined they also prove to have risen from one of the causes mentioned. Nor does it seem that the leaf-like prolifications mentioned above are to be considered as normal formations.

The form *ocellata* forms thinner crusts than f. *torosa*, 0,5—1 mm. thick. They frequently cling more closely to the host plant than in the said form, never distended between its branches, nor covering several branches collectively. If several crusts are established on the same substratum, they finally coalesce completely. The form is otherwise perhaps rather to be considered as a young f. *torosa*. It is most frequently found in small numbers associated with the latter.

As to structure the species in all essentials corresponds with *Ph. polymorphum*. The hypothallium is often strongly developed, and the cells are in part longer than those of the said species, 14—30 μ long and 6—12 μ broad. The perithallic cells resemble those of *Ph. polymorphum* both in shape and in size.

The reproductive organs of this species are not yet sufficiently known. The form *torosa* now and then bears numerous conceptacles of sporangia. They are a little prominent, i. e. the roof is at the level of or a little above the surface of the plant, with elevated annular border and mostly with but a small portion of the central part impressed, 250—400 μ in diameter, and the roof being frequently perforated only by a comparatively small number of muciferous canals. These conceptacles, however, do not seem to be normally developed. I have examined a considerable number of them without finding any sporangia. In several conceptacles, on the other hand, I have found small animals which attack the germs of the sporangia, and which by growing and perhaps occurring in considerable numbers seem to bring about a raising of the roof of the conceptacle. The roof is of a looser consistency than usual, and is apt to decay. The conceptacles sometimes bear similar disc-shaped and easily decomposable formations of tissue as those mentioned under *Ph. lævigatum*. Overgrown conceptacles I have not seen in this form, but in a vertical section of the perithallic layer I have found some which have been effaced by local formations of tissue after the dissolution of the roof. The conceptacles of cystocarps are convex or subhemispheric, become decorticated, and are finally often scarcely rising above the surface of the frond; they are of about the same diameter as the conceptacles of sporangia. However, I have never seen them cup-shaped, as is often the case with *Ph. polymorphum* and particularly *Ph. lævigatum*.

In the form *ocellata* the conceptacles of sporangia are frequently of the same shape as those of *Ph. polymorphum*, but generally a little larger, or 250—400 μ in diameter, and the roof is traversed with 50—70 muciferous canals. They contain four-parted sporangia which are 120—135 μ long and 45—60 μ broad. There are, however, also such conceptacles as those mentioned

under f. *torosa,* and without sporangia. The conceptacles of cystocarps resemble those of f. *torosa.*

As to the synonymy it must be observed that when in Norw. Lithoth. I referred f. *torosa* to *Lithoth. glaciale,* it was owing to the conceptacles not normally developed. Besides the specimens pictured l. c., I then only knew a few others. The conceptacles of this form, with their central parts but a little or faintly impressed, are more nearly approaching the corresponding organs at a certain stage of development in *L. glaciale* than typical conceptacles of *Ph. polymorphum.* From the considerable material afterwards collected it must be considered beyond doubt that f. *torosa* belongs to the same series of forms as f. *ocellata,* and certainly also to the same species.

This species is nearly connected with *Ph. polymorphum.* I have even had doubts whether it should not properly be regarded only as a form of the said species. Particularly f. *ocellata* is hardly distinguishable from certain forms of *Ph. polymorphum,* principally such ones, occurring along the northern part of the coast of Norway, in which new crusts frequently are covering older ones. It is of no rare occurrence that *Ph. polymorphum* is growing gregariously or even anastomosing with *Lithoth. glaciale,* and, being attacked by animals, both species at an older stage detach themselves from the substratum. In certain circumstances also the part turning downwards of both the coalesced species is covered by a new crust, which will bear a considerable resemblance to *Ph. investiens* f. *ocellata.* Also young crusts of *Ph. investiens* on *L. glaciale* can be confounded with new crusts of the latter attached to older ones. To this may be added — as I mentioned under *Ph. polymorphum* — that along the northern coast of Norway this species is often developing abnormal conceptacles resembling the corresponding ones in *Ph. investiens.* The form *torosa,* however, when most strongly defined, is much diverging and well marked. Besides, the species does not develop excrescences or branches, which is generally the case with *Ph. polymorphum,* and the conceptacles are mostly a little larger.

Ph. investiens abounds in many places on the northern coast

of Norway, occurring in the sublitoral region at a depth of 3—15 or up to 20 fathoms. On some banks it nearly suppresses the other calcareous algæ occurring. Thus at Galten in West-Finmarken was found a bank where *Ph. investiens* at the depth of 6—8 fathoms seemed to cover all other larger calcareous algæ there occurring, particularly a species which is likely to belong to *Lithoth. Ungeri* and *L. soriferum* or *L. tophiforme.* I did not succeed in getting any specimen of the latter which was not almost completely covered with *Ph. investiens.* Inside Tamsö in the Porsangerfjord is found a bank of calcareous algæ which is about 10 km. long. In the parts of this bank which I examined, *Ph. investiens* also occurred abundantly at the depth of 10—15 fathoms, covering now a coarse form probably of *L. Ungeri,* now *L. soriferum,* and perhaps other species. On *Ph. investiens* there was in part a very rich vegetation of *Ptilota.* Besides there are both at Tamsö, in the Altenfjord, and in several other places found rather considerable numbers particularly of young specimens of *L. glaciale* covered with *Ph. investiens.* On the contrary, it apparently can not get the upper hand in banks of older and well developed *L. glaciale* or *L. fornicatum.* The alga bears mature reproductive organs in the months of June and July.

Area: Norway: From Lebesby in East Finmarken to Lyngö near Tromsö(!); East Greenland?[1])

Subgen. **Clathromorphum** Fosl. mscr.

Gen. Clathromorphum Fosl. Syst. Surv. Lithoth. (1898), p. 4; Rev. Syst. Surv. Melob. (1900), p. 9; De Toni, Syll. Alg. IV (1905), p. 1726.[2])

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[1]) A sterile crust of *Lithoth. glaciale* from Heklahavn, picked up from a depth of about 10 fathoms (Hartz), is in part loosely covered with another crust, which perhaps belongs to this species. Cp. Rosenv. l. c.

[2]) In Rev. Syst. Surv. Melob. p. 10 I still kept *Clathromorphum* as a separate genus, but remarked that it is perhaps to be considered as a subgenus of *Phymatolithon.* I have not yet succeeded in finding unquestionable cystocarps, and as the sporangia show a close relation to *Phymatolithon,* I now think it most correct to admit it as a subgenus of the latter.

4. *Phymatolithon compactum* (Kjellm.) Fosl. mscr.

Lithothamnion compactum Kjellm. N. Ish. Algfl. (1883), p. 132, t. 6, fig. 8—12!

f. *typica.*

Descr. Kjellm. l. c. Lithothamnion circumscriptum β validum Rosenv. Grönl. Havalg. (1893), p. 103, fig. 3! Lithothamnion compactum Fosl. Norw. Lithoth. (1895), p. 103, t. 19, fig. 1—4; Saund. Alg. Harr. Alaska Exp. (1901), p. 442! Clathromorphum compactum Fosl. Syst. Surv. Lithoth. (1898), p. 4, Rev. Syst. Surv. Melob. (1900), p. 10; Jönss. Mar. Alg. Icel. I (1901), p. 154! Setch. and Gardn. Alg. Northw. Amer. (1903), p. 357! De Toni, Syll. Alg. IV (1905), p. 1726.

f. *testacea* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 10; Lithothamnion testaceum Fosl. Norw. Lithoth. (1895), p. 107, t. 19, fig. 5—9; Clathromorphum testaceum Fosl. List Lithoth. (1898), p. 8. Non Lithothamnion testaceum Heydr. Lithoth. Helgol. (1900), p. 77, t. II, fig. 16 (= Phymatolithon polymorphum)!

f. *circumscripta* (Strömf.) Fosl. mscr.

Lithothamnion circumscriptum Strömf. Algveg. Isl. (1886), p. 20, t. I, fig. 4—8; Fosl. Contrib. I (1890), p. 9, II (1891), p. 10, t. 3, fig. 8; Lithothamnion circumscriptum α areolatum Rosenv. Grönl. Havalg. (1893), p. 774! L. circumscriptum Fosl. Norw. Lithoth. (1895), p. 132; Rosenv. Deux. Mem. Alg. Mar. Grönl. (1898), p. 13! Clathromorphum circumscriptum Fosl. Rev. Syst. Surv. Melob. (1898, p. 5, Rev. Syst. Surv. Melob. (1900), p. 10; Jönss. Mar. Alg. Icel. I (1901), p. 154! Saund. Alg. Harr. Alaska Exp. (1901), p. 442! Börg. Mar. Alg. Færöes (1902), p. 400? Setch. and Gardn. Alg. Northw. Amer. (1903), p. 357! De Toni, Syll. Alg. IV (1905), p. 1728.

f. *coalescens* Fosl mscr.

Lithothamnion coalescens Fosl. Norw. Lithoth. (1895), p. 134, t. 19, fig. 15—20; Clathromorphum coalescens Fosl. List Lithoth. (1898), p. 8.

Syn: Lithothamnion polymorphum Kjellm. Algenveg. Murm. Meer. (1877), p. 8; Farl. Mar. Alg. New Engl. (1881), p. 182, partim!

Lithothamnion durum Kjellm. Beringh. Algfl. (1889), p. 22, saltem pro parte!

Lithothamnion scabriusculum Fosl. Norw. Lithoth. (1895), p. 142, t. 22, fig. 9, De Toni, Syll. Alg. IV (1905), p. 1758?

Lithothamnion evanescens Fosl. Norw. Lithoth. (1895), p. 137, t. 22, fig. 6—8, partim, De Toni, Syll. Alg. l. c. p. 1728?

In Norw. Lithoth. I assumed that *L. compactum* and *L. circumscriptum* were to be considered as independent species. Afterwards, however, I have found that, strictly speaking, no line can be drawn between them. The same is the case of *L. testaceum* and *L. coalescens.* The former of these species is, indeed, described as bearing sporangia four-parted. But it was only known

from a single locality, and I have also afterwards found sporangia two-parted. I have above, when treating of *L. tophiforme,* mentioned the species in question and other crustformed species as partly bearing sporangia two-parted as well as four-parted ones. It might seem likely that each of these species should on that account have been divided into two distinct ones, as in the case of some of the branching species. In the latter, however, as a general rule only one kind of sporangia or the other is found, corresponding to a certain distribution, whereas in the crustformed ones both two-parted sporangia and four-parted ones rather often occur in the same specimen, and sometimes in the same conceptacle. In *Ph. compactum* I have even seen sporangia two-parted, three-parted and four-parted in the same conceptacle both in specimens from Norway and from America, the first-named ones in preponderating majority. The same is the case with specimens from Greenland. Cp. Rosenvinge l. c. fig. 3. Besides I have, in typical *L. foecundum,* seen two-parted sporangia and four-parted ones in specimens both from Norway and from Ellesmereland. I, therefore, at present do not venture to consider this state of things otherwise than partly an abnormal development of the said organs, partly they have probably not been fully developed. This is, however, in many cases hardly or even impossibly decidable.

As remarked by Professor Kjellman l. c., the alga forms a crust almost circular, when developed freely on a plane substratum. The surface is even and faintly shining. When several crusts are formed on the same substratum and finally get confluent, the limit of each of them may be more or less visible and sometimes be formed by raised ridges. When growing older, the alga mostly becomes more or less uneven, partly as a consequence of the form of the substratum, partly by irregular effacing of the scars after emptied conceptacles. New crusts are often developed one above the other in a rather irregular manner, or sometimes small crusts circular and almost disc-shaped occur upon old ones, representing independent individuals. An uneven surface, however, particularly rises from growing over and covering up small extraneous objects, sometimes forming small angular excrescences like similar ones in

Lithophyllum incrustans. The alga is then also more easily attacked by animals, and will now and then be detached from the substratum, while elsewhere it is hard attached to it. I have even seen specimens partly detached, with crusts new, but feebly developed, over parts of the side turning downwards.

The typical form of the species is most vigorously developed and attains to a thickness of up to about 2,5 cm. With this form is connected f. *testacea* with smaller conceptacles. In both forms the conceptacles are finally overgrown. The form *circumscripta* is always more faintly developed with conceptacles densely crowded. A form nearly approaching the last mentioned one is f. *coalescens,* which is smaller and becomes more regularly confluent with conceptacles mostly less densely crowded. In both the forms last-mentioned, grown-in conceptacles do not occur.

As to the structure of the frond, the hypothallic layer is always feebly developed, the cells are 14—30 μ or up to 43 μ long, and 5—10 μ broad, their length usually being 3—5 times the breadth. The perithallic cells are partly squarish, 6—10 μ in diameter, partly and more frequently a little vertically elongated, and 9—14 μ, or occasionally up to 16 μ long, and 7—11 μ broad, the length being up to about $1^1/_2$ or seldom twice the breadth. Now and then occur cells a little elongated in horizontal direction of the frond.

