

The Norwegian Forms of Lithothamnion.

By

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(With 23 Plates).

The following account is intended to comprise all the species of the algal genus *Lithothamnion* (including *Lithophyllum*) at present known to occur on the coast of Norway. It is founded on a considerable number of specimens (more thousand), most of which I have gathered myself in different tracts especially along the northern part of the coast. However, of some of the species I have seen only a few, or even but a solitary specimen. The most northern part of the coast is in this respect tolerably well known, except Lofoten and Vesteraalen in Nordland's Amt and the greater part of Tromsø Amt. The Christiania- and the Trondhjem Fjord also is rather well known. But the other parts and especially the very long western and south-western stretch of coast from Hiteren or Christiansund N. to Lindesnes and eastward off Christiania is very little searched and long stretches quite unknown. Therefore, still much remains to be done, not only in regard to the Lithothamnia, but the marine algæ in all.

The limits between the species are as a rule not easily drawn, and often still more difficult without a greater number of specimens from different tracts for comparison. A form may appear rather well marked in one locality, but in another transitions to other forms may be rather common, and one and the same species often

varying between wide limits, approaching not only nearly allied species, but even species which in their typical development are quite different. This may, not seldom, depend partly on local relations, partly and more frequently caused by attack of animals, as saxicavous sponges, or worms and especially boring-muscles, destroying particularly the lower or inner parts, or numerous other animals fastened to or living on the plant. The consequence of it is often an alteration in the development of the individuals in their struggle for existence by a tendency to overlap the animals, or other external objects, and thereby assuming much varying forms.¹⁾ Individuals attacked by boring-muscles may occasionally be quite destroyed thereby, that their growth has not been able to keep pace with the destructive work of the muscles. I have seen numerous individuals, especially densely branched ones lying loose on the bottom, in their inner parts so filled with boring-muscles, that only a thin peripheral portion has been left, forming what may be called a common testa around the colony of muscles. Together with these muscles is also to be found numerous perforated and broken pieces or branches of the plant. By a feeble pressure, a push, or by the continued labour of the muscles the remaining peripheral portion gets broken, and the whole plant collapses. In specimens more attacked towards the one than the other side an opening often is produced, through which other not perforating muscles and other animals push their way into the plant. However, such specimens apparently seldom get quite destroyed, as the other parts of the plant becomes more vigorously developed, but, on the contrary, they sometimes assume peculiar forms much differing from the typical ones. Most of the specimens that I have examined have, moreover, been infested with numerous perforating algæ, which in general rather destroy chiefly the lower layers of tissue. Growing in shallow water, from or a little below extreme low-water mark to a depth of about 2—3 fathom, in narrow sounds with somewhat strong currents, or else in places

¹⁾ In one locality especially I met with numerous killed or dying muscles (*Mytilus modiolus*) caused thereby, that the Lithothamnia encompass the shells. Cp. Contrib. II, p. 3, and Alg. og Musl. p. 17.

with rather rapid tides densely branched and typically developed globular or hemispherical individuals, especially of the larger forms, very often assume a more depressed shape; and the apex of the branches become truncate or assume disc-shaped, not seldom confluent or nearly confluent and even crustlike expansions, while the part turning towards the bottom bears branches of another and apparently typical shape. On the other hand, in more sparsely branched individuals living in sounds with rapid tides, the apex of most of the branches are often denudated or bitten off. This I have not seen on greater depths than about 5 fathom, although in certain localities it probably also takes place farther down.

It appears not to be excluded, that hybrids arise from some of the species growing together in banks. The *Lithothamnia* generally grow gregarious in great masses, sometimes and most often only one or two species, sometimes more, together. I have seen widely extended banks, once even as far as about 3 kilometer in length, composed of millions of individuals of up to four or five species, not only of the smaller forms, but large ones up to nearly 2 feet in diameter. It has, however, not been possible in this varying group of species to decide with any degree of certainty, whether hybrid forms really occur. I certainly possess specimens which, in my opinion, probably are hybrids, but these I do not quote here, as on closer examination I did not arrive at any satisfactory result. However, a solitary one is mentioned under *L. fruticosum f. flexuosa*.

Specimens of more species are frequently to be found fastened to one and the same substratum, growing together, covering each other, or one fastened to and growing over the other. Branched individuals growing together not unfrequently continue their growth together even being loosened from the substratum, and without any defined limit, not seldom looking as a solitary individual.

The greatest difficulty in regard to the identifying especially of many of the branched *Lithothamnia* consists, however, therein, that proportionally very few specimens of these are to be found with reproductive organs. In some species the very greatest number of the specimens gathered in summer have been sterile, only now

and then a specimen richly provided with the named organs, and all the other ones from the same place and time quite sterile. Specimens collected in autumn, winter and spring have now and then been fertile, but still the greater number sterile. Thus the development of the reproductive organs, at least in some of the species, with us probably takes place nearly all the year, but in proportion to the number of individuals always in apparently few of them. Only a couple of species are more commonly to be found fertile in summer. I have examined hundreds of specimens of other species from different localities and at different seasons, but only met with a couple or very few ones bearing the named organs, and those not well developed. In species, by which the conceptacles of sporangia always grow down into the frond, I often also met with specimens with the very greatest number of branches not showing overgrown conceptacles. I am, therefore, inclined to suppose, that at any rate in some of the branched species, and especially specimens much attacked by animals, the development of the organs of propagation in all rather seldom takes place. Moreover, from a certain age the plant appears not to develop reproductive organs, though the vegetative part still continue its growth, the plant being alive.

The crustaceous species are on the other hand more commonly furnished with organs of propagation, mostly sporangia.

The named organs after being founded appear in their further development also to be checked by attack of animals, especially the conceptacles of sporangia, but probably also those of antheridia and cystocarps. I have seen rather numerous superficial conceptacles of sporangia filled with animals or animal substance, and still more overgrown, many of which apparently attacked before growing down into the frond. Besides, the sporangia themselves may often be infested with small perforating algæ, or animals.

The colour of the *Lithothamnium* also is subject to much variation. In deep water it nearly always seems to get darker than in more shallow, but, on the other hand, less varying. Growing in shallow water especially with sandy or else light bottom it gets very light, and the part turning upwards even whitish in summer,

but dark in winter, and in this respect showing a great difference. Thereby even the colour of a fracture of the plant becomes rather varying. On the other hand, specimens living in the litoral region, on the bottom of deeper and shady rock-pools, or else in the named region covered with *Fucaceæ* and other algæ, appear to be less varying in colour. However, being much exposed to the light, or changing strong light and shade the colour here sometimes seems to be even more variable than in the upper part of the sublitoral region. Some specimens change their colour much in drying, others less, and are, as a rule, rather fading.

I have subsumed the genus *Lithophyllum* as a subgenus of *Lithothamnion*, and the *Lithothamnion* proper I propose to name *Eulithothamnion*. The former was originally established as a genus by Philippi¹⁾, by him, however, only characterized from the external shape. In the same sense Kützing²⁾ afterwards quoted both as sections of his genus *Spongites*, however, species of *Lithophyllum* in some cases referred to *Mastophora* Desne.³⁾ Areschoug⁴⁾ was the first, who pointed out certain peculiarities in the development, and regarded *Lithothamnion* and *Lithophyllum* as co-ordinate genera. Rosanoff⁵⁾ followed him and drew more thoroughly the limits between them.

However, according to Rosanoff l. c. and Solms-Laubach⁶⁾ there is no definite distinction in the development of the organs of propagation between both the named genera. Strömfelt⁷⁾ supposes, that the walls of the sporangia in *Lithothamnion* are formed all but simultaneous, but in *Lithophyllum* successively. It is already shown by Kolderup Rosenvinge⁸⁾ that this cannot be the case. I have seen in more species of the former bearing four-parted sporangia numerous not fully developed ones, and the parti-

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- 1) In Wieg. Archiv, p. 387.
 - 2) Phyc. gener. p. 386.
 - 3) Kütz. Spec. Alg. p. 696.
 - 4) In J. Ag. Spec. Alg. II, p. 520.
 - 5) Mélob. p. 97.
 - 6) Corall. Monogr. p. 62.
 - 7) Algveg. Isl. p. 22.
 - 8) Grøn. Havalg. p. 780.

tion, so far as I have been able to judge, always taking place successively. In some species, and especially those provided with superficial conceptacles, it appears, however, that the walls of the tetrasporic sporangia are founded in a more quickly succession. In others, on the contrary, and especially in species with immersed conceptacles, the partition takes place in a more slow succession, and the middle wall often appears to be fully or nearly fully developed before the two other walls are founded. Thus it often looks, as if the sporangia were only bisporic, sometimes with a well developed wall, sometimes even looking fully developed, but others in the same conceptacle or in other ones of the same specimen showing more or less indistinct partition of the one or both cells; or one or both other interwalls partly so far founded partly more developed, and the partition at first issuing only from the one side.¹⁾ Once I have seen the middle transverse wall later developed than the two other walls. And in the same group of species I also have seen overgrown sporangia only two-parted, probably not fully developed before they, together with the conceptacle, grew down into the frond. It is in this connection to be remarked, that I, on the other hand, have not seen anything which with probability seems to suggest, that a species produces both bisporic and tetrasporic sporangia. If perhaps it may now and then occur, that a species provided with the one kind of sporangia also bears fully developed sporangia of the other kind, this must most probably be considered only an abnormal development. So also in regard to the three-parted and irregularly three- or four-parted sporangia which occasionally may be met with, though in all seldom and, so far as I have seen, only in species of the section *Immatæ*.

Thus the only distinction between the named genera consists in a difference as to the vegetative part of the plant. In this respect I refer to Solms-Laubach l. c., who has shown almost fully transitions between both.²⁾ Moreover, Rosenvinge mentions

1) Cp. under *L. orbiculatum*, *L. coralloides* and other species.

2) Mentioning *Lithothamnion* Solms-Laubach remarks l. c. p. 26: „Bei consequenter Anwendung des unterscheidenden Merkmals würden freilich

l. c., that in thin crusts of *Lithothamnion tenue* Rosenv. (*L. Strömfeltii* mihi) the structure may rather approach that of *Lithophyllum Lenormandi* (Aresch.). I found in the former the structure occasionally so nearly approaching, or even almost fully coinciding with that of the last named species, that in my opinion any true limit cannot be drawn. Other and coarser species of both genera seem to approach one another much in habit, and probably they are also as to the structure nearly related. *Lithoph. crispatum* Hauck, Meeresalg. p. 270, t. II, fig. 3 reminds one much of certain forms of *Lithoth. incrustans* f. *Harveyi* (*L. polymorphum* Harv.), and Mr. Batters informs me, that the latter often comes near to *Lithoph. expansum* (Phil.) in appearance. On the other hand *Lithoth. denticatum* (Kütz.) Aresch. seems as well to be referrible to *Lithophyllum* as coarser forms of *Lithoph. cristatum* (Menegh.), supposing the structure of these species stands in the same relation as *Lithoph. decussatum* and *Lithoph. expansum* to other species of *Lithothamnion*. Cp. Hauck l. c. t. II, fig. 2, 5 and Solms-Laubach l. c. *L. investiens* occasionally reminds one of certain forms of *Lithoph. lichenoides* in habit, and even as to the structure much approaching, or perhaps nearly coinciding with that of the named species. I, however, have not had the opportunity to examine any of the coarser forms of *Lithophyllum*. The structure is in all rather varying, and also the size of the cells may be somewhat differing in specimens of one and the same species.

I, therefore, consider *Lithophyllum* a not well characterized subgenus of *Lithothamnion*. I have, on the contrary, been in doubt whether it ought not, perhaps, to be drawn in even as such. Farlow¹⁾ subsumes it under *Melobesia*, and Batters²⁾ considers

hierher auch die meisten *Lithophyllumen* zu rechnen sein. Bei *L. decussatum* und *L. expansum* tritt ein derartiges Dickenwachstum, wensschon in rudimentärer Form, gewöhnlich auf; dasselbe kann soweit gehen, dass die ersterzeugten Conceptacula ins Gewebe versenkt, und dass über ihnen neue gebildet werden. Zwei dergleichen übereinander gelegene Schichten fanden sich öfters, drei erinnere ich mich bei *L. decussatum* nur selten gesehen zu haben“.

¹⁾ Mar. Alg. New Engl. p. 179.

²⁾ Mar. Alg. Berw. p. 139.

it a subgenus of *Melobesia*, but the latter is probably to be regarded a rather well defined genus, to which *Lithophyllum* is less related than to *Lithothamnion*.¹⁾

I have divided *Eulithothamnion* into two sections, *Innatæ* and *Evanidæ*, the one comprising species by which the conceptacles of sporangia grow down into the frond, the other species by which this is not the case. There is, certainly, not any defined limit between these two sections, as transitions now and then are to be found, but that appears rather to be conditioned by external causes. Sometimes in species of the first named section, by which the thickening meristema of the frond apparently is superficial, overlapping the roofs of the conceptacles and the latter growing down into the frond the cavity may be found filled with new-formed tissue. That is, however, so far as I have seen, nearly always formed by new local formations and most often in species by which the conceptacles are not much immersed, and the whole roof for some reason fallen away, or dissolved. Together with the overgrown conceptacles is to be found some sporangium not escaped, or sometimes even all or nearly all the sporangia formed, partly apparently mature partly but little developed. In species of the other section, with the thickening meristema of the frond apparently lying below the basal surface of the conceptacles, I have never seen overgrown ones, not even in species with immersed conceptacles.