The conceptacles of sporangia in f. *typica* will be developed under favourable circumstances almost over the whole surface of the frond, except a narrow peripherical portion, mostly, however, only a smaller part. They are rather crowded, sometimes irregularly scattered, at first visible as light points which gradually become decorticated, finally forming shallow holes, impressed pointlike or almost trumpet-shaped, 100—200 μ in diameter, the bottom of which forms a part of the roof and is intersected with 5—18 muciferous canals. In this form it is usually only the said part of the roof which falls to decay at maturity, sometimes, however, the whole roof is dissolved. In a median vertical section the conceptacles are spherical or flattened spherical, 200—250 μ in diameter. In f. *testacea* the said conceptacles mainly resemble those

of the preceding form, but they are usually smaller, 120—180 μ in diameter. In f. *circumscripta* the conceptacles are situated very little below the surface of the frond, or less deeply than in the preceding forms, but they are more densely crowded, usually forming a zone sharply defined. The central portion of the roof at first becomes decorticated, by and by forming a very shallow hole, 100—150 μ in diameter, the bottom of which forms a part of the roof and is intersected with 10—20 or up to 30 muciferous canals. After maturity this central portion first falls to decay, and at the same time the surrounding parts of the roofs become lighter and gradually disappear, frequently — owing to the conceptacles densely crowded — leaving hexagonal holes, 200—300 or up to 350 μ in diameter, the latter representing the emptied conceptacles which look like a mesh-work with thin walls. Also the greater part of the said intermediate walls falls to decay. The scars are effaced by a new thickening layer of the frond or by new local formations, and when the scars are nearly replenished the surface often appears areolate. Such areolating is sometimes to be seen also before the conceptacles are fully developed. In the form *coalescens* the conceptacles mainly resemble those of the latter, but they are mostly less crowded. — The sporangia in this species are frequently bisporic, now and then tetrasporic, particularly in f. *testacea,* occasionally irregularly three- or four-parted. Cp. above. They are rather varying in size, and smallest in f. *testacea,* judging from a few measures, 90—120 μ long and 25—50 μ broad. In the other forms they are 100—300 μ or even up to 390 μ long and 50—100 μ or up to 150 μ broad.

As to the synonymy, *L. scabriusculum* l. c. probably represents a young and somewhat stunted form of the species in question. At any rate it will scarcely prove to be an independent species. Besides, I now consider the Norwegian specimen of *L. evanescens* mentioned l. c. as representing a peculiar f. *circumscripta.* This is perhaps also the case with the typical specimen from America. I have only seen the fragment pictured in Norw. Lithoth. pl. 22, fig. 6. The decortication of the conceptacles seems to take place in another way than in typical f. *circumscripta,* but

this is perhaps a mere accident, as the alga in other respects resembles the form last-mentioned. Cp. Norw. Lithoth. p. 138, t. 22, fig. 8.[1]) — The *Lithoth. durum* recorded from Behring's Sea still seems to me to have to be referred at any rate partly to the species in question, most consistent with f. *circumscripta,* which it fully resembles both in habit and in structure. The perithallic cells in the type-specimen of *L. durum* are squarish, 7—9 μ in diameter, vertically elongated, up to 14 μ long and 11 μ broad, or here and there slightly horizontally elongated. It is, however, described as bearing tetrasporic sporangia. As to the occurrence of such ones in the species in question, cp. above. From the north west coast of America I have several specimens of *Ph. compactum* bearing bisporic sporangia, which seems to show that it also there is usually bearing such ones. On the contrary, *Ph. loculosum,* which is nearly related, is generally carrying tetrasporic sporangia. Cp. below.

Although *Ph. compactum* is a characteristic species and well defined, it can be confounded with some other species. Thus it sometimes bears in habit a great resemblance to *Lithophyllum incrustans,* particularly when it carries irregular or angular excrescences. Besides young or even fertile specimens of the species are easily confounded with *Lithoph. orbiculatum.* As a matter of fact, when the roof of the conceptacles is decorticated, it often happens that first only one pore becomes visible, afterwards more, and if the conceptacles are at the same time feebly developed and smaller than usual, it will be almost impossible to distinguish particularly stunted specimens from the species last mentioned or from a stunted *Phym. polymorphum.*

Ph. compactum, however, is particularly closely connected with *Ph. loculosum (Lithoth. loculosum* Kjellm.), which was originally found in the Behring's Sea.[2]) Specimens of the latter species which are not too old are provided with similar striæ as in

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[1]) If this species is kept as an independent one, it is to be denominated, consistently with the other species of this subgenus:
Phymatolithon (Clathromorphum) evanescens Fosl.

[2]) F. R. Kjellman. Om Beringhafvets Algflora. Stockholm 1889. Pag. 21.

the former one. A specimen of *Ph. loculosum* I got from Mr. K. Yendo, who had collected it at Shimushu, the northmost of the Kurile Islands, forms a large flat piece, 1—2 cm. thick, with even surface, and was hauled up, attached to the hold-fast of *Alaria fistulosa,* from a depth of about 20 fathoms. New crusts have been developed on the primary one which was partly dead and apparently loosely attached to the substratum. This specimen belongs to the typical form of the species with numerous grown-in conceptacles. Cp. Kjellman l. c. Another specimen from the said place encompasses a pebble and was found at the lowest tide mark. The reefs were covered with the same species, which was, however, here firmly attached to the substratum. The latter specimen represents a somewhat diverging form of the species, which I propose to name:

Phymatolithon (Clathromorphum) loculosum (Kjellm.) Fosl. mscr.
f. *evanida* Fosl. mscr.

The conceptacles of sporangia in this form are densely crowded, resembling those in *Ph. compactum* f. *circumscripta,* but frequently larger, in a median vertical section 300—500 μ in diameter.

In *Ph. loculosum* the hypothallic layer is more vigorously developed than in *Ph. compactum* and the cells are usually larger, 18—40 or up to 55 μ long and 7—14 μ broad. The perithallic cells are squarish, 7—11 μ in diameter, or vertically elongated, of a length being $1^1/_2$—3 times the breadth, being 7—20 or up to 26 μ long and up to 14 μ broad, not or seldom a little elongated in horizontal direction of the frond. Thus the cells are frequently larger than in the latter species, though specimens occur which in this respect are hardly distinguishable. This is also the case as to the conceptacles of sporangia. In *Ph. loculosum* too they are visible after decortication as point-like or small cup-shaped holes 200—300 μ in diameter, the bottom of these holes forming a part of the roof intersected with 10—20 muciferous canals. In f. *typica* only a part of the roof falls to decay after maturity, corresponding with *Ph. compactum* f. *typica,* whereas in f. *evanida* the conceptacles get fully dissolved as in f. *circumscripta.* The sporangia usually are tetrasporic, occasionally only bisporic, 160—

240 by 70—110 μ. Specimens from the Kurile Islands bore such organs towards the end of June.

A specimen from Rubetsu, the north-side port of the largest of the Kurile Islands called Etorufu, I also refer to *Ph. loculosum* f. *evanida*. It was collected by Mr. Yendo a few feet below low water mark. This specimen fully resembles certain forms of *Ph. compactum* f. *circumscripta* in habit. The cells partly are as small as in the latter, but the conceptacles are usually larger. A sterile specimen from St. Paul of the Pribilof Island in the Bering Sea (Setchell, no. 5811) coincides with the latter. I formerly considered it identic with *Ph. compactum* f. *circumscripta*, as in habit it exactly resembles certain forms of the latter, and overgrown conceptacles do not occur, but the cells are usually a little larger and therefore the specimen probably belongs to *Ph. loculosum* f. *evanida*. — A big piece of a dead specimen from Allex Island of the Aleutian Islands (comm. Dr. Dawson!) much approaches *Ph. compactum* f. *typica*, but the cells are usually a little longer than in the latter, and therefore also this specimen is likely referable to *Ph. loculosum*.

Phym. compactum is frequently attached to rocks or stones, often, however, also to shells of mussels. A specimen from Iceland attached to the stem of *Laminaria hyperborea* (Hrauni Fljöt, Davidsson!) is almost quite like *Lithoph. Crouani* in habit and only almost 1 mm. thick, but it bears sporangia and belongs to the species in question. On the Atlantic coast of North America crusts feebly developed of this species once have been found attached to the shell of a live crab associated with young crusts probably of *Lithoth. læve*. The alga occurs both in places sheltered with strong tides and in exposed ones. In the latter it now and then appears in rock-pools in the litoral region, and it descends to a depth of about 20 fathoms. It is commonly spread almost everywhere in the areas where it is dispersed, seldom occurring in any large number, but often growing gregariously with other calcareous algæ, particularly with *Lithoth. læve*. Mature sporangia have been found in June—November.

The forms *typica* and *circumscripta* occur in all the areas

recorded below, whereas f. *testacea* is known only from Bergsfjord in the Finmark (Norway) and the Trondhjem Fjord, f. *coalescens* only from the latter place.

Area: Norway: From the north-eastern boundary to the Trondhjem Fjord and Kristiansund, N(!); Iceland (Strömfelt, Davidsson, Jönsson!)[1]; the Færöes (Börgesen!)[2]; the Atlantic coast of North America: Massashusetts—Maine, Nova Scotia, Newfoundland (Farlow, Collins, Penhallow, Waghorne, Mackay, Holden, Howe!); Ellesmereland, southern coast: Havnefjord, Exkrementbugten, Gaasefjord, Hvalrosfjord, Jammerbugten (Baumann, Bay, Simmons!); Ellesmereland, east coast: Rice Strait (Simmons!); West Greenland (Ryder, Hartz, Rosenvinge!); East Greenland: Tasinsak, Heklahavn (Kruuse, Hartz, Rosenvinge!); Spitzbergen: between Norsköerne and Amsterdamöen (Nils Johnsen!); King Charles Land (Dircks!); Novaia Zembla, west coast (Kjellman!); Northwestern America: Alaska: Port Clarence (Kjellman!), Unalaska, St. Michael, Prince William Sound, Kukak Bay and Sitka (Saunders, Setchell!).

Melobesieæ Aresch.

J. Ag. Spec. Alg. 2 (1852), p. 508; Den bot. Saml. 1902 (1903); char. mut.

Melobesia Lamour.

Bull. phil. (1812) sec. Polyp. flex (1816), p. 315; Fosl. List of Lithoth. (1898), p. 10; Rev. Syst. Surv. Melob. (1900), p. 20, Alg. Not. (1904), p, 3; char. mut.

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[1]) A stunted specimen from Eyrarbakki (no. 486) referred by me to *Ph. compactum* is rather approaching *Lithoph. orbiculatum*. The conceptacles are small and feebly developed without sporangia, so that a certain determination is impossible.

[2]) Owing to a slip of pen on my part, an error has slipped into Börg. Mar. Alg. Færöes p. 400. The form is recorded to have borne in the month of June „young sporangia" instead of young conceptacles. Therefore, the determination of the only specimen known from that place is not quite certain. Specimens faintly developed are hardly distinguishable from similar ones of *Lithoph. orbiculatum*.

Subgen. **Eumelobesia** Fosl.

List of Lithoth. (1898), p. 10; char. mut.

Frond monostromatic with solitary small cortical cells, except around the conceptacles; heterocysts present.

1. *Melobesia farinosa* Lamour.

Polyp. flex. (1816), p. 315, t. 12, fig. 3.

f. *typica.*

Melobesia farinosa Rosan. Rech. Melob. (1866), p. 69, pl. II, fig. 3—5, 10—12, pl. III, fig. 2—13, pl. IV, fig. 1, 10, pl. VII, fig. 12.

Conceptacles of sporangia and cystocarps hemispherical or hemispheric-conical, 130—200 (250) μ in diameter.

f. *borealis* Fosl. mscr.

Frond frequently coarser than in the typical form, conceptacles of sporangia and cystocarps frequently larger, hemispherical, 200—300 μ in diameter.

f. *callithamnioides* (Falkbg.) Fosl.

Siboga Exp. LXI (1904), p. 55, Melobesia callithamnioides Falkbg. Alg. Neap. (1879), p. 265; Solms, Corall. Monogr. (1881), p. 11, t. I, fig. 9, 12, 13; Hauck, Meeresalg. (1885), p. 262, fig. 106; De Toni, Syll. Alg. IV (1905), p. 1765. Non Batt. Cat. Brit. Alg. (1902), p. 96! Nec Hapalidium callithamnioides Crn. Fl. Finist. (1867), p. 149 (= Rhodochorton sp.)! Melobesia Solmsiana Falkbg. Rhodom. (1901), p. 109.