The conceptacles of cystocarps and antheridia always use to be superficial, or as a rule very little immersed. The former generally do not grow down into the frond, the whole roof falling away and leaves a cup-shaped scar in most cases with elevated edges. The latter, probably, do not, as a rule, become overgrown. I have in four species of the section *Innatæ* (*L. dehiscens*, *L. fruticulosum*, *L. polymorphum* and *L. flavescens*) seen overgrown conceptacles of cystocarps. This is caused thereby, that the roof

1) „Wenn schon zwischen *Melobesia* und *Lithophyllum* intime Beziehungen bestehen, so lassen sich diese Gattungen doch im entwickelten Zustand wenigstens an bestimmten Merkmalen erkennen“. Solms-Laubach l. c. p. 26.

either is not dissolved and has become overlapped by a new thickening layer of the frond, or, at maturity, only the uppermost part of the roof is fallen away, and the cavity under the remaining part gets overgrown by a new thickening layer or a local new formation; or, as in *L. polymorphum* and probably also in *L. incrustans*, by the conceptacles frequently being somewhat immersed, and in such cases perhaps always getting overgrown. In species of the section *Evanidae* I have also seen the roof of the cystocarpic conceptacles only in part dissolved, but at the same time the cavity effaced by a new thickening layer of the frond and, therefore, the conceptacles not become overgrown, nor a section of older parts of the frond showing scars after conceptacles filled by local formations of tissue. This, no doubt, corresponds with the above mentioned difference in regard to the thickening meristema of the frond.

In reference to the character of species I have, besides the general appearance and development of the plant, particularly laid stress upon the shape and size of the conceptacles of sporangia, which, in my opinion, affords a good and in most cases recognizable characteristic. But the size of the sporangia themselves is, on the other hand, rather varying, and in shape they are in general much varying even within one and the same conceptacle. Therefore, they cannot as a rule in this respect serve as an identifying character, setting aside their partition. The conceptacles of cystocarps are often uniform in different species, in others again there may be some difference, though in most cases only as to the size. The carpospores are so uniform in the different species examined and, on the other hand, mutually so varying in shape as well as size, that I have in the character of species taken no account of them. The conceptacles of antheridia are, so far as I have seen, always of the same or nearly the same shape as the cystocarpic conceptacles, but probably always smaller. The spermatia are, I expect, equal in variation to the carpospores, and in this respect the one species nearly resembling the other. Cp. Born. et Thur. Etud. Phyc. p. 99. It should, however, be remarked, that I have not seen or examined any great number of the last

named ones, nor of the carpospores, and it may be, that those I have seen have not always been fully developed.

Besides the *Lithothamnia* collected by myself, I have had the opportunity to examine a rather great number of other specimens from different localities and herbaria, also from abroad, and among these several original specimens, which, I hope, has enabled me to give to the following list of species a degree of accuracy it could not otherwise have possessed. I would here express my sincere thanks to Professor A. Blytt for his permission to examine the collection of algæ in the University's botanical Museum at Christiania and fossil *Lithothamnia* collected by him at Bodø; to Cand. real. P. Boye for specimens from the west coast; to Cand. med. O. Bugge for fossil specimens from Bodø; Mr. Kr. Dahl for numerous specimens from the harbour of Vardø obtained by the harbours stirring up mud; the Rev. Gunnar Frette for winter-specimens from Frøjen; Cand. real. H. H. Gran for various species from the west coast and the Christiania Fjord; Docent B. Hansteen for specimens from the west coast; Stud. techn. Sigvald Schmidt-Nielsen for specimens from the outer part of the Trondhjem Fjord; Conservator Sparre Schneider some species found in a zoological collection from Spitzbergen brought together by Capt. Niels Johnsen of Tromsø; Stud. med. Kr. Schreiner specimens collected at Herø in Helgeland and summer- as well as winter-specimens from the Christiania Fjord; the head-master A. C. Ullmann specimens from the botanical collection in Kragerø Mid-delskole; and Professor Dr. N. Wille specimens collected at Mandal. I am particularly indebted to Mad. A. Weber van Bosse of Amsterdam for several original specimens from the late Dr. F. Hauck's herbarium for comparison; to Mr. E. A. L. Batters of Wormley for several British specimens and informations as to Harvey's *Lithothamnia* in Phyc. Brit.; Dr. Ed. Bornet of Paris for an original specimen from Crouan's *exciccata* for examination, and various other French specimens; Mr. F. S. Collins of Malden, Mass. for American specimens; Professor W. G. Farlow of Cambridge, Mass. one of the species quoted in his *Mar. Alg. New Engl.*; Professor Dr. Chr. Gobi and Mr. C. Deckenbach of St.

Petersbourg specimens from the White Sea; Professor Dr. F. R. Kjellman of Upsala a fragment of what he supposes to be *L. fasciculatum* Aresch.; Dr. P. Kuckuck of Helgoland several specimens there collected; Dr. Kolderup Rosenvinge of Copenhagen the species described in his Grøn. Havalg.; Professor van Tieghem and Mr. P. Hariot of Paris original specimens for comparison from Crouan's collection in Museum d'Histoire Naturelle; Mr. Geo. Will. Traill of Edinburgh for British specimens; and to Professor Dr. V. Vittrock of Stockholm for permission to examine the late Professor J. E. Areschoug's herbarium in the Riksmuseum.

I have previously distributed several *Lithothamnia* and quoted most of the northern species in Contrib. I and II. As it appears from the following, my apprehension of some of the species or their limits is, however, not the same as then. I want, therefore, to remark that specimens hereafter distributed will be accompanied by a reference to the present paper.

Trondhjem 27. II. 1895.

Gen. **Lithothamnion** Phil.

in Wieg. Arch. p. 387; Aresch. in J. Ag. Spec. Alg. 2, p. 519;
Rosan. Melob. p. 96.

Subgen. **Eulithothamnion** Fosl. mscr.

Lithothamnion s. s. auct.

Sectio I. **Innatæ** Fosl. mscr.

Conceptaculis sporangiferis demum innatis.

Lithothamnion boreale Fosl.

Contrib. II, p. 2.

Descr. et Fig. Lithothamnion boreale Fosl. l. c. et t. 1.

Syn. Apora polymorpha Gunn. in Act. Nidros. p. 70; ex parte?

Remark on the species and its synonymy. Of this vigorously developed species no other specimen has been found than the solitary and sterile one described l. c. A fragmentary one from Mehavn in East-Finmarken may perhaps be referrible to the present species. The latter, however, only forms the uppermost part of the branch-system of a larger specimen, and, therefore, it cannot be determined with certainty.

In Gunnerus' zoological collection in the Museum (Scientific Society) here are four specimens of *Lithothamnion*¹⁾, one or two of which probably being nearly related or referrible to *L. boreale*. They are, however, fragmentary and sterile, forming a part of a larger specimen like the above mentioned, and, as no locality is known, not even wheter they are collected on the Norwegian coast, I have not examined them more closely.

Relation to other species. The plant appears to be nearly related to certain forms of *L. glaciale*. However, it must be considered a separate species, even if the organs of propagation may prove to be identic, characterized especially by its vigorous

¹⁾ Cp. under *L. fruticosum*.

and long branches. Besides, from the lower part of the hypothallus at first apparently crustlike and pretty strongly developed in a later stage of development coarse and occasionally decumbent branches issue, so that the hypothallus by and by forms a subcentral main axis, which never appears to be due to *L. glaciale*.

Habitat. The species apparently lives in the lowest part of the sublitoral region, or in the elitoral one. It is said to have been picked up by fishermen from a depth of 20—30 fathom.

Occurrence. Hitherto with certainty only found at Gjesvær in the neighbourhood of the North Cape, a solitary specimen.

Lithothamnion glaciale Kjellm.

N. Ish. Algfl. p. 123 (93).

f. *typica* Fosl. mscr.

f. *ramis conicis*, obtusis vel subcylindricis, usque 7—8 mm. altis, inferne diametro usque 5 mm.

Fig. *Lithothamnion glaciale* Kjellm. l. c. t. 2—3.

f. *torosa* Fosl. mscr.

f. *crusta tuberculis subhemisphaericis*, 0.5—1 cm. magnis instructa. Tab. nostr. 1.

Syn. *Lithothamnion calcareum* Kjellm. Vinteralg. p. 64.

” ” Kleen, Nordl. Alg. p. 11; sec. Kjellm.

” *fasciculatum* Aresch. Obs. Phyc. 3, p. 5 (ex parte); sec. Kjellm.

” ” Gobi, Algenfl. Weiss. Meer. p. 22.

” ” Kjellm. Spetsb. Thall. 1, p. 3, Algenv. Murm. Meer. p. 7.

” *glaciale* Fosl. Contrib. I, p. 7.

” ” Strömf. Algveg. Isl. p. 18.

” ” Rosenv. Grönl. Havalg. p. 773.

Remark on the species and the definition of the form. The most extreme forms of this species are rather differing. It probably includes more than the above quoted ones, but they are on the other hand not well defined, as transitions frequently are to be found. The form figured by Kjellman l. c. I consider to be the typical one, characterized by its mostly numerous conical branches in the crust as well as the lobes. Smaller specimens of this form

sometimes approach *L. varians* f. *verrucosa* in habit and may be even difficult to separate in a sterile state. On the other side it passes into the form *torosa*, in which the crust and lobes bear more or less subhemispherical, smaller or larger processes, in some respects corresponding with the form *irregulare* of *L. varians*, being, however, a much larger and coarser plant than the latter. At Kjelmö in East-Finmarken I also met with a form, in which the simple branches are rather thicker than in the typical one carrying more or less numerous wart-like processes, and now and then even forming bundles, in all most closely related to the named form. I, however, did not succeed in finding the sporangia, but the conceptacles fully resemble those in *L. glaciale*. Cp. pl. 2, fig. 2, a specimen anastomosed with *L. breviaxe*. The species is, in the Arctic Sea, one of the largest of the genus, attaining a diameter of at least 0.5 m.

The conceptacles of sporangia frequently are, in the specimens that I have seen, somewhat larger than those quoted by Kjellman l. c., or the circular or oblong and convex roof up to 400 μ , most frequently about 300—350 μ in diameter. It is intersected with 50—70 canals, which are crowded in the middle of the roof. After the central or greater portion of the roof is nearly dissolved, this portion often gets somewhat depressed, and then it looks, in a certain stage, as if the conceptacles were surrounded by an annular border. Sometimes the whole roof falls away, and the scar becomes effaced by a local formation of tissue. The sporangia appear to be much varying in size. I found them up to 180 μ long and 80 μ broad. Cp. Kjellm. l. c.

I have not seen cystocarpic conceptacles in typical specimens of this species, but some few ones found in a form apparently referable to f. *typica* are conical, low and about 400 μ in diameter at the base. Some other conceptacles are about 250—300 μ in diameter at the base, probably antheridian ones, and in shape agreeing with the former.

Relation to other species. The present plant is a true hyperborean Lithothamnion, that has probably originated within the Arctic Sea, and not unlikely more species have issued from it and been

developed in a more southward direction, for inst. *L. boreale*, *L. varians* and *L. colliculosum*. As mentioned above, smaller individuals of the species in question may be confounded with *L. varians*, but the sporangia are not yet well known in the last named species. On the other hand, as remarked by Kjellman l. c., it shows some affinity to *L. fruticulosum* (*L. intermedium* Kjellm.). Although they are in general easily distinguished by the external shape, one or the other sometimes assumes forms which in a steril state may be difficult to identify, or easily confounded.

Habitat. Along the coast of Finmarken the species generally lives on a depth of 10—20 fathom, and here it apparently prefers sandy and shingly bottom. It is found on open shore as well as in sheltered places, and it penetrates rather far up the fjords. Here, I occasionally met with it on a depth of only 3—5 fathom. Specimens collected in July and August have partly been sterile partly richly provided with ripe sporangia, or newly emptied conceptacles.