Syn: Melobesia farinosa Kütz. Spec. Alg. (1849), p. 696, partim; Harv. Phyc. Brit. (1846—51), pl. 347 B (partim?); Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 512, partim (non Obs. Phyc. III, p. 4!); Crn. Fl. Finist. (1867), p, 150, partim; Farl. Mar. Alg. New. Engl. (1881), p. 180; Solms, Corall. Monogr. (1881), p. 11, t. I, fig. 4, pl. III, fig. 11; Ardiss. Phyc. Medit. I (1883), p. 445 (partim?); Hauck, Meeresalg. (1885), p. 263, fig. 107; Debr. Cat. Alg. Maroc. etc. (1897), p. 72! Batt. Cat. Brit. Alg. (1902), p. 96 (partim?); De Toni, Syll. Alg. IV (1905), p. 1764; non Reinke, Algenfl. westl. Ostsee (1889), p. 32!

Melobesia granulata Menegh. in Zanard. Saggio (1843), p. 44 (nomen) sec. spec. herb. De Toni! Kütz. Spec. Alg. (1849), p. 696; Tab. Phyc. XIX (1869), p. 34, t. 95.

Melobesia verrucata Crn. Fl. Finist. (1867), p. 150, partim!

Hapalidium coccineum Crn. Fl. Finist. (1867), p. 149, partim! Non Not. Hapal. in Ann. Sc. Nat. Ser. 4. Bot. Tome 12 (1859), p. 285.

Melobesia membranacea Le Jol. Liste Alg. Cherb. (1863), p. 150, partim, Alg. mar. Cherb. no. 194!

Melobesia confervicola Mazé et Schr. Alg. Guadel. (1870—77)? Murray, Cat. Mar. Alg. West. Ind. (1888—89), p. 21?

Melobesia pustulata Ardiss. Phyc. Medit. I (1883), p. 446, partim, Erbar. Crittog. Ital. no. 856!

Though this species is fairly well circumscribed by the description made by Mr. Rosanoff l. c., still it has been somewhat differently perceived. Thus, according to authentic specimens, *M. farinosa* Aresch. Obs. Phyc. 3. p. 4 represents a typical *M. Lejolisii*. He expresses, however, l. c. some doubt as to the identity with the true *M. farinosa*. Besides, strange to say, Mr. Rosanoff, under *M. membranacea* l. c. p. 66, refers to Le Jolis, Liste Alg. Cherb. p. 150. In the latter is referred to Alg. mar. Cherb. no. 194. But the alga here distributed is a well developed, typical *M. farinosa* growing on *Cystosira discors*. It also seems as if several authors have partly referred forms of *M. Lejolisii* to *M. farinosa*, but I find no reason here to enter more fully upon it. The said two species are easily confounded when the specimens are feebly developed, stunted, or coalescing on a small substratum, or growing together with other species so as to check the development mutually. In such specimens there is frequently no distinct line to be drawn either as to the cells or as to the conceptacles. Sometimes the heterocysts are not traceable in *M. farinosa*, particularly when the conceptacles are somewhat crowded, and if at the same time the cells are smaller or the conceptacles lower than usual, the species can not be determined with certainty. On the other hand, *M. Lejolisii* may show characters recalling *M. farinosa*, and peculiarly f. *limitata* of the former species and f. *borealis* of the latter species may often be hardly distinguishable.

As representing a typical *M. farinosa* — or as good as a typically developed one — I take the form mentioned above, distributed by M. Le Jolis under the name of *M. membranacea*, though apart from the shape and the extent of the frond, which are conditioned by the shape of the substratum. As a matter of fact the frond is more regularly developed on broader or more foliaceous host plants than the *Cystosira discors* in question. The cells of the said form are partly squarish, partly and more fre

quently of a length $1^1/_2$ the breadth, being 12—18 μ long and 9—15 μ broad. In a vertical section the basal cells are partly squarish, partly slightly horizontally or vertically elongated, 8—14 μ in diameter. The heterocysts are 22—36 μ long and 12—18 μ broad. In specimens from other places and on other host plants, I have found the cells partly being a little smaller than the said measures (e. g. once on *Fucus vesiculosus*), partly a little larger (e. g. on *Zostera*), the length being twice, and exceptionally even twice and a half the breadth, up to about 24 μ long and up to 18 μ broad. Also the heterocysts will become larger or up to 40 μ long and up to 30 μ broad, though they are mostly smaller. They are rather varying, partly rather narrow proportionally to the length, partly very broad and both in f. *typica* and in f. *callithamnioides* occasionally almost circular in shape. The latter partly appear in large numbers, partly they may be few in number and hardly traceable. The solitary small cortical cells are frequently semicircular and distinct, sometimes, however, rather indistinct and resembling those of *M. Lejolisii*. The conceptacles of sporangia and cystocarps are hemispherical, sometimes hemispheric-conical, scattered or somewhat crowded, 140—200 or up to 250 μ in diameter. The sporangia are four-parted, 50—90 μ long and 30—50 μ broad. The conceptacles of antheridia are of the same shape as the preceding ones, but only 60—80 μ in diameter.

The form *borealis* is distinguished for a little coarser frond, which seems to be more incrusted with carbonate of lime than that of the typical form, and a little smoother. A new crust is often developed over the primary one, and of about the same extent as the latter. The cells are of about the same shape and size as f. *typica*. The conceptacles are, as a general rule, larger, 200—300 μ in diameter.

I have found f. *borealis* at Roundstone on the West coast of Ireland, growing scantily on *Gigartina mamillosa* and on the leaf of *Laminaria saccharina*, partly associated with *M. Lejolisii*. Its occurrence on the coasts of Denmark, Norway and Sweden is unsure, the form occurring there perhaps belong wholly or in part to *M. Lejolisii*. From Denmark (Nykjöbing Mors) I have thus

only seen two small crusts of about 4 mm. in diameter, growing together with *Lithoph. macrocarpum* on *Fucus vesiculosus*. In habit they resemble *M. farinosa* f. *borealis*. The cells, on the contrary, are smaller than usual, 9—15 μ long and 9—11 μ broad, recalling *M. Lejolisii*, whereas the cortical cells are larger than usual in the said species. I have seen no heterocysts. As to the conceptacles, they are partly of almost the same shape as those of *M. farinosa* f. *borealis*, 225—300 μ in diameter, partly approaching those of *M. Lejolisii* f. *limitata*. The orifice of the conceptacles is not ciliated, but on this fact scarcely any stress can be laid. Particulars are to be found under *M. Lejolisii*. The same is the case with specimens from the coast of Norway growing on *Chondrus* and *Phyllophora* together with *Lithoth. membranaceum*. The conceptacles, however, are here in part smaller than in f. *borealis*, while the crust resembles this form in habit. Also from the coast of Sweden (Koster) there are some similar small specimens which approach *M. Lejolisii* f. *limitata* in habit. Here, however, the cells are longer than in the Danish and Norwegian ones mentioned above; thus in this respect they are corresponding with the typical specimen; heterocysts, on the other hand, have not been found. The material I have in hand is very little, so that I can not yet decide whether the specimens in question are perhaps only extreme forms of *M. Lejolisii*, unquestionable specimens of which are found on the same host plants.

As to the f. *callithamnioides* admitted above, it appears to me to be an unquestionable form of *M. farinosa*. In my opinion it cannot be regarded as an independent species. In fact I have seen specimens absolutely running into the typical form. It is much varying and may be now slightly lacunose, now greatly so, or composed of cell-rows subdichotomous or dichotomous-radiating. I have sometimes also seen typical *M. farinosa* scantily lacunose. A corresponding state of things is found in *M. minutula*. The same is the case particularly with young specimens of *Lithoph. zonale*, but less emphatically.[1]) The cells of f. *callithamnioides*

[1]) Cp. Foslie. Rem. Melob. Herb. Crouan p. 4.

show about the same size and almost the same condition of things as those of f. *typica*. They may, however, be now a little shorter, now a little longer than usual in the said form, and the corners are often more or less rounded. The conceptacles are also of the same size as in f. *typica*, but they are of scarce occurrence. The form is mostly sterile.

As already observed by Mr. Rosanoff, this species occurs on very heterogeneous substrata, particularly on a series of other algæ. It is often found abundant also on eelgrass *(Zostera, Thalassia, Cymodocea, Poseidonia* or *Enalis)* except in cold boreal areas, where it is replaced on *Zostera* by *M. Lejolisii*. The form *callithamnioides* has been met with on *Peyssonnelia* and several other algæ, on chitine tubes of hydroids and on tubes of *Serpula* among specimens of *Cladophora prolifera* and *Corallina rubens* from the Adriatic. On the hydroids it was found partly associated with *Lithoph. macrocarpum* (or *L. pustulatum*). One of these species frequently accompanies *M. farinosa* in warm or warm-boreal areas, but farther to the north, where *M. farinosa* does not occur, it accompanies *M. Lejolisii*. Sometimes, however, both the species last mentioned or even all the three species are found growing gregariously on the same substratum, e. g. on the West coast of Ireland and in the Mediterranean. Thus in the former place *M. farinosa* f. *borealis* partly occurs associated with *M. Lejolisii* and *Lithoph. pustulatum* on *Gigartina mamillosa*, and the two species first mentioned are found gregariously on the leaf of *Laminaria saccharina*. The form distributed by Mr. Holmes in Alg. Brit. rar. exsicc. under the name of *Melobesia myriocarpa* on the leaf of *L. saccharina* from Weymouth also embraces both species, in conformity with a specimen communicated to me by Mr. Batters. In more southern areas both species sometimes grow gregariously also on *Zostera*. This is e. g. the case with the alga from Ancona distributed by Mr. *Caldesi*, admitted in Erbar. Crittog. Ital. no. 127 (1127) and in Rabenhorst Algen Europas No. 1676 under the name of *Melobesia verrucata*. At any rate it includes partly both *M. farinosa* and *M. Lejolisii*. Among algæ worth noting on which the typical form of the species in

question is growing, I will mention *Chætomorpha* sp. from Porto Rico (Howe!) The cells are here a little smaller, and the conceptacles are a little lower than usual. It, therefore, somewhat approaches *M. Lejolisii,* but as it bears heterocysts, it must be referred to *M. farinosa.* Therefore, I think it likely that the *M. confervicola* from Guadeloupe admitted by Mssrs. Mazé and Schram[1]) and Mr. Murray[2]) also belongs to this species.

The species seems mostly to occur in the upper part of the sublitoral region and to prefer localities fairly sheltered. It bears reproductive organs during the whole of the year.

Area: The typical form of the species is distributed in boreal and tropical areas: On the Atlantic coast of Europe as far to the north as Cherbourg and the southern part of the British Isles[3]); the Mediterranean and the Adriatic; on the Atlantic coast of North America as far to the north as Wood's Holl, Mass. Its occurrence southward in the South Atlantic is not exactly known. It also occurs in the Red Sea, and in the Indian and the Pacific Oceans it is widely dispersed, especially in the former, e. g. on the East coast of Africa, at Mauritius, in the Gulf of Siam, in the Malayan archipelago. But specimens typically developed are not yet known from the Pacific coasts of America, and its northern and southern limits here are at present uncertain.

The form *borealis* is only known from Roundstone on the West coast of Ireland(!); Denmark: Nyköbing Mors (Rosen-

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1) Mazé et Schram. Essai de classification des Algues de la Guadeloupe. Basse Terre 1870—1877.

2) George Murray. Catalogue of the Marine Algæ of the West Indian Region. Journal of Botany 1888—1889. Pag. 21.

3) The distribution to the north along the British Isles is unknown to me. It is recorded by Batters, Catal. of Brit. Mar. Alg. (1902), p. 96, as being not uncommon on the coasts of the British Isles. It seems doubtful to me that the alga should occur even as far to the north as to the north of Scotland. On the other hand, it is possible that f. *typica* appears as far to the north as on the coasts of Denmark and on the south coast of Norway. It does not, however, occur among the large material I have examined from Denmark, so that it is likely to be here contingently of rare occurrence.

vinge!)?[1]); Sweden: Koster (Bovallius and Kjellman!)?[1]) Norway: Hvalöerne(!)?[1]).

The form *callithamnioides* is known from the Mediterranean (Falkenberg, Solms Laubach, Berthold), the Adriatic (Hauck, Wille!), Rhodes (Nemetz sec. Reinbold)[2]); the Canary Islands: Teneriffe (Sauvageau!); the West Indies: Bahamas (Howe!)[3]).

Subgen. **Heteroderma** Fosl.

Syst. Surv, Lithoth. (1898), p. 6, Alg. Not. (1904), p. 3; char. mut.

Frond monostromatic with or without solitary small cortical cells, except around the conceptacles.

2. *Melobesia Lejolisii* Rosan.

Rech. Melob. (1866), p. 62.

f. *typica.*

M. Lejolisii Rosan. l. c. p. 62, pl. I, fig. 1—13; pl. VII, fig. 9—11.

Conceptacles of sporangia and cystocarps crowded, convex or subhemispherical, 150—250 (300) μ in diameter.

f. *limitata* Fosl. mscr.

Conceptacles of sporangia and cystocarps subhemispheric-conical, less crowded than in the typical form.