Occurrence. With us the species apparently is most commonly dispersed along the coast of East-Finmarken. Here it has been found at several places, partly even abundant. I met with it at Kjelmö, pretty plentiful but local, Vardö, Mehavn, Kjöllefjord, and at Lebesby in Laxefjord, local but abundant. It appears also to be dispersed along the whole coast of West-Finmarken, but here apparently less numerous, except perhaps in the most eastern part of this district. It has been found at Kistrand in Porsangerfjord (f. *typica* and f. *torulosa*), Kjelvik, Magerö Sound, Maasö, Gjesvær, Kvalsund (f. *torulosa*) and Bergsfjord. Within Tromsö Amt Kjellman collected it at Karlsö, and I found a small specimen in Polden in the inner part of the Lyngen Fjord. I also met with some few specimens at Tromsö and Mestervik in Malangen, but they are sterile and rather uncertain. Within Nordlands Amt Kleen l. c. quotes it from Fleinvær and Givær, not far from Bodö, and I gathered a specimen, however, uncertain at Borgevær in Lofoten, apparently anastomosing with *L. varians* and mentioned under this species.

Geogr. Distribution. Spitzbergen and the west coast of No-

vaya Zemlya (Kjellman); the coast of Russian Lapland (Gobi); Greenland (Rosenvinge); Iceland (Strömfelt).

Lithothamnion breviaxe Fosl. mscr.

L. fronde initio plerumque circum lapides vel conchas effusa(?), demum libera in fundo jacente, diametro usque 20 cm., irregulariter subdichotome ramosa, ramis brevibus, confertis, subcylindricis, 2 mm. crassis, plus minus coalitis, parte superiore uno alterove ramulo brevissimo, verrucæformi sæpe præditis, apicibus obtusis; conceptaculis sporangiferis convexiusculis at parum prominentibus, diametro a superficie visa 350—450 μ ; conceptaculis cystocarpiferis depresso-conicis, diametro 400—500 μ . Sporangii quaternas sporas foventibus, circa 160 μ longis, 45 μ latis. Tab. 2.

Description of the species. Of this plant I have seen but an old specimen, and a younger one probably belonging to the same form, and besides I met with some few others anastomosing with a form of *L. glaciale*. However, this anastomose was in most cases so thoroughly, that any limit is impossible to draw especially in the central or lower part of the plants. Pl. 2, fig. 2. The named younger specimen appears not to have been fastened to any harder object, subglobose and branched from the centre, but here the branches rather anastomosed in an apparently early stage of development. The other and old specimen appears to have at least in part encompassed a stone or another object, which later is fallen out. It is about 22 cm. long, 15 cm. broad at the broadest part and 8—10 cm. in thickness. Pl. 2, fig. 1. It is in part somewhat hollow, and has apparently at first been provided with a thinner crustlike hypothallus, but shows in an older stage only here and there a tendency to continue a crustlike development of this hypothallus, or is in part rather rubbed. The specimen is branched in an irregular subdichotomous or trichotome manner, with very short axes. The branches are densely crowded in the upper part as well as in that turning towards the bottom, subcylindrical and about 2 mm. thick, partly rather straight partly somewhat bent and frequently fastigate, and the ends as a rule

obtuse. The upper part of the branches often carry some short, wartlike process, and especially the lower part rather anastomosing.

The structure of the frond accords with that of *L. fruticulosum*. The cup-shaped layers of tissue are rather regular and distinct.

The conceptacles of sporangia are convex, but little prominent, seen from the surface 350—450 μ in diameter and scattered in the upper part of the branches, more seldom somewhat crowded. The roof is intersected with 60—70 muciferous canals, rather thin and gets occasionally quite dissolved, and the scar effaced by local formations of tissue, frequently, however, only the central portion, as in most other species of this section. I succeeded in finding but some few sporangia, however, not all fully developed. Mature ones are four-parted, about 160 μ long and 45 μ broad. Overgrown conceptacles are very scarce in the specimens that I have examined.

The conceptacles of cystocarps are conical, low, traversed by a canal at the summit, and 400—500 μ in diameter at the base. I found some few ones on a younger branch developed in the outer part of the cavity of the plant. I have not seen the carpospores.

Relation to other species. This plant seems to be closely related to *L. fruticosum*, or in some respects forming an intermediate species between this and *L. glaciale*, more nearly allied, however, to the former and sometimes apparently difficult to distinguish. In habit it stands between *L. fruticosum* f. *typica* and f. *fastigiata*, and is separated especially as regards the conceptacles of sporangia and its tendency to form a crustlike hypothallus.

Habitat. The species grows on hard bottom on a depth of 5—6 fathom, found together with *L. glaciale* and *L. fruticosum* in a somewhat sheltered harbour. Specimens taken in the beginning of August were rather richly furnished with conceptacles of sporangia, most of which, however, emptied, and others with in part apparently ripe sporangia.

Occurrence. Only found at Kjelmö in East-Finmarken, where it appears to be rare.

Lithothamnion fruticulosum (Kütz.) Fosl. mscr.

Spongites fruticulosa Kütz. Polyp. calcif. p. 33; Spec. Alg. p. 699. Lithothamnion fasciculatum Hauck, Meeresalg. p. 274; excl. syn. plur.

f. *typica* Fosl. mscr.

Descr. Lithothamnion fasciculatum β fruticulosum Hauck l. c. p. 274.

Fig. " " " " l. c. t. III, fig. 10, t. V, fig. 4-5.

" Spongites fruticulosa Kütz. Tab. Phyc. 19, t. 99.

" Lithothamnion fruticulosum f. *typica* tab. nostr. 3 et 4, fig. 1-2.

f. *fastigiata* Fosl. mscr.

f. ramis valde coalitis, fastigiatis, apicibus obtusis vel truncatis.

Tab. 5.

f. *intermedia* (Kjellm.) Fosl. mscr.

Lithothamnion intermedium Kjellm. N. Ish. Algfl. p. 127 (97).

Descr. et Fig. Lithothamnion intermedium Kjellm. l. c. et t. 4, fig. 2.

f. *nana* Fosl.

Contrib. II, p. 6.

Descr. et Fig. Lithothamnion intermedium f. *nana* Fosl. l. c. et t. 3, fig. 5.

f. *glomerata* Fosl. mscr.

f. fasciculis subglobosis e parte centrali solida undique egredientibus, ramis brevissimis. Tab. 4, fig. 3.

f. *corymbiformis* Fosl. mscr.

f. fasciculis subcorymbosis e parte centrali lobata undique egredientibus; ramis superioribus non vel parce coalitis, circa 2.5 mm. crassis. Tab. 6.

f. *curvirostra* Fosl. mscr.

f. ramis superioribus curvatis, plerumque elongato-conicis vel subulatis, apicibus obtusis vel acuminatis.

Fig. Spongites ramulosa Kütz. Tab. Phyc. 19, t. 99 (excl. concept. sporang.).

f. *flexuosa* Fosl. mscr.

Descr. Lithothamnion fasciculatum s. s. Hauck l. c.

Fig. " " " t. III, fig. 11; t. V, fig. 3.

" " fruticulosum f. *flexuosa* tab. nostr. 7-8.

Syn. Apora polymorpha Gunn. in Act. Nidros. IV, p. 71; ex parte; t. 15, fig. 1.

Nullipora polymorpha Johnst. Brit. Spong. and Lithoph. p. 238; ex parte pl. 24, fig. 2?

Melobesia fasciculata Harv. Phyc. Brit. pl. 74; Man. p. 108; ex parte?

- Syn.* Lithothamnion ramulosum Phil. in Wieg. Arch. p. 388; Kütz. Tab. Phyc. 19, p. 35; Aresch. in J. Ag. Spec. Alg. 2, p. 524?
 Lithothamnion ramulosum Solms Laub. Corall. p. 19; ex parte?
 „ fasciculatum Farl. New Engl. Alg. p. 182; ex parte.
 „ Ungerii Kjellm. N. Ish. Algfl. p. 120 (91); excl. syn.; Fosl. Contrib. I, p. 8.
 „ intermedium Strömf. Algveg. Isl. p. 19; Fosl. Contrib. I, p. 7.
 „ „ Rosenv. Grönl. Havalg. p. 774?

Remark on the determination of the species. As quoted below under *L. crassum* I consider *L. fasciculatum* (Lam.) to be most nearly connected or probably identic with that species. I consequently do not adopt this name for the plant, that Hauck l. c. more nearly describes under the name of *L. fasciculatum*. Judging from authentic specimens of the latter that I have seen, it in my opinion appears not to be identic with Lamarck's plant, although probably nearly related to it. I on the other hand agree with Hauck, that his plant most probably is to be referred to the same series of forms as *L. fruticosum* (Kütz.), considered by Hauck a variety of his *L. fasciculatum*, though in part rather differing from that. Taking *L. fruticosum* (Kütz.) in the same sense as Hauck it appears to constitute the typical form of a Lithothamnion, which on the one side approaches *L. glaciale* and other species in habit, on the other side being closely related to *L. crassum* Phil., and I regard the named typical *L. fasciculatum* Hauck as one of the most extreme forms of this species, the above f. *flexuosa*.

However, the limits between this species and *L. crassum* are not easily drawn neither in regard to the external shape nor to the structure. Hauck remarks l. c. „Manche Formen sind schwer von *L. crassum* zu unterscheiden“. I have seen too few specimens of the latter, an apparently more southern species, to be able to get any clear idea of their affinity to each other. In their typical forms they certainly are easily distinguished and even more differing than several other species of this genus. But on the other hand *L. fruticosum* is much varying and shows in its most extreme forms close affinity chiefly to *L. crassum*, and even to various other species which in their typical development are quite

different. They appear, so far as I have seen, to be distinguished especially as to the shape and size of the conceptacles of sporangia.

Remark on the definition of the form. The present plant includes numerous forms, the principal of which are quoted above. A couple of these might perhaps be regarded as separate species, but it has not been possible to draw any true limit, and I, therefore, regard them as forms of the species in question, to which they appear at least to be closely related.

Through the kindness of Mad. A. Weber van Bosse I have had the opportunity to examine three specimens from Hauck's herbarium of his *L. fasciculatum* β *fruticulosum*. One of these fully accords with specimens in my collection of the above f. *typica*. Cp. pl. 3. The second is a younger individual, probably belonging to the same form. The third may perhaps also be referrible to this form, but on the other hand it rather reminds one of *L. nodulosum* in habit, nor did I succeed in finding overgrown conceptacles of sporangia. The form is somewhat varying, but in general easily recognized. The branches more or less densely crowded are in Hauck's as well as in my specimens generally 1.5—2 mm. thick, rather anostomosing especially in older individuals, and frequently carrying short and wart-like or longer and branch-like processes. Pl. 3 and Hauck l. c. Much attacked by boring-muscles it occasionally becomes more or less hollow and opened in the lower part, but it apparently never assumes a cup-shaped form like several other Lithothamnia. In old specimens growing in shallow water with strong currents the upper branches frequently become more or less denuded, or bitten off, the rest afterwards in part anastomosing, forming crustlike expansions, or here and there with new branches in development. Pl. 3, fig. 6 and pl. 4, fig. 1—2. This form is in general to be found freely developed on the bottom, seldom encompassing shells or smaller stones. It attains a diameter of about 15 cm., more frequently, however, about 10 cm. or less.

The form *fastigiata* is nearly connected with the typical form. Pl. 5, fig. 7 represents a specimen somewhat approaching the latter. It also commonly develops freely on the bottom, sometimes fastened

to but seldom encompassing smaller stones. However, growing more scattered, or in the periphery of a greater bank it often fastens itself, apparently in a somewhat advanced stage of development, to smaller stones, but later again it appears to loosen itself from the stone. Pl. 5, fig. 4. Occasionally different individuals become confluent. Pl. 5, fig. 3. In shallow sounds with rapid tides the frond often gets rather compressed, forming subhemispherical masses, that attain a diameter of 12 cm., more commonly, however, globose or subglobose and about 8 cm. in diameter, or less. The branches are short, generally shorter than in *f. typica*, very densely crowded, straight and level-topped, and towards the apex nearly always carrying short and wart-like processes. It is much anastomosing especially in the central portion and here now and then forming lobes, however, the anastomose frequently extending pretty far upwards, and here and there even nearly to the tip of the branches. The ends are as a rule obtuse or almost truncate; but particularly if being under the influence of rapid tides they become quite truncate in the part turning upwards, or also in the part turning towards the bottom, but, so far as I have seen, more seldom only in the last named part, and sometimes nearly disc-shaped. Under such conditions the upper part of the branches occasionally gets denuded, as in the typical form, however, apparently more seldom than in the latter. The plant frequently is much attacked chiefly by boring-muscles, and, as is common at least in nearly all the northern Lithothamnia, intersected with numerous passages made by worms, occasionally leaving only a thin peripheral portion; or a part of the plant, or even the whole plant collapses. Pl. 5, fig. 4.

I have not been able to draw any limit at all between the plant that Kjellman l. c. describes under the name of *L. intermedium* and the present species, and I, therefore, consider it a form of this species. Specimens determined by Kjellman himself show transitions especially to the typical form of *L. fruticosum*, and, as I apprehend Kjellman's description of his plant, it in part includes the named form. Thus fig. 1 on pl. 4 l. c. can scarcely be separated from *L. fruticosum f. typica* in the sense the latter

is taken by me. Cp. pl. 3. I on the other hand regard the plant delineated l. c. pl. 4, fig. 2 as typical or nearly typical f. *intermedia*. This form is characterized by its central or lower portion forming coarse and clumsy lobes, which are coarser than such ones in f. *typica*, or sometimes being nearly solid. From the named lobes issue simple and rather coarse, most often conically cylindrical branches with obtuse ends, now and then carrying wart-like processes. This form frequently encompasses smaller stones, and it apparently seldom attains any considerable size.