Syn: Melobesia membranacea Aresch. Phyc. Scand. (1846), p. 289 et in J. Ag. Spec. Alg. 2. (1852), p. 512, partim; Harv. Phyc. Brit. (1846—51), pl. 347 A; Le Jol. Liste Alg. Cherb. (1863), p. 150, partim! Crouan. Alg. mar. Finist, no. 244, Fl. Finist. (1867), p. 150! Kleen, Nordl. Alg. (1874), p. 11? Magnus,

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[1]) As above remarked, the specimens from these places are uncertain and perhaps belonging to *M. Lejolisii.*

[2]) Th. Reinbold. Meeresalgen von der Insel Rhodos. Gesammelt von Lehrer J. Nemetz. Hedwigia. Bd. XXXVII. 1898. Pag. 90.

[3]) The occurrence of f. *callithamnioides* on the south coast of England seems doubtful to me. Cp. Batters, A Catalogue of the British Marine Algæ (1902). Pag. 96. I have a sterile specimen from Mr. Batters' herbarium under the name of *M. callithamnioides* collected at Plymouth, which in my opinion represents a young *Lithoph. zonale.* Cp. Crouan in Ann. Sc. Natur. Ser. 4. Bot. T. XII. Paris 1859. Pl. 21, fig. C. 15. This form of *Lithoph. zonale* and *M. farinosa* f. *callithamnioides* as well as *M. minutula* f. *lacunosa* approach each other in habit.

Nordseef. (1874), p. 70! Kjellm. N. Ish. Algfl. (1883), p. 137? Batt. Cat. Brit. Alg. (1902), p. 97, partim?

Melobesia farinosa Kütz. Spec. Alg. (1849), p. 696, partim, Tab. Phyc. XIX (1869), p. 34, t. 95, cfr. Rosan. Rech. Melob. p. 62; Le Jol. Liste Alg. Cherb. (1863), p. 150! Crn. Fl. Finist. (1867), p. 150, partim; Aresch. Obs. Phyc. III (1875), p. 4! Reinke, Algenfl. westl. Ostsee (1889), p. 32!

Lithophyllum pustulatum Le Jol. Liste Alg. Cherb. (1863), p. 151, partim!

Hapalidium confervicola Magnus, Nordseef. (1874), p. 70.

Melobesia Lejolisii Aresch. Obs. Phyc. III (1875), p. 3! Farl. Mar. Alg. New. Engl. (1881), p. 180! Solms, Corall. Monogr. (1881), p. 11; Ardiss. Phyc. Medit. I (1883), p. 445; Hauck, Meeresalg. (1885), p. 264, fig. 108; Weber-van Bosse, Bijdr. Algenfl. Nederl. (1886), p. 3, fig. 1; Reinke, Algenfl. westl. Ostsee (1889), p. 32; Debr. Cat. Alg. Maroc. etc. (1897), p. 72! Batt. Cat. Brit. Alg. (1902), p. 96; De Toni, Syll. Alg. IV (1905), p. 1766.

I take the typical form of the species as it is described l. c., at first forming small orbicular patches or irregularly flabellate ones, which gradually become densely confluent. The cells are frequently smaller, as well as shorter in proportion to the breadth, than in *M. farinosa.* They are partly squarish, partly of a length $1^1/_4$ or up to about $1^1/_2$ the breadth, being 8—15 μ long and 7—10 μ broad, occasionally a little larger. The cortical cells are very small, but rather varying and sometimes approaching those of *M. farinosa,* in which they are frequently a little larger and more regularly semicircular. The last cell before a beginning dichotomy is often hyaline here and there in the frond, and partly larger than the adjacent cells. It sometimes greatly reminds of the heterocysts in *M. farinosa,* and under slight magnifying it may easily be confounded with such ones. In a vertical section the basal cells resemble those in the said species, but they are frequently slightly smaller, partly squarish, partly a little vertically, seldom horizontally, elongated, 7—12 μ in diameter. In old specimens, and particularly in such ones with crowded conceptacles, the greater part of the frond is composed of 2—4 layers of cells, or new crusts are developed over the primary one. Therefore, the monostromatic part of the frond is generally smaller in this species than in *M. farinosa.* The conceptacles of sporangia and cystocarps are convex or subhemispherical, frequently crowded, and almost confluent, 150—250 (300) μ in diameter. The conceptacles of antheridia are 75—100 μ

in diameter. In young specimens or in feebly developed ones, the conceptacles may be very low and only slightly rising above the surface of the frond. The sporangia are tetrasporic, 50—80 μ long and 30—50 μ broad. I have sometimes seen bisporic sporangia which seemed to be fully developed, and which occurred in the same conceptacle as the tetrasporic ones.

The form *limitata* is characterized by smoother and apparently more solid crusts, which seem to be more incrusted with carbonate of lime than in the typical form. Besides, it is generally more regular in outline than the said form. As to structure, it agrees with the typical form. The conceptacles, on the other hand, are less crowded, often rather scattered, of about the same diameter as those of the said form. But they are frequently a little higher and somewhat pointed or subhemispheric-conical and more sharply defined.

It has been stated by Mr. Rosanoff l. c. that in *M. Lejolisii* the cells surrounding the orifice of the conceptacles are elongated, forming a corona. Concerning *M. farinosa* is, on the other hand, stated: „L'ostiole est entouré de cellules un peu allongées et un peu relevées, mais qui ne forment jamais une couronne sembable à celle du *M. Lejolisii*." I have seen conceptacles in *M. Lejolisii* whose orifices are only subciliate and in all essentials resembling the picture given by Mr. Rosanoff l. c. pl. I, fig. 8, with the cells 10—12 μ long. As to the said picture, Mr. Rosanoff, however, declares l. c. p. 104 that „la couronne de poils n'est pas encore formée." The sporangia, however, seem to have been fully developed so that the conceptacle appears rather to have been on the point of decomposition than not fully developed in any direction. On the other hand, there is l. c. fig. 11 a picture of a corona, alleged to be a typical one, the upper part of which is falling to decay. I have examined a great number of specimens of this species, among which several distributed by M. Le Jolis. But I have not been able to find such a corona as the last mentioned one. This is perhaps owing to the fact that I have only had dried material for examination, or it may be that the cells of the corona have a short phase of development and are soon falling

to decay. In dried specimens of *Melobesia coronata,* however, is partly found a distinct corona, in all essentials consistent with the picture given by Mr. Rosanoff l. c. pl. IV, fig. 9.[1]) Among the said conceptacles in *M. Lejolisii* it is those of sporangia whose cells around the orifice are 10—12 μ long, while those of cystocarps mostly seem to be shorter. Perhaps it is the conceptacles last mentioned which are in a certain phase of development carrying the corona described by Mr. Rosanoff. In the *M. farinosa* the state of things is nearly the same as that of *M. Lejolisii* described above, the corresponding cells of some conceptacles, however, being 15—18 μ long.

As I already observed under *M. farinosa,* these two species are easily confounded one with the other, when they are not well developed. The same is the case habitually with young or feebly developed specimens of *Lithophyllum (Dermatolithon) pustulatum* (or *L. macrocarpum*) and *M. Lejolisii,* which are often growing gregariously on the same substratum. As is besides evident from the synonyms, and as I have already observed under *Lithoth. membranaceum, M. Lejolisii* has partly been referred to this species. This even appears to have been done by Mr. Rosanoff himself. Cp. above under the said species. Mr. Rosanoff declares l. c. that *M. Lejolisii* occurs at Cherbourg on *Zostera* and on *Bornetia,* but is not known on other algæ. The form distributed by M. Le Jolis under no. 240 by the name of *M. pustulata,* however, essentially represents *M. Lejolisii* and small crusts of *L. membranaceum.* I have examined two specimens of the no. mentioned, and one of them also includes a minute crust which has not been closely examined, but which is likely to belong to *L. pustulatum* (or *L. macrocarpum*). The species in question and *Lithoth. membranaceum,* however, are, as a general rule, easily recognizable, if they are not growing together on the same substratum and *L. membranaceum* only carrying conceptacles of cysto-

[1]) In Siboga Exp. LXI, p. 57 I have written that the conceptacles of cystocarps have no corona. This is a misstatement owing to a lapsus calami. All the conceptacles examined in a dried specimen had a ciliated orifice, but in some of them the cells mentioned are rather short.

carps. They may sometimes be confounded, when *M. Lejolisii* is growing over *L. membranaceum* or a new crust of the latter species is partly extending over an older one so as to give the alga a somewhat solid appearance. The structure, however, of these two species is different. Among recent authors who seem to have referred forms of *M. Lejolisii* to *L. membranaceum,* I will mention Mr. Kleen l. c., being of interest from a phytogeographical point of view. Unfortunately there is, according to the liberal communications of Professor Kjellman, found no specimen in his herbarium. He declares, however, l. c. that the species grows on *Fucus vesiculosus* f. *vadorum.* As far as I have seen, *L. membranaceum* does not occur, on *Fucus,* while, on the contrary, this is often the case with *M. Lejolisii* and *Lithoph. macrocarpum* in northern areas. Both the species last mentioned, besides, appear to be dispersed more to the north than *L. membranaceum.*

As to host plant, *M. Lejolisii* is somewhat more circumscribed than *M. farinosa,* as it does not occur on so many different plants as the latter. This is, however, only in part due to the fact that its area is smaller. It occurs most frequently in northern areas, where it often takes the place of *M. farinosa,* e. g. on *Zostera.* It appears particularly growing on this plant. But it is also found on the leaf of *Laminaria,* on *Chondrus, Gigartina, Furcellaria, Fucus* and others. On the coast of Denmark it has even been found scantily and feebly developed on *Ruppia.* Besides it seems to be a form of this species which scantily occurs on *Corallina rubens* at Alger (Debray!). The cells of the latter are small with minute cortical cells. The conceptacles are about 140 μ in diameter and are in shape approaching partly those of *M. farinosa,* partly those of typical *M. Lejolisii.* A similar form occurring on *Polysiphonia violacea* has been collected to the south east of Bragerne in the Skager Rack (Rosenvinge!). It forms minute crusts on the branches, sometimes surrounding a part of a branch, or extending over two branches closely connected, occasionally even covering parts of the cystocarps of the said host. The crusts are always less than 1 mm. in diameter or in length. The alga is scantily provided with conceptacles (of cystocarps?), which are

100—140 μ in diameter and, in shape, intermediate between typically developed ones of *M. farinosa* and typically developed ones of *M. Lejolisii,* or most nearly akin to those of the latter species. The form greatly resembles *M. minutula.* The conceptacles are but little larger than usual in the latter species, and also as to structure they come very near to each other. However, I refer this form to *M. Lejolisii,* because it is more incrusted with carbonate of lime than *M. minutula,* the cells are mostly squarish and the cortical cells are found almost everywhere. Besides occur several of the hyaline cells mentioned above, which are frequently appearing in *M. Lejolisii.*

Like *M. farinosa* this species seems to occur in the upper part of the sublitoral region and to prefer places fairly sheltered. At Fredriksværn on the southern coast of Norway I found specimens fairly well developed on dead *Zostera* lying loose at the bottom in a depth of 7—10 fathoms. It is furnished with reproductive organs throughout the year.

Area: Norway: Nordland (Kleen)? From Espevær southward! Sweden: West coast! Denmark! Western Baltic! The British Isles! Atlantic coast of France! The Mediterranean! The Adriatic! Atlantic coast of North America: Key West of Florida (Howe!)[1]; Massachusetts (Farlow, Collins!)[2].

3. *Melobesia minutula* Fosl.

Alg. not. (1904), p. 8.

f. *typica.*

Frond forming patches small and irregular on hydroids, com-

[1] The form occurring in this place is not quite certain. It appears on *Thalassia* and is like an old *M. Lejolisii* in habit and as to the conceptacles, which, however, are frequently a little smaller than usual in this species. The cells, on the other hand, are a little longer than usual, up to about 20 μ. The cortical cells partly approach those of *M. farinosa.* I have found no heterocysts. I, therefore, think it to be a somewhat extreme form of *M. Lejolisii.*

[2] As to the supposed occurrence of this species in Greenland, according to Kjellman, N. Ish. Algfl. p. 137, compare Rosenvinge, Grönl. Havalg. p. 781. Besides, concerning the questionable form from Spitzbergen mentioned by Kjellman l. c., compare below under *Lithophyllum Crouani.*

posed of a solitary layer of cells except around the conceptacles, frequently destitute of small cortical cells; conceptacles of sporangia and cystocarps hemispherical, 75—120 μ in diameter.

f. *lacunosa* Fosl. mscr.

Descr. M. minutula l. c.

Syn: Lithocystis Allmanni Harv. Phyc. Brit. (1846—51), pl. 166?

Melobesia inæquilaterata Solms, Corall. Monogr. (1881), pl. 12, t. III, fig. 13—18?

Lithothamnion (Epilithon) Van Heurckii Heydr. in Chalon, Liste Alg. Mar. (1905), p. 207, fig. 1—5?

The form of the species which I described l. c. (the f. *lacunosa* recorded above) corresponds to f. *callithamnioides* of *M. farinosa,* and to a form of *Lithophyllum zonale* which is almost similar, but young. In sterile state it is almost undistinguishable from the form first mentioned. As a general rule, however, the cells are smaller. It occurred sparely in the upper part of the branches of *Corallina officinalis,* partly also on small tubes of *Serpula* attached to *Corallina,* and was found at Hvalöerne on the southern coast of Norway. The alga is difficult to be discovered, particularly in sterile state, and is easily overgrown by other algæ, e. g. *Lithophyllum macrocarpum.* It forms indistinct patches, not or feebly incrusted with carbonate of lime, of irregular shape, lacunose or with narrower or broader shoots, now and then consisting of a single row of cells. Sometimes the essential part of the plant is composed of subdichotomous cell-rows. It is monostromatic, except quite a small part round the conceptacles. When looked on from the surface, the cells are partly squarish, 6—12 μ in diameter, partly of a length being $1^1/_4$ or even $1^1/_2$ of the breadth, or being up to 14 μ long. In a vertical section the cells are now squarish, 6—8 μ in diameter, now — and more frequently — horizontally elongated, and up to about 14 μ long. Small cortical cells mostly seem to be wanting. The conceptacles of sporangia resemble the conceptacles of antheridia in *M. farinosa,* and are of about the same size as the latter, or 75—120 μ in diameter, with a single orifice. The sporangia are bisporic, 40—50 μ long and 20—25 μ broad. The form is, therefore, easily confounded

with specimens carrying antheridia of *M. farinosa,* partly even with *M. Lejolisii,* when growing on the same substratum as either of these species. It bore ripe sporangia at the end of July.

Among some Melobesiæ from the West coast of Sweden, which Professor Kjellman kindly sent to me for examination, the species in question was found, but also here very scarcely. Thus a few crusts occurred on a piece of a leaf of *Laminaria,* taken at Koster, not far from Hvalöerne, which were partly representing typical f. *lacunosa,* partly a transition to f. *typica.* The species here appeared associated with or partly overgrown by a *Melobesia* perhaps belonging to *M. farinosa* f. *borealis.* Cp. above under the latter. The alga here carried conceptacles of 80—100 μ in diameter with ripe, bisporic sporangia at the end of May, 30—35 μ long and 20—25 μ broad. A similar form of the species occurred very scarcely on a piece of the leaf of *Laminaria hyperborea* labelled „Bohuslän" without any further statement of locality. Here it was partly overgrown by a form of *M. Lejolisii* which very nearly approaches f. *limitata,* and which carried conceptacles of about the same size as those mentioned above, with ripe carpospores.

In the same locality at Hvalöerne in which f. *lacunosa* was found, I afterwards met with the form which I have above denominated f. *typica.* It occurred very sparely on chitine tubes of hydroids attached to other algæ. It was sterile, when collected. The same form, however, was found in fertile state among some Melobesiæ from Denmark which Dr. Kolderup Rosenvinge kindly sent to me for examination. It also here appeared on hydroids attached to *Polysiphonia elongata,* collected at Tönneberg Banke. This form stands in the same relation to the f. *lacunosa* above mentioned as *M. farinosa* f. *typica* to f. *callithamnioides.* Therefore, it seems to me that both forms ougth to be considered as belonging to one and the same species, even though they are sometimes somewhat diverging from each other. The form last met with must have to be considered as the typical form of the species. No particular stress needs to be laid on the fact that this form has hitherto been found only on chitine tubes of hydroids,

and f. *lacunosa* only on other algæ. As a matter of fact, both *Melobesia farinosa* and *Lithophyllum pustulatum* have been found on substrata quite as different. In f. *typica* the cells are on an average a little larger than in the specimens hitherto known of f. *lacunosa* (which are very few), but they do not, however, exceed the maximum measures stated for this form. Cortical cells generally seem to be wanting. I have only found a few inconsiderable ones, which resemble the smallest cortical cells in *M. Lejolisii.* The reproductive organs in both forms coincide with each other.

As to the questionable synonyms recorded, it is to be observed that I have earlier supposed that *Melobesia inæquilaterata* Solms might belong to *Lithoth. membranaceum* or to *Melobesia farinosa.* Cp. Rem. Melob. Herb. Crouan, p. 7. The said alga, of course, cannot be identified with certainty, as the specimens which underlie the description and the pictures l. c. are sterile and quite young. However, I do not think it precluded that it should be identical with *M. minutula,* as it is indicated to want cortical cells, and such ones seem to be of rare occurrence in *M. minutula.* Besides the cells in a vertical section are often horizontally elongated.

The same is the case of *Lithocystis Allmanni* Harv. The magnified crust l. c. fig. 2 greatly recalls *M. minutula* f. *typica.* The description, on the contrary, is only in part consistent with the species in question.

As to *Lithothamnion Van Heurckii,* Dr. H. Van Heurck, on my application, most kindly sent both specimens and preparations of this alga to me to be examined. It proves to be completely consistent with *M. minutula* f. *typica* in structure as well as in the form and the size of the conceptacles. The frond l. c. is stated to be „çomposé d'une couche de cellules quadratiques, ayant de 6 à 8 ou de 8 à 8 μ de diamètre, et est pourou de cellules corticales très plates, qui sont complètement enfoncées dans les grandes, et qui couvrent la moitié de la grande." According to my measures the cells are of about the same size as those of the Danish specimens above mentioned of *M. minutula* f. *typica,* though in part oftener elongated in the direction of the radius, up to about 18 μ long, and the length being up to $1^1/_2$ the breadth.

As far as I have seen, the cortical cells show the same state of things as in the species mentioned. As to reproductive organs the following statement is found l. c.: „Les tétraspores, divisées transversalement en deux, se trouvent dans les conceptacles soriformes de 80 à 100 μ de diamètre, qui renferment 7—8 tétrasporanges et ont autant de pores (fig. 2 et 3); ces conceptacles sont parfaitement sphériques." I have not had the opportunity of ascertaining the correctness of this statement, as most of the conceptacles I have examined were empty. I have found two conceptacles with a single orifice. But I have not been able to determine whether they represent conceptacles of sporangia. I should think it likely that the species is identical with *M. minutula* f. *typica*.

The species in question on one hand approaches *M. farinosa*. Particularly f. *lacunosa* bears a considerable resemblance to f. *callithamnioides* of the latter species. On the other hand the species is more closely connected with *M. Lejolisii*, and when the conceptacles are a little lower than typically developed ones, *M. minutula* is hardly distinguishable from stunted forms with small conceptacles of the said species. The basal cells, however, in a transverse section are more frequently horizontally elongated, and comparatively more so, in *M. minutula* than in *M. Lejolisii;* the cortical cells are few, and the alga is not incrusted or but little incrusted with carbonate of lime. Cp. under *M. Lejolisii*.

Area: South coast of Norway: Hvalöerne, f. *typica*, f. *lacunosa* (!); West coast of Sweden: Koster, f. *lacunosa* (Bovallius and Kjellman!); Denmark: Tönneberg Banke, f. *typica* (Rosenvinge!); Jersey (Van Heurck)? Ireland: Dublin Bay (Allmann, Harvey)? The Mediterranean (Solms Laubach)?

Lithophyllum Phil.

Wiegm. Arch. Jahrg. 3, Bd. 1 (1837), p. 387; Fosl. Syst. Surv. Lithoth, (1898), p. 5, Rev. Syst. Surv. Melob. (1900), p. 10; De Toni, Syll. Alg. IV (1905). p. 1778; char. mut.

Subgen. **Eulithophyllum** Fosl.

Rev. Syst. Surv. Melob. (1900), p. 17; De Toni l. c.

1. *Lithophyllum orbiculatum* Fosl.

Rev. Syst. Surv. Melob. (1900), p. 19; Lithothamnion orbiculatum Fosl. Norw. Lithoth. (1895), p. 143, t. 22, fig. 10—11; Batt. Cat. Brit. Mar. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1786.

Syn: Lithophyllum incrustans f. orbiculata Fosl. in Setch. and Gardn. Alg. Northw. Amer. (1903), p. 358(?).

This species forms small orbicular crusts at a young stage or often even at a stage advanced, finally, however, becoming more or less confluent. It is firmly attached to the substratum, and attains a thickness of about 1,5 mm., but usually less. It is in fact crustaceous. Sometimes, however, occur excrescences small and irregular, partly even slightly angular, but they seem always to have been formed by covering up and growing over foreign bodies.

In a vertical section of a crust the hypothallic layer mainly resembles that of *Lithoth. læve*. It is rather feebly developed, and the convergence of the lower anticlines towards the substratum is feeble or wanting. The cells of this layer are of a length twice to four times the breadth, being 12—25 μ long and 5—8 μ broad. The perithallic layer is composed of squarish cells 6—9 μ in diameter, or, more frequently, a little vertically elongated, 9—14 or up to 18 μ long, by 7—11 μ broad. They are, however, here and there slightly elongated in horizontal direction. Be it said, I have examined but a few sections of small crusts, and in other ones the cells perhaps are larger.

The conceptacles of sporangia are immersed, at first slightly convex and about 100—200 μ in diameter, finally slightly decorticated, forming shallow, point-like holes, the bottom of which forms a part of the roof, intersected with a single pore. The sporangia are tetrasporic, 100—160 μ long and 45—60 μ broad. The conceptacles of cystocarps in this species as in many other species appear in other crusts than those of sporangia, but when the crusts

get confluent, it often looks as if both the said kinds of reproductive organs are developed in one and the same crust. They are more distinct and frequently a little larger than the last named ones, slightly more rising above the surface of the frond, indistinctly convex or sometimes almost disc-shaped, but less distinctly visible than in several other species, 200—300 μ in diameter, with a single orifice. I have seen only a few ones, which probably also are by and by decorticated. I have not seen those of antheridia. The conceptacles do not become gradually overgrown, as far as hitherto seen. The roofs frequently falls to decay, and the scars from the conceptacles are gradually effaced by new-formed tissue.

It is questionable whether this species represents something more than a northern form of *Lithoph. incrustans*. On the coast of Norway it is well marked, but on the coasts of the British Isles it seems to be difficult to draw the line, as *L. incrustans* f. *depressa* apparently assumes forms which are hardly distinguishable from *L. orbiculatum*. I have e. g. collected such a form at Roundstone on the west coast of Ireland, occurring here in rock-pools in the litoral region. However, *L. incrustans* f. *depressa* does not at first form orbicular crusts, but always rather extended and irregular ones, and the surface is less even than in *L. orbiculatum*. Besides, the cells seem usually to be smaller in the latter than in the former species. It is, however, to be observed that specimens of both species approaching each other are as yet too little known and compared. The species in question also approaches *Lithoph. Crouani*. On the other hand, specimens of this species appearing on the coasts of Norway and Denmark are very easily confounded with *Phym. compactum*, when it is sterile, or when the conceptacles are not well developed, as in the latter species the conceptacles of sporangia are often of about the same diameter as in *Lithoph. orbiculatum*, the impressed part of the roof, however, being intersected with a few muciferous canals, though in a certain stage to a cursory view it sometimes appears to be traversed by a single pore. Thus a stunted form collected at Fæö near Haugesund bears a striking resemblance to young

specimens of *Ph. compactum*. Among the specimens examined from the coast of Denmark, a specimen from Læsö also bears a great resemblance in habit to *Ph. compactum* f. *testacea*, with conceptacles smaller than usual in *L. orbiculatum*, and in this respect standing in the same relation to specimens typically developed as f. *testacea* stands to a *Ph. compactum* typically developed. Specimens from the south part of the Cattegat much resemble young specimens of *Ph. compactum* f. *coalescens*. However, I succeeded at length in finding characteristic conceptacles and sporangia. Besides, the cells are usually smaller than in the species last named. The alga in question sometimes also approaches in habit *Ph. lævigatum* and certain forms of *Ph. polymorphum*.

Lithoph. orbiculatum occurs in the upper part of the sublitoral region, attached to rocks or stones, in exposed localities occasionally also in rock-pools in the litoral region, e. g. Fæö near Haugesund. The best developed specimens I have seen I found at Tusteren in a depth of 1—3 fathoms, rather abundant and partly growing in company with a stunted form of *Lithoth. Lenormandi*. On the coasts of Denmark, where solitary specimens are known from six places, it has been collected in depths from 2 to 15 fathoms, partly covering *Phym. lævigatum*, partly and particularly sharing substratum with *Lithoth. Granii*. The species is sparingly furnished with reproductive organs in the months of May and August—September.