The form *nana* is in the cited paper recorded as little independent. It is rather characteristic in its typical development, but intermediate forms between this one and partly f. *typica* partly f. *intermedia* and occasionally even f. *curvirostra* are more generally to be found than quite typical specimens. It frequently is only 0.5—1.5 cm. in diameter.

The form *glomerata* is characterized by its generally solid central portion or occasionally coarse lobes, from which issue in all directions subglobose bundles of branches. These bundles are composed of very short branches, in their upper part carrying wart-like processes, and nearly always rather anastomosing, often even towards the apex. Pl. 4, fig. 3. The ends are rounded or obtuse. If not much attacked by animals the central part is continuing thick and solid, or intersected with cavities and canals, encompassing smaller stones, or not, but if attacked especially in a younger stage it forms coarse and clumsy lobes, and the plant sometimes at length becomes quite hollow. It attains a diameter of about 10 cm.

A rather independent plant is f. *corymbiformis*, and it, perhaps, ought to be regarded as a separate species. However, I have seen but few specimens of this form. On the one side it appears to pass into the typical form and on the other is nearly connected with f. *glomerata*, or even showing close affinity to f. *flexuosa*. It never forms a solid central portion, but coarser lobes, although not so coarse as in the preceding form. From the named lobes issue subcorymbose clusters of branches, which are far less anastomosing than in f. *glomerata*, but on the other hand coarser,

about 2.5 mm. in diameter, with longer and branch-like or shorter and wart-like processes. The ends are obtuse or, not seldom, somewhat spherically thickened. Pl. 6, fig. 1. This form also becomes more or less hollow, caused by animals, especially boring muscles. Pl. 6, fig. 2 represents the upper part of a specimen, by which most of the branches are denudated, and rather more than those of the lower part of the plant. Fig. 3 on the same plate shows the lower and much denudated portion of a specimen most nearly related to this form, but in the upper and not denudated part not forming distinct bundles. It is hollow, and the cavity occupied by *Mytilus*, *Pecten* and other animals.

The form that I have named f. *curvirostra* so nearly accords in habit with the plant figured by Kützing l. c., that I have referred to it. It is *L. ramulosum* Phil., and Kützing got the specimen from Philippi himself. Cp. l. c. p. 35. I, however, am not sure whether my form in fact may be identic with that, as the apparently numerous conceptacles of sporangia, scattered or partly crowded over the whole plant in Kützing's figure, do not agree with my specimens, being larger and apparently more superficial. Hauck l. c. certainly refers this plant to his *L. fasciculatum*, and it appears rather probable that they are identic and the conceptacles only delineated too large in Kützing's figure. However, I do not adopt that name for the form in question, until an authentic specimen has been examined, as besides more species probably have been recorded under the same name. This form is, most commonly, at first fastened to smaller stones, but it soon loosens itself and lies free on the bottom, then forming roundish balls about 4—5 cm. in diameter. It seldom encompasses stones. The lower branches are more or less anastomosing, the upper ones rather spreading and most often curved, at the base about 2 mm. thick, elongated conical and acute in typically developed specimens. In others, however, the branches are often conically cylindrical and obtuse, seldom nearly cylindrical, and in the upper part occasionally bearing some wart-like process. Such specimens form transitions to f. *flexuosa*, and in part nearly related especially to Adriatic specimens of the last named form, which frequently

appear to be smaller than northern ones, and, being more densely branched, even to f. *typica*. It seems not to be any well defined form, although it deserves to be specially mentioned.

As quoted above, I consider the typical *L. fasciculatum* Hauck to be one of the most extreme forms of the present species, the above f. *flexuosa*. I have seen 3 authentic specimens determined by Hauck as „*L. fasciculatum*.“ The one of these agrees with specimens in my collection referred to f. *typica*. The two others accord with the form *flexuosa*, smaller but otherwise fully resembling the specimen represented pl. 7, fig. 1. This form apparently gets much larger with us than in the Adriatic Sea, attaining a diameter of up to 15 cm., or more, and as a rule freely developed on the bottom. I very seldom met with it fastened to or encompassing shells. The branches are less crowded than in f. *typica*, in the lower or central portion rather coarse, or forming smaller lobes, and more or less anastomosing, though far less than in the named form. They are rather spreading in the peripheral portion, much bent and about 2 mm. in diameter, cylindrical, or sometimes slightly tapering towards the obtuse ends, which, however, now and then may be a little roundish-thickened. Pl. 7, fig. 1—2. It sometimes is rather rubbed in the part turning towards the bottom, and now and then in part hollow. Pl. 7, fig. 3 represents a transition to f. *typica*, partly with the upper branches somewhat denuded. The form occasionally is provided with an apparently coarse hypothallus. Cp. pl. 8, fig. 1. This is, however, produced by epiphytic Lithothamnia, mostly *L. flavescens*. The specimen that Hauck delineates l. c. t. V, fig. 3 looks coarser than the specimens which I have seen from his herbarium, on the one side resembling and probably identic with f. *flexuosa* in the sense here taken, but on the other side reminding one of certain forms of *L. tophiforme*. A similar, but larger, form is represented on pl. 8, fig. 2. This also is coarser than typical f. *flexuosa*, closely related to or probably identic with the latter, but on the other hand it coincides in several particulars with *L. tophiforme*. I met with this form in one locality growing in company with f. *typica*, typical specimens of f. *flexuosa* and *L. tophiforme*. In another locality I found the

latter, f. *typica* and transitions to f. *flexuosa* growing together. It is not unlikely that this form in part constitutes a hybrid between *L. fruticosum* and *L. tophiforme*, but on the other hand, as remarked p. 3, it appears nearly impossible in this extremely varying group of species to decide whether hybrids in fact arise. The figured specimen exhibits transition to typical f. *flexuosa*, however, also closely approaching certain forms of *L. tophiforme*, that a limit is very difficult to draw, and I possess several sterile specimens which I have not been able to identify with certainty, as also *L. tophiforme* shows a tendency to develop itself in the same direction. It is nearly always sterile, or some other specimen very scantily provided with conceptacles of cystocarps and sporangia, the latter in this as well as in typical specimens of f. *flexuosa* sometimes approaching those of *L. tophiforme*. I, however, have not succeeded in finding the sporangia in the named most extreme form, and it may be that this form in fact represents a separate species.

The structure of the frond is described by Kjellman l. c. I here only want to remark, that the inner cells of the cup-shaped layers in the branches or processes frequently appear to be about 10—12 μ long and 5—6 μ thick. The named layers are more or less regular, in part depending on older overgrown conceptacles of sporangia.

The reproductive organs of this species are also described by Kjellman l. c. The conceptacles of sporangia in f. *typica*, f. *fastigiata*, f. *intermedia*, f. *glomerata* and f. *curvirostra* resemble each other. They are scattered especially in the processes or upper part of the branches or occasionally somewhat crowded, very little prominent, in part not distinctly marked, and the slightly convex roof frequently about 250—300 μ in diameter, more seldom only about 200 μ . The roof is rather thick, and the muciferous canals appear to be visible from the surface first in a rather late stage of development of the conceptacles. In some specimens I partly found the central or greater portion of the roof thinly decorticated, and the canals visible and distinct in a number of about 30—40, partly not decorticated and the canals not visible. However, in

other specimens I found the roof apparently not decorticated, but the canals visible, so that this decortication perhaps may be attended on external causes. Later the middle part of the roof gets quite dissolved, more seldom the whole roof. The sporangia I frequently found to be 110—140 μ long, occasionally only about 90 or up to 150 μ , and 35—45 μ broad, seldom even up to 60 μ . The thickness apparently is about $\frac{1}{3}$ of the breadth, or more.¹⁾ In f. *nana* the conceptacles as well as the sporangia themselves are slightly smaller than is general in the above quoted forms. In f. *flexuosa* they frequently agree with those in the other forms, but on the other hand sometimes a little larger, more distinct and more prominent, the roof up to 350 μ in diameter, thinner and more easily dissolvable or falling away than in any of the other forms. Hauck l. c. records the conceptacles to be „flach-warzenförmig“, which, so far as I have seen, accords rather better with those of *L. crassum*. In one of his specimens of f. *flexuosa* I found some few very little prominent, convex, but in part not sharply marked and in all fully agreeing with typical ones of the present species. In f. *corymbiformis* I have only seen overgrown conceptacles, which in a median section are of about the same size as in f. *typica*.

Overgrown conceptacles in general are to be found only in the peripheral portion of the branches or processes, rather seldom in any greater number. They appear to be proportionally most common in the forms *fastigiata*, *intermedia*, *nana*, *glomerata* and *curvirostra*. In f. *typica* they sometimes are rather numerous, sometimes very few or apparently wanting, which appears to relate to the fact that the plant does not probably always develop the named organs, or that the whole roof occasionally falls away and the conceptacle becomes effaced by local formations of tissue, as for inst. in *L. glaciale*. In f. *flexuosa* overgrown conceptacles

¹⁾ The sporangia of the present genus altogether appear to be convex-concave and thickest in the middle, and, therefore, the measures of the thickness only are approximate. They appear partly to be thicker partly and apparently more frequently thinner in proportion to the breadth than above quoted, but more exactly measures are not to be got without dissecting the sporangia, which, however, may not be required in a systematic point of view, as they also in this respect seem to be rather varying.

partly and most often occur in small numbers, partly not, and especially in the most extreme form of this type the overgrown as well as superficial ones appear to be very scarce. Also in Adriatic specimens of the two last named forms older grown-in organs of this kind seem to be scarce. Now and then occur apparently two-parted overgrown sporangia in this species, but these probably have not been fully developed before they together with the conceptacles grew down into the frond.

The cystocarpic conceptacles are in the present species conical, low, seldom somewhat acute, about 400—500 μ in diameter at the base. Some other conceptacles, only 200—300 μ in diameter at the base and in shape coinciding with the former, probably are those of antheridia. I have not seen the carpospores, nor the spermatia. These organs are on the whole scarce in the specimens that I have collected, and scattered in the branches without any order. Also in this respect the form *flexuosa* in part rather differs from the typical development, as I found the conceptacles of cystocarps in some cases to be more acute than ever in f. *typica* or in other and more typical specimens of f. *flexuosa* as well as in Adriatic specimens of the latter, somewhat reminding one of these organs in *L. tophiforme*.

Remark on the synonymy. I suppose that Gunnerus referred to his *Apora polymorpha* all the Lithothamnia then known to him. Among the 4 specimens mentioned under *L. boreale* apparently from his own collection¹⁾ are two which, no doubt, belong to the present species, the one nearly according with the cited figure in Act. Nidros., referrible to the form *fastigiata*.

The figures that Johnston l. c. gives of his *L. polymorphum* are much differing from each other and most probably designate different species, and even still more judging from his list of synonyms. Thus the plant that he delineates l. c. pl. 24, fig. 2 very much reminds one of f. *intermedia* of the present species, to which it probably belongs. The other forms referred by him to the same species will be mentioned under *L. crassum* and *L. incrustans*.

As remarked below under *L. crassum* Phil. I consider *L.*

¹⁾ Cp. Wittrup, Catal. p. 88.

fasciculatum Harv. in the main to be referrible to that species. By the liberal communications of Mr. Batters as to Harvey's Lithothamnia there are, so far as he knows, no really authentic specimens in existence. I, however, got under the name of *L. fasciculatum* two specimens gathered by Mr. G. W. Traill at Falmouth, where the plant according to Mr. Batters has grown in the same locality since Harvey's time. They unfortunately are dead, bleached and rather rubbed, probably found cast on shore, and they cannot be determined with certainty, very likely, however, belonging to *L. fruticosum* and most closely related to the typical form.

I in part refer *L. fasciculatum* Farl. to the species in question, on the authority of Mr. F. S. Collins, who kindly sent me a specimen stated to be the form recorded by Farlow l. c. under that name. It is said to be „common in pools at low-water mark along the coast of Maine“. However, it appears, as if the specimen that I got has been washed ashore from the sublitoral region. This specimen I without any doubt refer to *L. fruticosum*, standing between f. *typica* and f. *intermedia*, however, most nearly related to the latter. It is only 2—3 cm. in diameter, having apparently at first nearly surrounded a stone or another hard object, which is fallen out, and the cavity appears partly being effaced by new-formed tissue. The conceptacles are very little prominent and slightly convex, the roof about 250 μ in diameter, intersected with about 30 canals, and they finally grow down into the frond. The four-parted sporangia are 90—115 μ long and 35—45 μ broad. A specimen kindly sent me by Prof. Farlow himself will be mentioned under *L. colliculosum*.

Another specimen that I received from Mr. Collins most probably belongs to the form *fastigiata*. Collins' coll. A. „Eagle Island, Maine. In pools at dead low water“. It is sterile and fragmentary, but has apparently been small, about 2—3 cm. in diameter. The lower part shows a tendency to form lobes, the branches fastigiate, with short axes, and rather anastomosing. The ends are obtuse or truncate, but in part somewhat denudated. The structure also accords with that of *L. fruticosum*. Overgrown

conceptacles are numerous, and in one of these I found a solitary sporangium, about 100 μ long and 50 μ broad, but I was not able to determine the partition.

Prof. Kjellman records l. c. a Lithothamnion under the name of *L. Ungerii*, which he, among others, got from me, gathered at Tromsö. He identifies this plant with *L. byssoides* Unger, Leithakalk p. 19—20, t. 5, fig. 1—8. In Contrib. l. c. I followed Kjellman and quoted the plant under the same name from East-Finmarken, by comparison of specimens determined by Kjellman himself. However, I then perhaps referred to it some specimens now considered to belong to another species. Later I have had the advantage of seeing Unger's description, and I also brought together greater and better materials as then for the classification of these much varying algæ. Two fragmentary specimens that I got back from Prof. Kjellman denominated as above agree with the form *typica* of the present species, the one, however, showing transition to f. *corymbiformis* and provided with an apparently coarse hypothallus like the above mentioned specimen figured pl. 8, fig. 1, but also this infested with an epiphytic Lithothamnion. He remarks, that the conceptacles of sporangia never grow down into the frond. I, however, found in the named specimens older grown-in organs of this kind, but they are scarce, which, as quoted above, is often the case in f. *typica*. It may be that Kjellman's plant includes also another species, or, more likely, the overgrown conceptacles escaped his observations. The specimens then known were sterile. I on the other hand do not coincide with Kjellman, that this form may be considered identic with the named species described by Unger l. c. This appears to be a smaller plant, with thinner branches, but otherwise certainly somewhat reminding one of *L. fruticulosum* f. *typica*. I think it identic with *L. gracilescens* described below.

Relation to other species. This species apparently has originated in more southern wathers than for inst. *L. glaciale*, and it is not unlikely that several other Lithothamnia have issued from it, as *L. crassum*, or vice-versa, *L. brevixae*, *L. divergens*, *L. apiculatum*, *L. dimorphum* and perhaps also *L. mamillosum*, and

others. It is, as remarked above, nearly connected with *L. cras-sum*, but shows closer affinity also to the other named species, as well as *L. glaciale* in habit, and sterile specimens are sometimes not easily separated from the latter. The form *intermedia* may especially in a younger stage even be confounded with *L. colliculosum*. The distinction between the present plant and *L. divergens*, *L. apicalatum* and *L. dimorphum* will be quoted under the named species.

I have seen three authentic specimens of *L. mamillosum* Hauck, Meeresalg. p. 272, which I propose to name *L. Hauckii*¹⁾, a species closely related to *L. fruticulosum* in habit, and probably sterile specimens may often only with difficulty be separated from the typical form of this. Cp. Hauck l. c. t. 5, fig. 1 and 5. However, it appears to be somewhat coarser, the apex of the branches sometimes rather acute and also showing some diversities of structure, the latter apparently coarser than in *L. fruticulosum*. Specimens bearing cystocarpic conceptacles are identified at a glance. These organs I found in the named specimens commonly to be 500—800 μ in diameter at the base, sometimes a little more, and of a considerable height. Hauck l. c. quotes them in general being about 1 mm. in diameter. The elongated tip seems to fall easily away, and then the conceptacles look rather low, though still higher than in *L. fruticulosum*. Besides, I found some other in shape similar conceptacles only about 300 μ in diameter, which perhaps are those of antheridia. Conceptacles of sporangia appear to be unknown.

Habitat. The plant lives in the upper part of the sublitoral region, on a depth of 1—10 fathom. It prefers sheltered places and rather hard bottom, partly more scattered (especially f. *intermedia*, f. *nana*, f. *glomerata*, f. *corymbiformis*) partly abundant or in great masses (especially f. *typica*, f. *fastigiata* and partly also f. *flexuosa*), not seldom in sounds with strong currents. Sporangia-bearing specimens have been taken in June, July and

1) Gumbel, Die sogen. Nullip. p. 41 records a fossil Lithothamnion by the name of *L. mamillosum* and, therefore, I propose the species to be named after the late Dr. F. Hauck.

August, and scantily provided with conceptacles of sporocarps in July and August.

Occurrence. The species, as understood in the above mentioned comprehensive sense, is not unlikely dispersed nearly along the whole of the Norwegian coast. It has been found at Kjelmö in Sydvaranger, pretty plentiful but local (f. *typica*); Bugönes, washed ashore (f. *intermedia*?); Vadsö, cast on shore in rather great numbers (f. *typica* and f. *intermedia*); Vardö (f. *typica*, f. *glomerata*); Havningberg, washed ashore (f. *intermedia*); Lebesby, apparently rather scarce (f. *intermedia*); Kistrand, rare (f. *glomerata*); Honningsvaag, washed ashore (f. *intermedia*?); Sopnes in Altenfjord, rare (an uncertain form, perhaps f. *flexuosa*); Skorpen in Kvænangen, scattered and rather scarce (f. *typica*, f. *intermedia*, f. *nana*, f. *curvirostra*); Karlsö (Kjellman), scattered (f. *intermedia*); Lyngö, rare (f. *glomerata*); Tromsö, abundant but rather local (f. *typica*, f. *intermedia*, f. *flexuosa*, f. *corymbiformis*); Mester-vik in Malangen (an uncertain form, perhaps f. *flexuosa*); Borgevær in Lofoten, cast on shore (f. *typica*); Herö in Helgeland (Kr. Schreiner), apparently not uncommon (f. *typica* and f. *intermedia*); Beian, abundant but rather local (f. *typica* and f. *fastigiata*); and Moltuen (Værnes) in the Trondhjem Fjord (Sigvald Schmidt-Nielsen), apparently scarce (f. *curvirostra*). It probably also occurs along the south-western coast, however, principally but some few and smaller *Lithothamnion* are known from there.

Geogr. Distribution. Iceland (Strömfelt); Greenland (Rosen-vinge)? Britain (Harvey, Johnston, Traill)? The Mediterranean Sea (Kützing); the Adriatic Sea (Hauck); the Atlantic coast of North America (Farlow, Collins).

Lithothamnion crassum Phil.

in Wieg. Arch. p. 388; Hauck, Meeresalg. p. 273.

f. *typica* Fosl. mscr.

f. ramis tenuioribus, in parte superiore sæpe subcompressis, non vel parce coalitis.

Fig. *Lithothamnion crassum* Hauck l. c. t. 1, fig. 1, 3.

f. *capitellata* Fosl. mscr.

f. ramis plerumque crassioribus, validis, valde coalitis, apicibus crassis, rotundatis.

Fig. Lithothamnion crassum Hauck l. c. t. 1, fig. 2.

Syn. Millepora fasciculata Lam. Hist. Anim. 2, p. 311?

Nullipora " Johnst. Brit. Spong. and Lithoph. p. 240, pl. 24, fig. 6.

" polymorpha Johnst. l. c. p. 238; ex parte; t. 24, fig. 1, 3.

Melobesia fasciculata Harv. Phyc. Brit. pl. 74; Man. p. 108; saltem ex parte.

Spongites crassa Kütz. Tab. Phyc. 19, p. 35, t. 99.

" fasciculata Kütz. Spec. Alg. p. 699; fide syn.

Lithothamnion fasciculatum Aresch. in J. Ag. Spec. Alg. 2, p. 522; ex parte fide syn.

" " Crn. Fl. Finist. p. 151?

" racemus Aresch. in J. Ag. l. c. p. 521; Crn. l. c. p. 151; Solms Laub. p. 17; ex parte?

Remark on the determination of the species. There can be no doubt as to the identity of this species. The figure by Kützing l. c. is from a specimen that he got from Philippi himself, and it on the other hand accords well with Hauck's description and figures. Through the kindness of Mad. A. Weber van Bosse I have had the opportunity to examine three authentic specimens from Hauck's herbarium. Two of these nearly coincide with fig. 1 and 3 l. c., the above f. *typica*, and the third one forming transition or most nearly related to f. *capitellata*. The species seems to be rather varying and probably includes more forms. I, however, have seen but some few specimens.

Remark on the form and addition to the description of the species. The form that I apprehend as the typical one is densely branched, but the branches appear to be rather thin and apparently less anastomosing, probably most often only in the lower or inner part, always, however, thickening towards the apex, and especially here often somewhat compressed, with the ends frequently rather obtuse or nearly truncate, or even depressed in the centre. This form has not been found with us.

A solitary specimen from Mandal nearly agreeing with fig. 2 by Hauck l. c. I refer to the above f. *capitellata*, as well as another one found washed ashore at Kragerö and scantily provided

with conceptacles of sporangia. The named form is characterized by its in general apparently more vigorous and coarse branches, which probably as a rule become much anastomosing and in part even nearly to the apex, the latter being thick and rounded.

The structure of the frond agrees in the main with that of *L. fruticulosum*. The cup-shaped layers of tissue are rather regular. The inner cells of these layers are about 12—16 μ long and 6—8 μ thick, thus in general apparently a little larger, and often a little thicker in proportion to the length than in the named species. Overgrown conceptacles are partly scarce partly numerous.

The cystocarpic conceptacles, which are mentioned by Hauck l. c., are conical, low, and about 400 μ in diameter at the base. They are at the summit intersected with a canal, which, contrary to most other species, appear to be formed in a rather advanced state of the development of the conceptacles, as in others and apparently nearly fully developed ones the canal was not visible. I, however, have seen but some few ones in one of Hauck's specimens of the typical form. The carpospores are much varying both in shape and size.

I found conceptacles of sporangia in the above mentioned specimen of the form *capitellata* from Hauck's herbarium. They are scattered or somewhat crowded towards the apex of the branches, slightly prominent and in general rather flattened, 350—450 μ in diameter, seldom less. A British specimen mentioned below has been richly provided with conceptacles of sporangia, scattered and in part crowded nearly over the whole frond, but it is dead and the roofs quite dissolved except some few according to those quoted. However, judging also from the holes after the conceptacles, they seem to have been a little smaller, or about 350—400 μ in diameter. In the above named Norwegian specimen I also found some similar conceptacles. The canals appear not to be numerous. I have numbered about 30—40. The sporangia, of which I have seen but some few, are four-parted and about 160 μ long and 40 μ broad.

Remark on the synonymy. It is a fact, that in *Lithothamnion* the various species have been more confounded and diffe-

rently understood by different authors than in any other genus of the higher algæ. It is, therefore, in many cases impossible, without having access to original specimens, to determine what an author has meant by a species recorded. In this respect *L. fasciculatum* (Lam.) affords a striking example. It has been very differently understood, and under this name have been quoted more sharply distinguished species. Even by Areschoug, the monographer of the Corallineæ, this species is taken in a wide sense probably including at least 3—4 species now separated, for inst. *L. glaciale*, *L. crassum* (*L. fasciculatum* Harv.), *L. tophiforme* (*L. soriferum* Kjellm.) and *L. apiculatum*. Cp. Kjellm. l. c. and below under the named species. The plant to which this name was originally applied by Lamarck is considered by Kjellman l. c. to be a species nearly related to *L. tophiforme* (*L. soriferum*), but in some respects different. It certainly is impossible to know what has really here been stated. I agree with Kjellman, that the character „ramis . . . apice incrassatis, obtusis“ does not in general accord with *L. tophiforme*, although the last named species includes a form a little thickened towards the apex of the branches, and the latter even truncate or nearly truncate. This form I, however, regard a merely local one, of which I have seen some few specimens from Finmarken. The plant that Kjellman from oral information considers to be identic with *L. fasciculatum* will be mentioned under *L. dimorphum*. In my opinion *L. (Millepora) fasciculatum* Lam. is identic with the present plant, the characters quoted on the whole pretty well according with certain forms of this species, and appears to have been apprehended in like manner by Johnston, Harvey and Crouan.

Melobesia fasciculata Harv. I suppose most essentially being included in the species in question, and is considered by Harvey himself not unlikely to be the same as *L. crassum* Phil. It is by Hauck l. c. referred to his *L. fasciculatum* (*L. fruticulosum*), but this I think rather to be a slip of the pen. The figure 1 in Phyc. Brit. l. c. much reminds one of *L. crassum*, and fig. 2 appears also to be a form of the same species, if not, perhaps, more nearly related to *L. incrustans* f. *Harveyi*. Besides, Harvey remarks

l. c., that the branches are „remarkably truncated at the tips, which are moreover depressed in the centre. These broad, flattened or subconcave tips are the least variable character of the species“. So far as my experiences goes, this is not due to any form of *L. fruticosum*, or any other species hitherto known but *L. crassum*, in the latter, however, apparently often occurring. So also in regard to one of Hauck's specimens of the typical form. I got a specimen collected at Falmouth by Mr. R. N. Tellan and determined by Mr. Batters as *L. crassum*, also by him considered in part identic with Harvey's plant. It has a nearly solid central portion, and the densely crowded and nearly fastigiata, rather coarse branches are very short and almost simple, with rounded-thickened ends, and in all most closely connected with the above f. *capitellata*.