As to the synonymy and the geographical distribution of this species is to be remarked that I got a number of calcareous algæ some years ago from Port Renfrew (Port San Juan), Vancouver Island, B. C., collected and kindly communicated to me by Mr. K. Yendo. Among these are a few specimens which coincide in habit and structure partly with young specimens of *Lithoph. incrustans* f. *depressa*, partly with *L. orbiculatum*. Therefore, I mentioned in lit. this species as a form of *L. incrustans*. The said form often grows together with another calcareous alga, or one covering the other in various ways. However, as the said specimens are sterile, and as I have lately seen how one species often approaches another both in habit and in structure, I now do

not venture to admit the species in question from that place, the less so because the calcareous algæ from the north-west coast of North America are as yet but very little known.[1])

Area: Norway: Kristiansund, N. (Ekman!), Tusteren north of Kristiansund, N. (!), and at Fæö near Haugesund (!); Denmark (Rosenvinge!); England: North-east coast: Robin Hood's Bay of Yorkshire (Holmes!); Scotland: South-west coast: Kyles of Bute, Arran, Seamill, Saltcoast (Batters, Holmes!).[2])

2. *Lithophyllum Crouani* Fosl.

Some new or crit. Lithoth. (1898), p. 17, Rev. Syst. Surv. Melob. (1900), p. 19.

Syn: Melobesia Laminariæ Crn. Fl. Finist. (1867), p. 150, partim?

Melobesia pustulata Aresch. Obs. Phyc. 3 (1875), p. 3, partim!

Melobesia spec. Kjellm. Spetsb. Thall. (1875), p. 4, N. Ish. Algfl. (1883), p. 137?

Lithophyllum Crouani Jönss. Mar. Alg. Icel. I (1901), p. 154! Börg. Mar. Alg. Færöes (1902), p. 401! Batt. Catt. Brit. Mar. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1788.

The alga occurs on the stem and on the hapters of *Laminaria hyperborea* and *L. digitata.* It usually grows associated with *Lithoph. macrocarpum,* particularly on the coast of Norway, one often growing over the other, but it appears in smaller number than the latter. It forms crusts orbicular or suborbicular up to about 2 cm. in diameter by a thickness of up to 1.5 mm., frequently, however, less than 1 mm. The surface is even and sometimes slightly shining. — Once I found a curious, subsimple piece of a calcareous alga at Fæö near Haugesund in a depth of about 5 fathoms. It is about 2 cm. long and 4 mm. thick, provided with young conceptacles as in *Lithophyllum* and recalling a small and stunted *Lithoph. fasciculatum* (Lam.) Fosl. It proved, however, to be a piece probably of a *Lithothamnion (L. norvegicum?)* completely and firmly surrounded by a *Lithophyllum* much resem-

1) There are two or three other species in the said collection from Port Renfrew, but I have not yet succeeded in finding reproductive organs in any specimen.

2) As to a doubtful specimen from the Færöes and a similar one from Iceland perhaps belonging to this species, cp. under *Phymatolithon compactum.*

bling the species in question both in structure and in the said young conceptacles as well as in a number of grown-in ones, and likely being identic.

As to structure, the hypothallic cells in this species are partly short, partly elongated, 14—40, sometimes 50 μ long, by 9—14 μ. The perithallic cells are rather varying, now 10—20 μ long and 8—14 μ broad, now up to about 30 μ long. It is, however, to be observed that only a couple of sections have been examined.

The conceptacles of sporangia are immersed, not, or scarcely, raised above the surface of the frond, 90—130 μ in diameter, finally sligthly decorticated as in *L. orbiculatum,* with a single pore. In a median vertical section they are about 150 μ in diameter, judging from a few measures. The sporangia are four-parted, 70—100 μ long and 30—40 μ broad. The said conceptacles are gradually overgrown and are then to be seen in rows parallel to the surface of the frond.

As to the questionable synonymy recorded above, viz. *Melobesia* sp. admitted with doubt by Prof. Kjellman l. c. under *M. Lejolisii,* I have seen an authentic specimen from Spitzbergen. It forms a small crust composed of several layers of cells, and seems to me to belong either to the species in question or to be a form of *Ph. compactum*

This species is on one hand nearly related to *Lithoph. orbiculatum,* and on the other hand it approaches *Lithoph. macrocarpum* f. *Laminariæ.* Sterile specimens will be confounded with the latter, though they are less extented, usually thicker, less brittle and less decreasing in thickness towards to edge. Besides, the colour is in fresh specimens a rather pale purplish one, always paler than in *L. macrocarpum* f. *Laminariæ,* and the latter becomes usually a little darkish in drying, whereas on the contrary *L. Crouani* usually becomes lighter. In habit it also often recalls *Ph. compactum,* even if bearing young conceptacles.

The alga occurs mostly in a depth of 2—8 fathoms both on the open coast and in places rather sheltered in the fjords. It is scantily furnished with sporangia in the months of March and June—July.

Area: Norway: Kiberg near Vardö (!), Syltefjord (!), the North Cape (!), the Trondhjem Fjord (!), and from Fröien as far as Haugesund (!), Lister (Wittrock, Areschoug!); Iceland (Jönsson!); the Færöes (Börgesen!); Scotland: Berwick of Northumberland and Bute of Arran (Batters!); Ireland: Roundstone (!); France: Cherbourg (Le Jolis!).

Subgen. **Dermatolithon** Fosl.

Alg. Not. (1904), p. 3; gen. Dermatolithon Fosl. List of Lithoth. (1898), p. 11.

Lithophyllum pustulatum (Lamour.) Fosl.[1])

Alg. Not. (1904), p. 3; Melobesia pustulata Lamour. Polyp. flex. (1816), p. 315, pl. 12, fig. 2.

f. *australis* Fosl. mscr.[2])

Frond orbicular or reniform, then often confluent or becoming irregular, attached, edge sometimes free, 50—350 μ thick, composed of two or few layers of cells; conceptacles of sporangia and cystocarps subhemispheric-conical, 300 (250)—450 (500) μ in diameter; sporangia four-parted.

f. *intermedia* Fosl. mscr.

Frond as in the preceding form; conceptacles of sporangia and cystocarps hemispheric-conical or subconical, 300 (250)—450 (500) μ in diameter, sporangia two-parted.

f. *macrocarpa* (Rosan.) Fosl.

List of Lithoth. (1898), p. 11; Melobesia macrocarpa Rosan. Rech. Melob. (1866), p. 74, pl. IV, fig. 4—8, 11—20; Aresch. Obs. Phyc. III (1875), p. 2! Farl. New Eng. Alg. (1881), p. 180! Simm. Meeresalg. d. Færöer (1897), p. 268; Dermatolithon macrocarpum (f. faröensis) Fosl. Rem. Melob. Herb. Crouan. (1900), p. 15, Rev. Syst. Surv. Melob. (1900), p. 21; Börg. Mar. Alg. Færöes (1902), p. 401; De Toni, Syll. Alg. IV (1905), p. 1772.

Frond orbicular or reniform, then often confluent, attached, edge sometimes free, 100—600 μ thick; conceptacles of sporangia and cystocarps hemishperic-conical, 400—600 μ in diameter; sporangia two-parted.

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[1]) Cp. below under *Lithoph. macrocarpum*, p. 127—128.

[2]) I have not seen f. *crinita* Möb. (Notarisia 1892, p. 1441) from Malta. — Therefore I pass over it for the present.

f. *Corallinæ* (Crn.) Fosl. mscr.

Melobesia Corallinæ Crn. Fl. Finist. (1867), p. 150; Aresch. Obs. Phyc. III (1875), p. 2! Reinke, Algenfl. westl. Ostsee (1889), p. 31; Fosl. List of Lithoth. (1898), p. 11; Batt. Cat. Brit. Alg. (1902), p. 97; Dermatolithon Corallinæ Fosl. in Börg. Mar. Alg. Færöes (1902), p. 402.

Frond orbicular or irregular, sometimes buckler-shaped convex, or lumpy, edge sometimes free, 100—500 μ thick; conceptacles of sporangia and cystocarps convex or subhemispheric-conical, often not sharply marked, 250 (200)—450 (600) μ in diameter; sporangia two (and four?) parted.

f. *Laminariæ* (Crn.) Fosl. mscr.

Melobesia Laminariæ Crn. Fl. Finist. (1867), p. 150! Traill. Mar. Alg. Orkney (1890), p. 36; Reinke, Algenfl. westl. Ostsee (1899), p. 31; Simm. Meeresalg. d. Færöer (1897), p. 268; Melobesia macrocarpa Kleen, Nordl. Alg. (1874), p. 11; Kjellm. N. Ish. Algfl. (1883), p. 137; Strömf. Algveg. Isl. (1886), p. 23; Dermatolithon Laminariæ Fosl. Rem. Melob. Herb. Crouan (1900), p. 13; De Toni, Syll. Alg. IV (1905), p. 1772; Dermatolithon macrocarpum (f. Laminariæ) Fosl. Rev. Syst. Surv. Melob. (1900), p. 22; Jönss. Mar. Alg. Icel. I (1901), p. 154! Börg. Mar. Alg. Færöes (1902), p. 401! Batt. Cat. Brit. Alg. (1902), p. 97! Börg. Mar. Alg. Shetl. (1903), p. 6.

Frond orbicular, becoming confluent, 200—600 μ or up to 1 mm. thick; conceptacles of sporangia and cystocarps convex or subhemispheric-conical, 300—550 μ in diameter; sporangia two-parted.

Syn: Melobesia pustulata Harv. Phyc. Brit. (1846—51), pl. 347 D; Harv. Ner. Austr. (1847). p. 110? Kütz. Spec. Alg. (1849), p. 696, Tab. Phyc. XIX (1869), p. 33, t. 94; Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 513; Le Jol. Liste Alg. Cherb. (1863), p. 151, partim; Crn. Fl. Finist. (1867), p. 150, partim; Rosan. Rech. Melob. (1866), p. 72, pl. IV, fig. 2—3; Magnus, Nordseef. (1874), p. 70; Aresch. Obs. Phyc. III (1875), p. 3, partim! Farl. New Engl. Alg. (1881), p. 180; Solms, Corall. Monogr. (1881), p. 10; Ardiss. Phyc. Medit. I (1883), p. 446, partim; Hauck, Meeresalg. (1885), p. 265; Born. Alg. Schonsb. (1892), p. 188; Debr. Cat. Alg. Maroc. etc. (1897), p. 72!

Dermatolithon pustulatum Fosl. List of Lithoth. (1898), p. 11; Batt. Cat. Brit. Alg. (1902), p. 97; Fosl. Lithoth. Adr. Meer. etc. (1904), p. 38; De Toni, Syll. Alg. IV (1905), p. 1771.

Melobesia verrucata Lamour. Polyp. flex. (1816), p. 316, cfr. Rosan. Rech. Melob. p. 78; Kütz. Spec. Alg. (1849), p. 696 (excl. var.), Tab. Phyc. XIX, p. 34, t. 96 (partim); Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 513.

Melobesia opalina Zanard. Saggio (1843), p. 44?

Melobesia membranacea Kütz. Phyc. gener. (1843), p. 385, t. 78 I; Spec. Alg. (1849), p. 696; Tab. Phyc. XIX (1869), p. 33, t. 93!

Pneophyllum fragile Kütz. Phyc. gener. (1843), p. 385, Spec. Alg. (1849), p. 695, Tab. Phyc. XIX (1869), p. 33, t. 93; De Toni, Syll. Alg. IV (1905), p. 1712.

Phyllactidium confervicola Kütz. Phyc. gener. (1843), p. 295.

Melobesia grandiuscula Mont. Fl. Alg. (1846), p. 138, Syll. crypt. (1856), no. 1526; De Toni, Syll. Alg. IV (1905), p. 1770?

Hapalidium Phyllactidium Kütz. Spec. Alg. (1849), p. 695! Tab. Phyc. XIX (1869), p. 33, t. 92.

Melobesia frondosa var. incrustans Picc. Erbar. Crittog. Ital. no. 177 (1177)!

Hapalidium confervicola Aresch. in J. Ag. Spec. Alg. 2 (1852), p. 509; Ardiss. Phyc. Med. I (1883), p. 449; De Toni et Levi, Phyc. Ital. no. 15!

Melobesia confervicola Fosl. Rem. Melob. Herb. Crouan (1899), p. 7; De Toni, Syll. Alg. IV (1905), p. 1766.

Melobesia confinis Crn. Fl. Finist. (1867), p. 150, partim!

Peyssonnelia involvens Kütz. Tab. Phyc. XIX (1869), p. 31, t. 87! (Non Zanard).

Melobesia Cystosiræ Hauck, Meeresalg. (1885), p. 265, partim! De Toni, Syll. Alg. IV (1905), p. 1770.

Melobesia Corallinæ Solms, Corall. Monogr. (1881), p. 9, t. II, fig. 25, III, fig. 21—24; Hauck, Meeresalg. (1885), p. 266; Born. Alg. Schousb. (1892), p. 188; Debr. Cat. Alg. Maroc. etc. (1897), p. 72! De Toni, Syll. Alg. IV (1905), p. 1768.

Lithophyllum Corallinæ Heydr. Corall. insb. Melob. (1897), p. 47.