Nullipora fasciculata Johnst. doubtlessly belongs to the same series of forms. Cp. l. c. pl. 24, fig. 6. Besides, probably also in part his *L. polymorphum*. Thus pl. 24, fig. 1 and 3 l. c. appear likewise to be referrible to the present species.

Of *L. fasciculatum* Crn. I have seen some fragments of an authentic specimen from Crouan's collection in Museum d'Histoire Naturelle of Paris. They are, however, too small to be determined with certainty, as they are also sterile. The specimen appears to have been very nearly related to fig. 2 by Harvey l. c., not unlikely being a form of the present species, or perhaps referrible to *L. incrustans* f. *Harveyi*.

L. racemus auct. appears to be a very uncertain plant. Hauck, who has perhaps seen original specimens, refers the form recorded by Solms-Laubach l. c. to *L. crassum*. The plant, to which the name was originally applied by Lamarck l. c. p. 311 I, however, should be most inclined to refer to *L. fruticosum*.

Relation to other species. As quoted under *L. fruticosum* these two species are closely related to one another. However, if the shape and size of the conceptacles of sporangia may prove to be as a general rule like those described above, the species must be considered rather well defined. Also *L. crassum* appears to show some affinity to certain forms of *L. glaciale*, but is separated

by essential characteristics. It apparently sometimes even approaches *L. incrustans* f. *Harveyi* in habit.

Habitat. Unknown to me. The specimens found with us are picked up from the sublitoral region, or found washed ashore. It bears sporangia in summer.

Occurrence. Only known from the most southern part of the coast, gathered at Mandal (Wille) and at Kragerö.

Geogr. Distribution. Britain (Johnston, Harvey, R. N. Tellan); the Atlantic coast of France (Crouan)? The Mediterranean Sea (Philippi); the Adriatic Sea (Hauck).¹⁾

Lithothamnion fornicatum Fosl.

Contrib. II, p. 3; excl. var.

f. *typica* Fosl. mscr.

Deser. *Lithothamnion fornicatum* Fosl. l. c.; excl. var.

Fig. " " " " t. 2 (non t. 1).

f. *robusta* Fosl. mscr.

f. ramis subcylindricis vel sæpe parum incrassatis, 3—5 mm. crassis, apicibus obtusis vel interdum truncatis. Tab. 9.

Addition to the description of the species. I recorded l. c., that the conceptacles of sporangia in this species do not grow down into the frond. I then examined several specimens destitute of grown-in organs of that kind. Later, however, I found such ones in small number especially in the form *robusta*, but also in f. *typica*, although they appear frequently not to be found. This may partly depend thereon, that probably old specimens of the plant in all rather seldom develop reproductive organs, partly that the conceptacles of sporangia apparently do not occur in the same individuals bearing those of cystocarps, which do not become overgrown. Besides, the whole roof of the conceptacles of sporangia seems easily to fall away, although they are very little prominent and the roof apparently nearly as thick as in *L. fruticulosum*, and

1) After this was in the hands of the printer I got some *Lithothamnia* from Mr. P. Harriot of Paris, gathered on the coast of California. Among these is a specimen of the present species, according with Adriatic specimens of f. *typica*. It will be recorded in a separate paper.

in such cases the conceptacles perhaps do not grow down. In one specimen I found numerous small and disc-shaped, slightly projecting, whitish and easily dissolvable processes which probably are local formations that efface scars after emptied conceptacles, but do not accord with similar formations that frequently occur in this and other species, and I do not know whether they may have been conceptacles of sporangia or cystocarps, probably, however, the former. I have occasionally seen scars after filled conceptacles on a section, overlapped by a new thickening layer of the frond.

What I have named f. *typica* is represented in Contrib. 1. c. pl. 2 (not the specimen under the same name on pl. 1) and is in a full-grown stage easily recognized. But on the other hand it is rather varying and assumes more or less irregular forms in its struggle for existence, with more irregular and more anastomosing branches bearing more numerous smaller and wart-like or occasionally longer and branch-like processes, or even showing a tendency to form smaller bundles. The branches frequently are 2.5—3 mm. thick.

The form *robusta* perhaps ought to be considered a separate species, but in the materials at my disposal, with nearly all the specimens sterile, I have not succeeded in drawing any true limit. Nor have I seen old specimens of this form, but in its development at least it very nearly accords with f. *typica*, and the reproductive organs appear to be similar in both, but the branches frequently are much coarser, more regular, with smoother surface.

Also this form is in general at first fastened to shells, forming a very thin crust, which soon produces densely crowded protuberances growing out into short branches divided in a subdichotomous manner. By and by it completely surrounds the object and becomes subspherical or hemispherical, attaining a diameter of about 15 cm., at length loosening itself and lies free on the bottom. The crust always is thin, never, so far as I have seen, increasing in thickness, but on the contrary by and by disappearing. The plant has, like the typical form, a tendency to get hollow and opening itself in the part turning towards the bottom, which, however, apparently is advanced by attack by boring-muscles entering the central

portion. Pl. 9, fig. 1 represents a specimen which is hollow, but has not yet opened itself, and fig. 3 a younger specimen nearly covering the one half of a muscle (*Mytilus modiolus*). The other (lower) half not visible in the figure is in part covered with *L. delapsum* described below, and both species grow over an earlier founded specimen of *L. Strömfeltii*. Hollow, or in the lower side opened or cup-shaped specimens are here much rubbed and the interwalls between the branch-systems visible. The subdichotomously divided branches are short, with axes of at least two orders, probably more, but the lower have always disappeared in older specimens. They are terete or nearly terete, erect, fastigiate and straight, 3—5 mm. thick, frequently slightly enlarged towards the apex, seldom slightly tapering with rounded ends, most often obtuse and occasionally truncate or nearly truncate. The branches are more or less anastomosing, always in their lower part, but often also farther up and nearly to the apex, at or below the latter now and then provided with wart-like processes.

There is a considerable difference in general appearance between typically developed specimens with the tip of the branches obtuse or rounded and those, in which the apex is truncate and even rather disc-shaped. Cp. pl. 9, fig. 4. This appears, however, to be caused by local relations, the part of the plant turning towards the bottom, or other branches of such specimens showing a typical development without any limit at all. I, therefore, do not record this form a separate and named one.

The named form as well as the typical also develops freely on the bottom. In this case it is branched from the centre, the branches more or less anastomosing especially outwards, and it also then gets hollow and at length cup-shaped, but apparently in a later stage than if surrounding other objects, or keeping a spherical shape for a longer time, if too much attacked by boring-muscles. Pl. 9, fig. 2.

With regard to structure both forms agree with one another. The inner cells of a section parallel with the longitudinal axis of a branch are nearly squarish or rectangular, frequently about 10 μ long and 6 μ thick, or a little shorter in proportion to the thickness

than for inst. in *L. fruticulosum*. The regular stratification does not become much disturbed by buried conceptacles, which, as remarked, partly appear to be wanting, especially in f. *typica*, partly and most often to be found only in the peripheral portion of the branches, very seldom in any great number.

I have seen but few conceptacles of sporangia. They rather resemble those in *L. fruticulosum*, and are scattered or somewhat crowded in the upper part of the branches, convex but very little prominent, about 250—300 μ in diameter seen from the surface, and not sharply marked. The sporangia are tetrasporic, 120—130 μ long and 40—55 μ broad.

The conceptacles of cystocarps, of which I have also seen but few, appear in other individuals than the first named organs. They are conical, frequently rather low, but higher than in *L. fruticulosum* and apparently not fully developed, about 400 μ in diameter at the base. Besides I met with a couple of smaller ones, together with the former and of the same shape as these, but only about 200 μ in diameter at the base. They probably are conceptacles of antheridia.

A couple of specimens found washed ashore at Kragerö probably belong to this species. They are fragmentary, but appear to coincide with *L. fornicatum* in development. The branches are 3—4 mm. in thickness, fastigiate, in one here and there somewhat rubbed also in the part that has turned upwards, in another with occasionally slightly compressed branches and the surface smooth. However, some newly emptied conceptacles of sporangia are more sharply marked than appear to be usual in the present species and frequently about 300 μ in diameter, sometimes less sometimes a little more. As remarked above I certainly have seen but some few conceptacles of sporangia in this species, and it may be, that they were not fully developed, although at least some of the sporangia themselves appeared to be so, and apparently not larger than above quoted, judging from scars after emptied ones.

Relation to other species. This species shows greater affinity to *L. fruticulosum*, but it on the other hand distinguishes itself

by essential characteristics even in a sterile stage. Cp. the three following species.

Habitat. In the only certain locality hitherto known it forms banks on a depth of 3—5 fathom, in a current in the inner part of a fjord, in company with other species. Among numerous specimens collected in the later half of September only a couple were provided with reproductive organs in development, or partly showing scars after emptied conceptacles of sporangia and cystocarps.

Occurrence. Found at Mestervik in Malangen (Tromsø Amt), local but abundant. A sterile and fragmentary specimen gathered in the middle of June at Lyngö near Tromsø probably belongs to the same species. So also a couple of specimens found cast on shore at Kragerö on the south coast.

Lithothamnion dimorphum Fosl. mscr.

L. fronde libera in fundo jacente, sphaerica vel subsphaerica, roseo-purpurea, decomposito-subdichotome ramosa, ramis e centro solido, exiguo, undique egredientibus, uno alterove ramulo brevissimo præditis, plus minus coalitis, teretibus vel subcompressis, subæqualibus vel apicem versus parum incrassatis, vel interdum attenuatis, 2—2.5 mm. crassis, fastigiatis, apicibus in parte thalli inferiore plerumque obtusis vel truncatis vel interdum rotundatis, in parte superiore plerumque truncatis vel interdum obtusis vel demum disciformibus; conceptaculis sporangiferis convexiusculis vel sæpe plano-convexis, parum prominentibus, infra apices ramorum creberrimis, a superficie visis diametro 400—450 μ ; sporangiis quaternas sporas foventibus, 100—140 μ longis, 40—60 μ latis. Tab. 10.

Description of the species. The frond is in a younger stage rather regularly spherical, but older occasionally getting somewhat compressed, or forming subspherical or nearly hemispherical masses, that attain a diameter of 10 cm., more commonly, however, about 8 cm. The colour is in winter, or the darker time of the year, a dark pink with a purplish tinge, and nearly the same shade of colour as deep-water specimens of *L. tophiforme*. In summer, on the contrary, it gets much bleached, like most other Lithothamnia

growing in shallow water, the part of the plant turning upwards whitish or brownish-yellow, and the part turning towards the bottom in general slightly darker, with a rather feeble rosy tinge, seldom any stronger colour, but occasionally here and there getting a little darker in drying, if dried in the shade, or under cover. It apparently always develops itself freely on the bottom. Among numerous specimens that I have seen, I have not met with any fastened to or encompassing a stone or any other harder object. Most of the specimens examined have been attacked by boring-muscles especially in the centre of the frond and partly hollowed. However, the solid central mass appears always to be insignificant, but an anastomose of the branches often takes place in a rather early stage of development. The frond is repeatedly subdichotomously branched, with axes of at least three orders, and the lower axes frequently rather long. The branch-systems issue in all directions from the centre of the frond. In typically developed specimens the branches are erect, fastigate and straight, terete or a little compressed, either cylindrical or slightly enlarged towards the tip, more seldom feebly tapering in the part turned towards the bottom, 2—2.5 mm. in diameter, here and there furnished with short branch-like or wart-like processes. In others, and especially if much attacked by animals, the branches are rather irregular, somewhat bent and more anastomosing. They are in the part of the plant turned downwards occasionally a little spreading, and not so regularly level-topped as in the part turned upwards, or in typically developed specimens. The ends are, as a rule, in the first named part obtuse, or here and there truncate, seldom thoroughly truncate (pl. 10, fig. 2—4), but sometimes rounded especially in somewhat spreading branched specimens. In the part turning upwards they are nearly always at least partly truncate, or even disc-shaped. Pl. 10, fig. 1, 5. In this part the tip of the branches may occasionally be rather denudated, sometimes even in the lower part of the plant, but now and then developing wart-like processes from a truncate or denudated apex. Pl. 10, fig. 5—6.

As remarked above, the plant nearly always is attacked by animals, especially boring-muscles destroying the central portions,

sometimes even nearly towards the peripheral portion, and then the branches often become still denser and more anastomosed than if not or only a little attacked. Pl. 10, fig. 3. Therefore, it frequently becomes rather hollowed, or the cavity filled with boring-muscles, seldom intersected, but occasionally opened either in the part turned upwards or in the lower part and rubbed, or even getting a nearly cup-shaped form, and the interwalls between the branch-systems visible from this side. However, this appears only to be caused by the animals, in part together with the compressing and denudating influence of rapid tides, as the plant apparently not exhibits any tendency to open and to develop itself in this direction, like some other *Lithothamnia*. In such specimens the branches of the peripheral portion around the opening often get rather denudated, so that only the half of a branch or less may be left in a longitudinal direction of the axis, which also appears to be caused by the influence of the water, and so also partly in regard to the much varying shape of the tip of the branches. The surface of the frond is in general smooth, sometimes, however, the apex of the branches, or other and especially denudated parts of the plant are furnished with scaly thickenings, or new local formations of tissue.

The structure of the frond frequently appears to be a little coarser than for inst. in *L. fornicatum*. The cup-shaped layers of tissue are, in a longitudinal section of a branch, shown to be distinct and rather regular, if not too much disturbed by the buried conceptacles of sporangia. The inner cells of the named layers are about 12—16 μ long and 6—8 μ thick.

I have seen but some few specimens bearing conceptacles of sporangia, and I have not met with cystocarpic ones. The first named organs occupy a frequently sharply defined zone below the tip of the branches, and apparently most often in great numbers, as in *L. tophiforme*, and the roofs sometimes even confluent, often much resembling the conceptacles in the latter, however, in general a little smaller, or 400—450 μ in diameter, seldom less. In a younger stage of development they are convex, very little prominent and not distinctly marked, and, therefore, easily confounded

with the conceptacles of other species, especially *L. fruticulosum*, as they in this stage sometimes look apparently fully developed. However, fully developed ones are distinctly marked and more easily perceptible than in most other species, but slightly convex and little prominent, the central portion or greater part of the roof being frequently somewhat flattened, and traversed by 60—70 muciferous canals.

The conceptacles finally grow down into the frond, and are frequently to be found in the peripheral portion of a branch, sometimes numerous and crowded, sometimes very scarce, the latter probably being connected with the fact, that the roofs are thin and easily dissolvable, and, therefore, often falling away, leaving nearly cup-shaped scars with somewhat elevated edges. Such scars occasionally become effaced by local formations of tissue, and these formations again covered with a new thickening layer of the frond, so that they are visible on a section as small cup-shaped layers of about half the size of an overgrown conceptacle. The sporangia are four-parted, about 100—140 μ long and 40—60 μ broad. I have seen but some few ones.

Relation to other species. The present species on the one side appears to be rather nearly related to *L. fruticosum* f. *fastigiata* and on the other side rather approaching *L. dehiscens*. Younger as well as sterile specimens may be confounded with the first named form. It is, however, separated thereby, that it never forms lobes, the branches frequently being coarser, with longer axes and less anastomosing, and the conceptacles of sporangia are different. It is more easily confused with certain and younger forms of *L. dehiscens* described below, but separated in its development and other characters quoted under this species. In habit it occasionally even reminds one of younger individuals of *L. fornicatum*, but is separated by essential characteristics.

A fragment of a specimen from an unknown locality kindly transmitted to me by Prof. Kjellman, from oral informations supposed by him perhaps to be identic with *L. fasciculatum* (Lam.) Aresch., very closely accords with the species in question. It may be, that this one is the same as described by Lamarck under the

above name, and perhaps also included in Areschoug's *L. fasciculatum*, which comprehends more species, but, as remarked under *L. crassum*, I am most inclined to refer Lamarck's plant to the latter. The named fragment is sterile, apparently branched in the same manner as *L. dimorphum*, the branches being of the same thickness as in the latter, with truncate tips. I found a solitary sporangium in an overgrown conceptacle also agreeing with that of the last named species, tetrasporic and about 90 μ long and 40 μ broad.

Habitat. The plant lives on sandy and stony bottom, from a little below extreme low-water mark to a depth of about 3 fathom, hitherto with certainty only found in a sheltered sound with rather rapid tides. Specimens gathered in January were partly sterile partly richly furnished with conceptacles of sporangia, most of which emptied, and others with ripe sporangia. Among numerous specimens collected in the former half of July a couple are provided with the named organs in development.

Occurrence. The only known locality is Fröjen (Rottingsundet) in Søndre Trondhjem's Amt, local but abundant and forming banks.

Lithothamnion dehiscens Fosl. mscr.

L. fronde libera in fundo jacente, subglobosa, hemisphærica vel demum cava, fornicata, roseo-purpurea, irregulariter subdichotome ramosa, ramis initio e centro solido, exiguo, undique egredientibus, demum inferioribus erasis, uno alterove ramulo brevissimo præditis, præcipue superioribus plus minus coalitis, teretibus, 2 mm. crassis; conceptaculis sporangiferis convexiusculis, at parum prominentibus, infra apices ramorum plerumque creberrimis, a superficie visis diametro 300—350 μ ; conceptaculis cystocarpiferis et antheridiferis conicis, acutis, his diametro 250—300 μ , illis 400—500 μ . Sporangii quaternas sporas foventibus, 120—180 μ longis, 45—80 μ latis.

f. *typica* Fosl. mscr.

f. ramis subæqualibus vel in parte thalli inferiore sæpe subatenuatis, apicibus rotundatis vel obtusis, parte superiore fastigiatis, apicibus plerumque obtusis. Tab. 11—12.

f. *grandifrons* Fosl. mscr.

f. ramis superioribus fasciculos minutos, confertos, e ramis brevissimis compositos formantibus. Tab. 13.

Description of the species. This plant is much varying, and, in the sense here taken, it perhaps includes more than one species, but nearly all the specimens that I have seen are sterile and, therefore, the limits difficult to draw. Like the preceding it in a younger stage also has a nearly spherical shape, but it apparently sooner becomes subhemispherical, at length hollow and assumes a cup-shaped appearance. It attains a diameter of at least 50 cm., frequently, however, smaller, the form *grandifrons* in general larger than the typical one, but also the latter attains a considerable size. The colour accords with that of *L. dimorphum*, in winter probably also getting as dark as this species, however, in summer now and then with a stronger colour than specimens of the named species at the same season, but apparently only depending on the locality where it grows. I have even seen specimens with a yellowish-green colour, thus in this respect much varying. The species apparently always develops itself freely on the bottom. Although often growing on stony bottom I never met with it fastened to or encompassing stones or other hard objects. The frond is somewhat irregularly branched in a subdichotomous manner, with axes of at least four orders. The branch-systems at first issue in all directions from the centre of the frond, and the solid central mass appears always to be insignificant. In a more or less advanced stage the central or inner portions by and by disappear, which, however, may be forced by attack of animals, the peripheral portion developed in a more horizontal direction, and the plant opening itself in the part turning towards the bottom, seldom in the upper part, at length assuming a frequently depressed cup-shaped form, rubbed in the part turned downwards, with the intervals between the branch-systems visible from this side, most often subcircular in circumference, and then only about 2 cm. thick. The figure on pl. 11 represents an old but fragmentary specimen, the longest diameter about 32 cm., depressed cup-shaped and rubbed in the part that has turned towards the bottom, here burdened

with numerous shells of *Balanidæ*, *Serpula* and other animals. Sometimes it is intersected in the middle, or even assuming a more or less whorl-shaped appearance. Pl. 12, fig. 2.

There is a considerable difference between younger individuals, or such branched from the centre of the frond, spherical or hemispherical, and old ones with the lower branch-systems disappeared, depressed cup-shaped or sometimes nearly flattened. In the former the branches are more or less bent, or even somewhat contorted, especially in the lower part not or only a little, but in the upper part always more or less anastomosing. In the latter the axes are very short, always much anastomosing, and even the uppermost part of the branches in old specimens often somewhat denuded. The branches are 2 mm. in diameter, or less, sometimes in the part of not opened specimens turned towards the bottom slightly attenuating, with rounded or obtuse ends (pl. 12, fig. 1), and in the part turned upwards either cylindrical, here and there bearing short branch-like or wart-like processes, or, more frequently, slightly enlarged apex, or towards the apex, more regularly fastigate than in the lower part, and the ends as a rule obtuse, more seldom nearly truncate, the latter also being due to the upwards turned part of old and cup-shaped specimens of f. *typica*. Pl. 11.

In the form *grandifrons* the uppermost branches form minute and rather densely crowded bundles, composed of very short, more or less anastomosing branches and wart-like processes. Pl. 13, fig. 1—2. These branches are often rather thin, sometimes even but 1 mm., the bundles occasionally rather depressed, or in part denuded, with wart-like processes issuing from the denuded and often more or less truncate bundles. Cp. Pl. 13, fig. 3, seen from the side that has turned towards the bottom. In the part that has turned upwards it is rather rubbed and the branches somewhat coarser, here and there denuded. Of this form I only have seen old or rather old specimens. It appears, as if the named bundles are not unfrequently developed from an older and somewhat denuded frond, rather reminding one of the new branches developed from the lower and rubbed part of other specimens. It is in its typical form rather characteristic, but on the other hand apparently

little independent, and, perhaps, it might merely be regarded as a monstrosity than a difference of type. In this as well as the typical form the edges of a hollow and in the lower part opened specimen, partly involucreted partly not, often grow inwards and by and by replenish the opening, forming a somewhat concave base. However, now and then the plant may open itself in the part turning upwards. So also in regard to old and cup-shaped or whorl-shaped individuals. Even here the edges often grow inwards, or new but frequently short branches issue from the lower and more or less rubbed part of the plant, by and by even developing more vigorous branch systems, though frequently composed of short and thinner branches.

I met with a form growing in very dense banks and closely related to the typical form of this species, partly in the same partly in another locality than the latter. It keeps a hemispherical shape for a longer time and often not opening itself or getting hollow, but the lower part even developed more downwards than usual and on the other hand rather rubbed and denudated in the part that has turned upwards, or here even concave, often with somewhat coarser, very dense and upwards much anastomosing branches, with obtuse ends. In the part that has turned towards the bottom and otherwise it accords with f. *typica*, therefore, I do not record it an independent, but merely a local form of the species, caused thereby that the individuals have been closely heaped together.

A coarser form from Husö in Sogn may perhaps be referrible to this species. I, however, have seen but two fragmentary, stunted and in the part turned upwards somewhat denudated specimens, collected in a „deep litoral lagoon“ by P. Boye. As they also are sterile, they cannot be determined with any degree of certainty.

With reference to the structure the present plant most nearly accords with *L. dimorphum* or the species resembling it. In a longitudinal section of a branch the cup-shaped layers of tissue are distinct and pretty regular, with the inner cells frequently rectangular, 10—15 μ long and 6—9 μ broad.

The conceptacles of sporangia are partly somewhat scattered

in the upper part of the branches partly and apparently more often densely crowded near the apex, or forming a border around the branches at or a little below the apex. They even sometimes are so densely crowded, that the roofs become angular, and in all rather resembling those of *L. dimorphum*, but smaller and, as in the latter, in a younger stage easily confounded with conceptacles of other species. They are slightly convex and little prominent, but never, so far as I have seen, flattened in the central portion, as often is the case in the named species, the roof 300—350 μ in diameter, seldom more. The sporangia are four-parted, 120—180 μ long and 45—80 μ broad. Among numerous specimens collected in summer only some few were furnished with these organs.

The named conceptacles at length become overgrown, commonly to be found only in the peripheral portion of a branch, but always in less numbers than in the preceding species, and in several specimens examined I have not found older grown-in organs of this kind. This probably is in part caused thereby, that the roof is rather thin and easily dissolvable, though apparently thicker than in *L. dimorphum*, and often falling away. I more frequently met with overgrown conceptacles effaced by local formations of tissue than in the named species, and in the same manner as mentioned under this one. Besides, the conceptacles of antheridia and cystocarps appear not to be found in the same individual bearing conceptacles of sporangia. These organs do not as a rule become overgrown, although now and then only the upper part of the roof falls away at maturity, the rest perhaps partly being filled with local formations of tissue partly not, and the whole covered with a new thickening layer of the frond, as remarked in regard to the conceptacles of sporangia.

The cystocarpic conceptacles are conical, acute, 400—500 μ in diameter at the base. They are up to 300 μ high, with a single orifice, but the upper portion easily falls away, then forming a low, nearly hemispherical or sometimes even convex conceptacle, in the middle intersected with a coarser canal about 30 μ in diameter, and at maturity this middle portion first falls away, and

then often resembles emptied conceptacles of sporangia, later as a rule the whole roof. The conceptacles are in a median section internally about $300\ \mu$ in diameter at the base and about $100\ \mu$ high. The carpospores appear to be much varying, about $85\ \mu$ long and $35\ \mu$ broad.