In the List of Lithoth. l. s. I stated *Melobesia macrocarpa* Rosan. as a form of *M. pustulata,* whereas in Rev. Syst. Surv. Melob. I admitted it as an independent species under *Dermatolithon.* I then mentioned that I had not seen any authentic specimen. Afterwards I have had the opportunity of examining such one. Cp. Rem. Melob. Herb. Crn. p. 14. However, I am not able to draw anything like a definite line between any of the forms stated above, most of which have formerly been looked upon as independent species. The shape an the thickness of the frond, the shape and the size of the cells, the shape and the size of the conceptacles are mutually much varying and numerous transitions may be pointed out from one form to another. The essential characteristic has been the parting of the sporangia. But even this criterion does not prove constant. Thus the forms *australis* and *intermedia*, stated above, are included in *Melobesia pustulata* in

the sense in which this species has been taken by most authors of late. It is an obvious conclusion that the species has actually included both four-parted sporangia and two-parted ones, though Rosanoff l. c. circumscribes it to including only specimens with sporangia four-parted. Nor does *M. macrocarpa* Rosan. always show bisporic sporangia. Thus Dr. Bornet has kindly communicated to me that in specimens of the said form growing on *Phyllophora* he has found partly bisporic sporangia, partly tetrasporic ones. Preparations with both kinds of sporangia have been kindly spared to me. The same is the case with *Melobesia Corallinæ*, in the sense in which it was formerly taken. Cp. Crouan, Solms Laubach and Hauck l. c. I have recently found both bisporic sporangia and tetrasporic ones in *Melobesia Cystosiræ* Hauck, which is partly referable to *L. pustulatum*, of which particulars are found below. It must also be observed that — as mentioned above — *Melobesia Lejolisii* seems to bear both bisporic sporangia and tetrasporic ones. According to this fact it is questionable whether the parting of sporangia can form any definite limit of species.

I have felt a doubt whether the name of *macrocarpa* Rosan. ought not to be bestowed upon the form which I have above denominated f. *intermedia*, although this form, as I have observed above, has formerly, at any rate in part, been referred to the series of forms of *M. pustulata*. In this case the denomination of *færöensis*, admitted in Rem. Melob. Herb. Crouan p. 15 and in Rev. Syst. Surv. Melob. p. 21 would have to be maintained for the form here designated as f. *macrocarpa*. The only authentic specimen which I have seen of *M. macrocarpa* Rosan. is intermediate between the said two forms. The crust is thin as in f. *intermedia*, but the conceptacles approach partly f. *færöensis*, partly f. *intermedia*, though they are mostly a little larger than in the last mentioned form. I therefore think it proper to admit and circumscribe the forms as I have done above.

The form *australis* is the most southern form of this species, and also the one which represents typical *L. pustulatum* in the main in the sense taken by Mr. Rosanoff l. c. It is rather varying. The frond is often very irregular, essentially dependent

on the shape and the quality of the substratum, and is mostly composed of a few layers of cells, often only 2 or 3. Sometimes, however, it can attain the same thickness as in f. *macrocarpa* or up to about 350 μ with up to 8 layers of cells. Particularly in *Zostera* and *Thalassia* the crust is, as a rule, very thin, and often only 1—3 mm. in diameter, even if it bears conceptacles. The conceptacles are then, for the most part, small and slightly developed. Peculiarly in southern areas the form very often grows associated with *Melobesia farinosa,* and, a little more to the north, with *Melobesia Lejolisii.* If it is not closely examined, it is easily confounded with coarser forms particularly of the species last mentioned. The conceptacles are also rather varying. They are almost always largest in crusts vigorously developed. The tetrasporic sporangia are 80—130 μ long and 30—70 μ broad.

The form *intermedia* is a more northern form than the last mentioned one. It is also much varying according to the quality of the substratum and most nearly approaches the f. *australis.* It is distinguished from the latter chiefly as to the shape of the conceptacles, which are generally more conic. The form, therefore, also nearly approaches the f. *macrocarpa* and is faintly defined against the latter. In northern areas the form often grows associated with *Melobesia Lejolisii,* and if it is not closely examined, it is easily confounded with coarser forms of the said species. The sporangia are bisporic, 60—120 μ long and 30—80 μ broad.

The form *macrocarpa,* as a rule, develops thicker crusts than any of the forms mentioned above, and it does not occur on so heterogenous substrata as those forms. It is best developed on algæ of fairly firm consistency, e. g. *Gigartina, Chondrus, Ascophyllum.* On *Phyllophora* it is rarely so vigorously developed as on the said algæ. It often encompasses branches of *Furcellaria,* in part also of *Ahnfeltia,* on which also the two forms last mentioned are sometimes found. As remarked above, it approaches f. *intermedia,* the crust only being thicker, the conceptacles larger and often a little lower proportionately to the diameter. The bisporic sporangia are 60—120 μ long and 30—60 μ broad.

The form *Corallinæ* I should be most inclined to put out as

a denominated form, referring it to each of the three forms last mentioned. Having, however, a comparatively small material of this form, peculiarly from the Mediterranean, I think I ought to admit it for the present as an independent one. It was first described by Crouan and stated by him as carrying bisporic sporangia, and this seems to be the case everywhere in the northern areas. The conceptacles of northern specimens partly approach or agree with those of f. *intermedia,* but are often less prominent and not so well defined as generally is the case with this form, partly correspond with those of f. *macrocarpa.* Thus on the west coast of Ireland I fell in with a form, growing on a coarse *Corallina officinalis,* whose conceptacles completely resembled those of f. *macrocarpa,* up to about 600 μ in diameter. On the other hand, it is rather probable that the form from the Mediterranean with tetrasporic sporangia, mentioned by Solms Laubach l. c. should be identical with f. *australis.* I have not yet fallen in with specimens with such sporangia. In the Adriatic Hauck mentions l. c. p. 266 and 575 that the alga appears now with tetrasporic sporangia, now with bisporic ones. Perhaps it is here identical with faintly developed specimens of f. *australis* and of f. *intermedia,* both of which occur in the same area. As far as I have seen, the form is always most vigorously developed, and the conceptacles grow largest on coarse specimens of the host plant, corresponding to the development of the forms *australis* and *intermedia* on different substrata. The bisporic sporangia are 60—110 μ long and 30—60 μ broad.

The form *Laminariæ* is the least varying form of this species. It very nearly approaches f. *macrocarpa* and is in the main distinguishable from this form only by the fact that the conceptacles are mostly somewhat lower, partly not well defined either. It occurs both on the stem and sometimes also on the hapters of *Laminaria hyperborea* and *L. digitata.* The sporangia are 60—100 μ long and 30—60 μ broad. They are recorded by Crouan l. c. to be tetrasporic, but I have till now only seen bisporic ones.

As to structure the species is also rather varying. The length of the cells of the basal layer is three to eight times, sometimes

even ten times the breadth. Their length is 30—90 μ, generally 50—70 μ, their breadth 6—20 μ, mostly about 12 μ. The length of the cells of the perithallium is twice to four times the breadth. They are 18—45 μ long and of about the same breadth as the cells of the hypothallium. I have not seen cortical cells like those figured by Rosanoff, Rech. Melob. pl. IV, fig. 5.

As to the synonymy it is to be observed that *Melobesia Cystosiræ* Hauck is partly referable to this species. I admitted it in Lithoth. Adriat. Meer. p. 27 as a form of *Lithophyllum papillosum*. But as I stated in the note l. c. p. 29, I afterwards found that it partly also includes the alga in question, probably both f. *macrocarpa* and f. *australis*. Therefore, it ought to be omitted as a denominated species or form.

Also *Melobesia confinis* Crn., which I admitted as an independent form under *Lithophyllum hapalidioides* in Rem. Melob. Herb. Crouan l. c., is partly referable to *L. pustulatum* on account of what I have had the opportunity of seeing afterwards. As observed below, it is, however, almost impossible to draw any certain line between *L. pustulatum* and *L. hapalidioides*.

Melobesia pustulata Aresch. Obs. Phyc. l. c. includes partly f. *Laminariæ*, partly *Lithophyllum Crouani* Fosl. according to an authentic specimen examined.

In Rem. Melob. Herb. Crouan l. c. I classed *Hapalidium confervicolum* Toni et Levi, Phyc. Ital. no. 15 with *Melobesia confervicola* (Kütz.) without having seen any authentic specimen of the latter. I observed, however, l. c.: „The species needs a closer examination of better materials than that which I at present possess". By the kindness of Prof. De Toni I have had the opportunity of examining one more specimen of the *Hapalidium confervicolum* distributed l. c. The alga then proved virtually representing a form of *L. pustulatum*. The oblique basal cells are about 36 μ long and 9 μ broad, and the perithallium is formed by a single layer with the cells about 18 μ long and 9 μ broad. The conceptacles are subconical and 250—300 μ in diameter. The alga, therefore, must be referred to *L. pustulatum*. Though the

sporangia are unknown, it most probably represents a stunted f. *intermedia*.

In Kützing's herbarium is not to be found any specimen under the name of *Phyllactidium confervicola* (Phyc. gener. p. 295). There is however a specimen bearing the following label: „*Melobesia farinosa* & *Hapalidium Phyllactidium*. Ad *(Chondriam) Laurenciam condensatam*. Neapel." (Cp. Spec. Alg. p. 695). The calcareous algæ belong to *M. farinosa* and *L. pustulatum*. This specimen is not the one which is figured in Tab. Phyc. XIX, t. 92 under the name of *Hapalidium Phyllactidium*, but the latter probably also belongs to *L. pustulatum*.

According to the liberal communication of Madame A. Weber-van Bosse the genus *Pneophyllum* does not occur in Kützing's herbarium. It is, however, stated l. c. that *Pneophyllum fragile* covers *Rynchococcus coronopifolius*. Under this species two specimens with attached calcareous algæ are found in the herbarium. One of them was kindly sent to me for examination. The upper part of this specimen is covered with a well developed *Melobesia farinosa*. Associated with the latter a few and very small fragments of *Lithophyllum pustulatum* occur between the branches of the host plant and in the top of a branch. The description l. c. seems partly to correspond to *M. farinosa*, but chiefly and most nearly to *L. pustulatum*. I, therefore, think myself entitled to presume that *Pneophyllum fragile* belongs to the latter species.

The great variation of *L. pustulatum* is mainly due to the fact that it occurs on very heterogeneous substrata, particularly on a number of different other algæ. When the substratum is of a fairly firm consistency, the crust always becomes thicker than if the consistency of the substratum is loose. In the latter case the alga in question, as a rule, also becomes of small extent. This concerns all forms, but the f. *macrocarpa* and f. *Laminariæ* are, for the most part, larger and more vigorously developed than the others. The crust also becomes more or less irregular, when the substratum is uneven. On filiform algæ most forms embrace the host plant cylindrically. Sometimes the alga grows in part freely. This I have seen particularly in specimens growing on *Valonia*

utriculosa from the Adriatic (f. *intermedia).* On *Halopteris filicina* from the same area I have seen it almost imbricate, or the edge of the crust bends either upwards or downwards as in young specimens of *Lithothamnion lichenoides* growing on smaller algæ. This is sometimes the case also when the plant is growing on *Cystosira.* In the Adriatic it sometimes also occurs on *Peyssonnelia Squamaria* and *P. rubra,* partly even in layers twice or thrice alternating with one of the said algæ. Here too it grows in part freely and may then become concentrically zonate on the part turning downwards. On the two host plants last mentioned it has been found associated with *Melobesia farinosa* f. *callithamnioides,* while on the others it often shares substratum with *M. farinosa* f. *typica.*

Already Rosanoff l. c. has enumerated several algæ on which *L. pustulatum* is growing. Still several may be added. I will, however, here only point out that it may also occur on chitin-tubes of hydroids, perhaps also on mollusk shells. Thus I found, among specimens of *Cladophora prolifera* and *Corallina rubens* from the Adriatic, on which f. *intermedia* occurred in no small number, some hydroids which were also covered with small crusts of the same form. On the said hydroids it shared substratum with *Melobesia farinosa* f. *callithamnioides.* Between the frond of *Valonia utriculosa* from the same area, mentioned above, were attached several quite small mollusks. On some of the shells were found young and sterile crusts, probably belonging to *L. pustulatum,* which was found numerously occurring on *Valonia.* At Roundstone on the west coast of Ireland I fell in with f. *Corallinæ* on specimens of *Lithothamnion calcareum,* which were growing among *Corallina officinalis,* on which f. *Corallinæ* or a form properly identical with f. *macrocarpa* occurred in abundance. This fact seems to me to impair the claim of the approaching *L. hapalidioides* to be considered as an independent species. The form growing on *Lithothamnion fruticulosum* mentioned in Lithoth. Adriat. Meer. p. 28 perhaps belongs to *L. pustulatum,* although also *L. hapalidioides* sometimes seems to occur on other calcareous algæ.

The species appears both in the lowest part of the litoral and in the upper part of the sublitoral region, f. *Laminariæ,* however, only in the latter region. It seems to be best developed in rather exposed localities, but it also occurs in sheltered ones. The alga is furnished with reproductive organs nearly all the year.

Area: Norway: Syltefjord in the East-Finmark, and the North Cape, f. *Laminariæ* (!) Nordland — southward, f. *Laminariæ* (Kleen, Wittrock!,!); south-west and south coast, all the forms except f. *australis* (!)[1]); west coast of Sweden, f. *intermedia,* f. *corallinæ,* f. *macrocarpa* (Areschoug, Wittrock, Strömfelt!); Denmark, f. *intermedia,* f. *macrocarpa* (Rosenvinge!)[2]); western Baltic, f. *Corallinæ,* f. *Laminariæ* (Reinke); S. and S. W. Iceland, f. *macrocarpa,* f. *Laminariæ* (Strömfelt, Jönsson!), the Færöes, f. *macrocarpa* (Simmons, Jönsson, Börgesen!), f. *Corallinæ,* f. *Laminariæ* (Börgesen!); Shetland, f. *Laminariæ* (Börgesen); the Orkneys, f. *Laminariæ* (Traill); the British Isles, all the forms? (Harvey, Batters,!); Atlantic coast of France, all the forms (Thuret, Le Jolis, Crouan, Rosanoff, Bornet!); the Mediterranean, all the forms except f. *Laminariæ* (Solms Laubach, Ardissone, Debray!); the Adriatic, all the forms except f. *Laminariæ* (Hauck, Wille!); Morocco, f. *australis* (Kuckuck!); Canary Islands, f. *australis* (Houegger!); Natal (Isipingo), f. *australis* (A. Weber—van Bosse!); Atlantic coast of America: From the West Indies, Florida and the Bermudas (Howe!) as far as Cottage City, Mass., f. *australis* (Collins!), Nahant, Mass., f. *Laminariæ* (Collins!), Newport, R. I. to Yarmouth, N. S., f. *macrocarpa* (Farlow, Col-

1) On the South-west coast of Norway has been found a delicate form of this species with small conceptacles on *Zostera*, but the sporangia are unknown. It approaches in habit f. *australis*, but is likely to belong to f. *intermedia* with bisporic sporangia.

2) Among a collection of calcareous algæ from Denmark, collected by Dr. Kolderup Rosenvinge and kindly sent to me for examination, are found some quite young, sterile and uncertain specimens partly associated with *Melobesia Lejolisii* on *Zostera*, probably belonging to the same form as that which occurs on *Zostera* at the South-west coast of Norway. — Sterile and stunted crusts of the species in question also occurred on *Chorda filum.*

lins, Penhallow!); West Greenland: Holstensborg Fjord northern side, f. *Laminariæ* (Ostenfeld!); Pacific coast of America: Monterey, Cal., f. *australis* (Gibbs!), La Jolla, Cal., f *macrocarpa*(?)[1]) California, f. *Corallinæ* (herb. Farlow!) The species is besides stated by Rosanoff from Australia. It is also possible that *L. canescens* Fosl. from Japan only represents a form of this species.

The above remarks concerning *L. pustulatum* were ready for the press, when I received from Dr. Rosenvinge the recorded f. *Laminariæ* from West-Greenland.[2]) He kindly communicated to me that the species of another alga to which the crusts are attached probably represent parts of the cortical layer of a rotten stem of *Laminaria longicruris*. After this find within the arctic zone, I do not think the view tenable that *L. pustulatum* should also embrace *L. macrocarpum*. It does not seem likely from a phytogeographical point of view. I, therefore, think it reasonable to propose that both shall be considered as independent species, though at present a definite line can hardly be drawn between them. On this account I have been rather uncertain as to the understanding of this series of forms. With altered delimitation of species, however, it will prove necessary, what I already suggested above, to drop f. *Corallinæ* as a denominated form. It ought to be referred partly to *L. pustulatum*, partly to *L. macrocarpum* f. *færöensis* and f. *intermedia*. The form *Corallinæ* being taken in the sense suggested by Mr. Crouan, this form and f. *intermedia* are likely to be identic. But it will be quite fallacious to admit the former denomination as embracing a form which occurs on many different

1) From Monterey, Cal., I have in hand a well developed specimen with sporangia, growing on *Nitophyllum Ruprechtianum*, which seems to be a certain f. *australis*. On the other hand, two specimens from La Jolla are uncertain. One of them growing on *Dictyota Binghamiana* bears conceptacles, about 280 μ in diameter, and the other growing on *Rhodymenia corallina* is furnished with empty conceptacles which are 400—500 μ in diameter. The former possibly belongs to f. *australis*, and the latter probably belongs to f. *macrocarpa*, though the conceptacles are somewhat lower than in this form.

2) It is also to be observed that they were written before my remarks under *Litholh. tophiforme* (p. 53) concerning the partition of the sporangia.

algæ. Thus most specimens which I have seen from the Adriatic belong to f. *intermedia,* growing on substrata of rather different kind, and the same is the case in several other areas.

The denomination, therefore, should be as stated below. Some consequent changes as to the synonyms are less important and will, as far as possible, be made on a later occasion.

Lithophyllum pustulatum (Lamour.) Fosl.

It appears from the area recorded above that the species — according to the circumscription now proposed — is at present known no farther to the north than Cherbourg and probably the southern coasts of the British Isles.

3. *Lithophyllum macrocarpum* (Rosan.) Fosl. mscr.

Melobesia macrocarpa Rosan. Rech. Melob. (1866), p. 74. Cp. under f. *macrocarpa,* pag. 117.

f. *intermedia* Fosl. mscr.

Cf. pag. 117 and 126.

f. *færöensis* Fosl.

Rem. Melob. Herb. Crouan (1900), p. 15. Cp. under f. *macrocarpa*, pag. 117 and 126.

f. *Laminariæ* (Crn.) Fosl. mscr.

Cf. pag. 118 and 126.

4. *Lithophyllum hapalidioides* (Crn.) Fosl.

Alg. Not. (1904), p. 3; Melobesia hapalidioides Crn. Fl. Finist. (1867), p. 150!

f. *typica.*

Frond orbicular, often becoming confluent and indefinite, 200 —600 μ thick, lobed, crenulated or entire, smooth.

f. *confinis* (Crn.) Fosl.

Rem. Melob. Herb. Crouan (1900), p. 12; Melobesia confinis Crn. l. c., partim!

Frond loosely and irregularly subsquamellate-imbricate.

Syn: Melobesia simulans Crn. l. c. p. 150!

Dermatolithon hapalidioides Fosl. List of Lithoth. (1898), p. 11; Rem. Melob. Herb. Crouan. (1899), p. 12; Börg. Mar. Alg. Færöes (1902), p. 402! Batt. Cat. Brit. Alg. (1902), p. 97! De Toni, Syll. Alg. (1905), p. 1772.

Lithothamnion adplicitum Fosl. On some Lithoth. (1897), p. 17.

Dermatolithon? adplicitum Fosl. Rev. Syst. Surv. Melob. (1900), p. 22; Batt. Cat. Brit. Alg. (1902), p. 97! De Toni, Syll. Alg. IV (1905), p. 1773.

As I observed above, *L. macrocarpum* and *L. hapalidioides* are hardly distinguishable one from the other. Certainly they are, as a general rule, growing on heterogeneous substrata, the former occurring on other algæ of frequently rather loose consistency, whereas *L. hapalidioides* appears on different shells of molluscs. I have, however, under *L. macrocarpum* instanced the occurrence of this species on shells of mussels appearing among such algæ on which the species is generally growing. Besides I have stated that it is likely to appear also on other calcareous algæ which occur in similar condition of things, which, by the bye, seems to be the case with both species. On the other hand *L. hapalidioides* seems likely to occur on algæ of rather loose consistency in the same conditions of things in which *L. macrocarpum* appears on substratum of hard consistency. This is e. g. the case with a specimen of *Melobesia confinis* in Crouan's herbarium which partly sticks to *Gelidium corneum*. As I have remarked l. c. it spreads to *Gelidium* probably from the shells of Balanides, which it also partly covers, the shells forming a part of the substratum of the said species. Some specimens, distributed by Le Jolis under the same name, growing on *Gelidium*, are partly encompassing the branches of the host plant, partly forming crusts over small shells of Balanides and other objects as well as over and between the branches of *Gelidium*. I am, however, not sure whether the latter form should be referred to *L. hapalidioides*. Although it is thus almost impossible to draw any line, I do not venture at present to subsume this species under *L. macrocarpum*, but admit it for the present as independent. On the other hand this species approaches *Lithoph. (Dermatolithon) prototypum* Fosl. from the West Indies.

The form *confinis* I take here in a somewhat altered sense. In the sense taken by Crouan it embraces partly *L. macrocarpum*, partly typical *L. hapalidioides*, whereas the specimen mentioned above, partly growing on *Gelidium*, is a little diverging from the typical form of the latter species and in part almost imbricate. I circumscribe the form to only embracing specimens with fronds loosely and irregularly subsquamellate-imbricate. In the

former case it is sometimes like *L. Lenormandi* f. *squamulosa* in habit. Otherwise the form seems to be little independent. It rises from small extraneous bodies — sometimes other algæ — forming an uneven substratum, or particularly from such bodies attaching themselves to the original crust and being gradually overgrown, the result of which are very uneven complexes of crusts of the alga in question or layers irregularly alternating, and up to about 5 mm thick. Such specimens may be greatly diverging from typically developed ones in habit. Besides they are frequently provided with wartlike excrescences, which, however, seem to have risen in the same way, and hardly ever are real branchings. This form includes *L. adplicitum* Fosl.

As to structure, the species in all essentials corresponds with *L. macrocarpum*. The length of the basal cells is 3—5 times or up to 8 times the breadth. They are 30—90 μ, generally 40—70 μ, long and 8—20 μ, mostly 12—15 μ broad. The length of the perithallic cells is twice to four times the breadth; they are 20 - 50 μ long and of about the same breadth as the hypothallic cells.

Also as to the conceptacles of sporangia the species corresponds with *L. macrocarpum*, particularly with f. *intermedia* and f. *færöensis*. The said organs are hemispheric-conical or subconical, 300 (250)—500 μ or sometimes up to 600 μ in diameter. The sporangia are two-parted, 90—120 μ long and 30—60 μ broad.

The alga occurs in the lower part of the litoral region and particularly in the sublitoral region. At Fredriksværn on the southern coast of Norway I have taken it in a depth of 7—10 fathoms. It has been found with reproductive organs from March till October.

Area: South coast of Norway: Fredriksværn, f. *typica* (!); the Færöes, f. *typica* (Ostenfeld, Börgesen!); Scotland: Berwick, f. *typica*, f. *confinis* (Batters!); South coast of England, f. *typica*, f. *confinis* (Holmes, Batters!); Ireland: Frenchport, f. *typica* (Johnson!), Fahy Bay (Hanna!), Roundstone (Hanna!,!); Atlantic coast of France, f. *typica*, f. *confinis* (Crouan, Thuret, Bornet, Debray, Sauvageau!); the Azores, f. *typica* (Bohlin!)

Addenda and Corrigenda.

Lithothamnion læve (Strömf.) Fosl. — Cfr. pag. 16.

After having a part of this paper printed, Dr. Rosenvinge kindly sent me some more Lithothamnia for examination. Among these is a specimen from Denmark probably belonging to the above species It has been collected S. E. of Hesselö in the Cattegat in a depth of 15 fathoms (Rosenvinge!). The crust is about 2,5 by 2 cm. in diameter, covering a small fragment of a mollusk *(Mya?)* and a tube of a *Serpula* attached to the said mollusk. It is about 100 μ thick and bears a few conceptacles of sporangia. The latter are 500—650 μ in diameter and coincide with those in the said species. The specimen was collected the 17th of July, and in a single conceptacle examined I found three sporangia unparted, one two-parted, and one apparently three-parted. It was found together with an entire mollusk *(Cyprina)* and a fragment of another one bearing some quite young crusts of a similar calcareous alga, and besides a pebble to which is attached a small crust resembling the latter as well as two young ones of *Lithoth. Granii.* There could perhaps be a possibility that the specimen in question and the first named young crusts also represent a young form of the latter species. However, it does not show any trace of branches founded, and the conceptacles are differing in shape and larger than in *L. Granii.* Nor have I seen conceptacles developed in the crust of this species. On the other hand, the alga approaches in habit certain forms of *Lithoth. Sonderi,* but the conceptacles are too large and too prominent, and besides

the roof is too thick to represent any form of the latter species. Therefore, the specimen likely represents a *Lithoth. læve* feebly developed, though it would seem but little probable that this species occurs so far to the south.

As formerly mentioned in other papers, the following species recorded by me in Norw. Lithoth do not in fact occur on the coast of Norway; the determination was based on stunted or sterile specimens:

Lithothamnion crassum l. c. p. 31.
„ *incrustans* l. c. p. 94.
„ *byssoides* l. c. p. 118.

Pag. 16, l. 19, for the Azores, read the Canary Islands: Puerto Orotava (Teneriffe).

Register.

The synonyms as well as genera and species incidentally mentioned are printed in Italics.

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