The organs that I suppose to be conceptacles of antheridia fully resemble the cystocarpic conceptacles in shape, and occur in the same individual bearing the latter. They are $250\text{--}300\ \mu$ in diameter at the base and up to $200\ \mu$ high. In a median section I found them to be about $230\ \mu$ in diameter at the base and $80\ \mu$ high, and also here the upper and thicker portion at least some times falls away. I have not seen the spermatia.

Relation to other species. It in some respects stands near to *L. dimorphum*, and younger individuals, or not opened ones may easily be confounded with that species. It is, however, separated by its branches being in general thinner and less regular, and the ends seldom or not at all truncate, being a much larger plant. Besides, it differs with reference to the development of the frond, as well as the conceptacles of sporangia. The species may also be confounded with certain forms of *L. fruticosum*, and in habit sometimes rather resembling the form *fastigiata* of that species. This, however, is only due to younger individuals. Older or cup-shaped ones are quite different, and merely showing closer affinity to *L. fornicatum*, from which it is separated by its thinner branches, coarser structure, frequently larger conceptacles of sporangia and apparently different cystocarpic conceptacles.

Habitat. The species grows in the uppermost part of the sublitoral region on a depth of 1—4 fathom, on stony and somewhat clayish bottom. It apparently prefers places with rather rapid tides. The very greatest number of specimens collected in July were sterile, some few ones partly scantily, partly more richly furnished with conceptacles of sporangia, some of which were emptied and others with ripe sporangia. Other specimens taken in July and August were richly provided with conceptacles of cystocarps and probably also antheridia, partly emptied and partly in

development. It frequently appears to form widely extended and more or less dense banks.

Occurrence. Herö in Helgeland, rather local but abundant (Kr. Schreiner); Hestvær at Froöerne in Søndre Trondhjem's Amt, local but abundant; the Skjörn Fjord (a branch of the Trondhjem Fjord), rather local but abundant, forming great banks especially at „Dalsören“.

Lithothamnion delapsium Fosl. mscr.

L. fronde initio circum lapides vel conchas effusa, demum libera, fornicata, parte centrali solida vel lobata, vel demum crustam tenuissimam formante, ramis brevissimis, subdichotome ramosis, plerumque valde coalitis, 1—1.5 mm. crassis instructa, apicibus obtusis; conceptaculis sporangiferis convexiusculis vel sæpe planoconvexis, parum prominentibus, a superficie visis diametro 350—400 μ ; sporangiis (binas sporas foventibus?) 120—160 μ longis, 40—60 μ latis.

f. *abbreviata* Fosl. mscr.

f. ramis confertis, fastigiatis. Tab. 14, fig. 1—3.

f. *conglutinata* Fosl. mscr.

f. ramis fasciculos breves, minores formantibus. Tab. 14, fig. 4.

Syn. *Lithothamnion fornicatum* var. Fosl. Contrib. 2. p. 5, t. 1.

Remark on the species. In Contrib. 1. c. I mentioned under *L. fornicatum* a couple of forms partly reminding one of and growing together with the named species partly approaching *L. Ungerii* (*L. fruticosum* in the present paper), and one of these were figured 1. c. The organs of propagation then were unknown in both. By closer examination of these specimens I found conceptacles of sporangia, and I also found the latter growing down into the frond. These forms I here record as a distinct species, but I am not sure whether they ought not, perhaps, to be considered as two separate species, as they somewhat differ in their development. However, judging from the scanty materials at my disposal they seem to belong to one and the same species.

Description of the form of the species. The form *abbreviata*

in its development fully accords with *L. fornicatum*. It at first fastens itself to, encompasses or nearly encompasses shells, stones or other hard objects, being closely and firmly attached to its substratum. Pl. 14, fig. 2. It forms a thin crust, or now and then smaller lobes, from which issue short and simple, or once or twice divided branches, with very short axes, much anastomosing in their lower part. Sometimes the crust increases in thickness, though never much, but apparently more frequently getting thinner or disappearing, which not unlikely is caused by attack of animals. The plant by and by gets hollow, loosens itself from the substratum (pl. 14, fig. 3) and at length assumes a more or less depressed cup-shaped form, attaining a diameter of up to 25 cm. Pl. 14, fig. 1. The inner or lower side of such specimens partly becomes somewhat rubbed, so that the interwalls here and there are visible from this side, partly and probably more commonly is still provided with a thin crust, or a new and in part local crust-like formation developed from this side. In the part turning upwards the branches always are short and much anastomosing, especially in younger specimens often looking like simple and short processes issuing from an apparently rather thick crust-like hypothallus, however, in the main composed of anastomosed branches or processes. The edges of opened specimens sometimes bend and grow inwards, and together with branches afterwards developed from the inner or lower side of the plant by and by appear to replenish at least a part of the cavity or concave base. The branches or processes are terete and cylindrical, seldom slightly attenuating towards the tip, straight and fastigate, in general 1—1.5 mm. thick, with obtuse or thickened obtuse ends.

A solitary and sterile specimen, in habit as well as in structure fully agreeing with the named form, seems to have developed itself freely on the bottom. It is nearly hemispherical, the longest diameter about 15, the shortest about 9 cm., but the central portions fully destroyed and filled by numerous boring-muscles leaving a peripheral portion about 1—1.5 cm. in thickness. The branches of this portion are much anastomosing. Thus it appears, as if

also this species in certain cases keeps its spherical shape for a longer time, if much attacked by animals.

The form *conglutinata* is characterized by its more or less remoted, short bundles composed of very short and much anastomosed branches and wart-like processes. The crust partly somewhat increases in thickness, though apparently not more than up to about 3 mm., or the central portions of not opened specimens forms lobes, from which the named bundles issue. Pl. 14, fig. 4 represents a specimen forming rather coarse lobes, with a smaller cavity in the part that has turned towards the bottom, looking, however, as if a larger cavity has been nearly replenished. Another and cup-shaped specimen is provided with a distinct and about 3 mm. thick crust, with new and crust-like formations in the part turned downwards, and in the part turned upwards with short branches or wart-like processes, or small bundles. Two other and cup-shaped specimens apparently stand between f. *abbreviata* and f. *lobata*. The part turned upwards most closely resembles the latter, forming, however, more indistinct bundles, but the lower part is sometimes furnished with a thin crust, sometimes rubbed, or here and there with new branches in development.

The colour is a light pink with a purplish tinge, which afterwards often passes into faint brownish-yellow.

A longitudinal section of a branch shows partly rather distinct partly undistinct cup-shaped layers of tissue, with the inner cells about 10—14 μ long and 6—8 μ broad.

The conceptacles of sporangia are sometimes scattered, sometimes rather densely crowded especially somewhat below the tip of the branches. They are convex, but very little prominent, often scarcely raised above the surface of the frond and rather flattened. The circular roof is 350—400 μ in diameter, occasionally even a little more. It is intersected with 45—60 muciferous canals. Overgrown conceptacles are partly numerous partly scarce. Also in this species I have seen some few filled with local formations of tissue, but the roof is apparently not so easily to be dissolved as for inst. in *L. dehiscens*, and, therefore, probably nearly all the conceptacles become overgrown. The sporangia appear to be two-

parted. I certainly did not meet with a great many, but those I have seen in superficial as well as overgrown conceptacles were bisporic. However, it may be, that they were not fully developed, and in such cases the partition cannot be stated with certainty until a greater number of conceptacles in different specimens have been examined. Thus in other species I have seen several not fully developed sporangia growing down into the frond together with the conceptacles, and overgrown ones very likely never have been mature. Often I have also seen two-parted and apparently fully developed sporangia in superficial conceptacles of species, by which the named organs typically are tetrasporic, and, as remarked before, such ones have probably in fact not been fully developed. The sporangia are in both the above forms about 120—160 μ long and 40—60 μ broad.

Relation to other species. The form *abbreviata* shows greater affinity to *L. fornicatum*, and cup-shaped specimens, rubbed in the lower part, may without closer examination be confounded with smaller specimens of that species bearing thinner branches than usual. It appears, on the other hand, to be more nearly connected with the preceding species, and particularly through the form represented by the above mentioned freely developed specimen it exhibits close relation at least to younger specimens of this species. It, however, differs by its branches being thinner than general in *L. dehiscens*, frequently larger and flattened conceptacles and, above all, by its tendency to form a crust-like hypothallus. Still, younger individuals of f. *abbreviata* as well as the form *conglutinata* much reminds one of certain forms of *L. fruticosum*, the former rather resembling *L. fruticosum* f. *fastigiata* or forms which are most nearly related to this, and the latter in its most extreme form apparently connected with *L. fruticosum* f. *glomerata*. However, it is plainly distinct from this species not only with reference to its development, but the conceptacles of sporangia also are different. The species probably includes more forms than the above mentioned.

Habitat. I met with this plant in the same bank as *L. fornicatum* and other species, and apparently growing scattered, the

bank chiefly composed of the last named species. It appears often to anastomose with *L. fornicatum*, one of the specimens gathered even nearly encompassed by the latter. Specimens taken in June and in the later half of September were provided with partly emptied conceptacles of sporangia partly apparently ripe sporangia. Some scars a little larger in diameter than the conceptacles of sporangia seem not unlikely to be those from dissolved cystocarpic conceptacles.

Occurrence. Hitherto only found at Mestervik in Malangen (Tromsø Amt), scarce.

Lithothamnion apiculatum Fosl. mscr.

L. fronde libera vel lapidibus affixa, diametro usque ad 5 cm., roseo-purpurea vel dilute rosea, decomposito-ramosa; ramis e centro solido, exiguo, undique egredientibus, vel omnino liberis vel plus minus coalitis, interdum parte centrali sublobata, teretibus, subæqualibus, apicibus rotundatis vel plerumque obtusis; conceptaculis sporangiferis convexiusculis, parum prominentibus, sparsis vel infra apices ramorum crebris, a superficie visis diametro 200—250 μ ; sporangiis quaternas sporas foventibus, 90—110 μ longis, 35—50 μ latis; conceptaculis cystocarpiferis depresso-conicis, apiculatis, diametro 350—450 μ .

f. *typica* Fosl. mscr.

f. ramis non vel parce coalitis, fastigiatis, apicibus rotundatis vel obtusis. Tab. 15, fig. 1—4.

f. *parvicocca* Fosl. mscr.

f. parte centrali sublobata vel ramos inferne plus minus coalitos, superiores nodulos vel fasciculos minutos formanti. Tab. 15, fig. 5—8.

f. *connata* Fosl. mscr.

f. parte centrali sublobata vel ramis valde coalitis, brevissimis, fastigiatis, apicibus obtusis. Tab. 15, fig. 9—13.

f. *patula* Fosl. mscr.

Descr. *Lithothamnion* norvegicum f. *globulata* Fosl. Contrib. II, p. 7.

Fig. " " " " l. c. t. 3, fig. 7; tab. nostr. 15, fig. 14—19.

Syn. Lithothamnion fasciculatum Aresch. Obs. Phyc. 3, p. 5; ex parte sec. spec.

Remark on the species. In Contrib. l. c. I recorded a Lithothamnion under the name of *L. norvegicum* f. *globulata*, considering it to be a form of the named species analogous to the form *globosa* of *L. tophiforme* (*L. soriferum*). Later I met with the same form also at other places together with another one, that constitutes the typical form of an undescribed species, the above *L. apiculatum*, to which the named f. *globulata* (the above f. *patula*) appears to be more closely related than to *L. norvegicum* (*L. coralloides* in the present paper), taking the latter in a more confined sense than then. On the other hand it is not unlikely that this form may perhaps be the type of a separate species, as in some particulars it rather differs from typical *L. apiculatum*, although it in habit as well as structure is very difficult to distinguish from the latter, but the reproductive organs are not yet well known, the cystocarpic conceptacles even unknown.

Description of the form of the species. The limits between most of the above quoted forms are not easily drawn, as intermediate forms nearly as often appear to occur as typically developed specimens of the one or other form, but the latter are on the other hand so well marked, that they ought to be specially mentioned. What I consider to be the typical form of the species, forms spherical or nearly spherical balls, freely developed on the bottom, seldom fastened to or encompassing smaller stones. It attains a diameter of 5 cm., frequently, however, about 3 cm. The colour partly is a darker partly a lighter pink, more or less fading in drying, now and then with a purplish tinge, or even rosy. The solid central mass always is insignificant, and ramification sets in at an early stage of growth. The frond is branched partly in a subdichotomous manner partly more irregular, with axes of two or three orders. The upper branch systems sometimes are arranged obpyramidal. In typically developed specimens the branches are erect, fastigate and straight, in others they are somewhat bent, but always fastigate, often furnished with some wart-like process. They are terete or nearly terete, either cylindrical

or slightly tapering, or a little enlarged towards the tip, with the ends rounded or more frequently obtuse or nearly obtuse, 1.2—1.8 mm. in diameter. Now and then the branches anastomose below, but more often they are free in the central portions and somewhat anastomosed in the peripheral portion of the frond, or not anastomosing at all. Pl. 15, fig. 1—4. The surface of the frond is partly rather smooth partly and most frequently provided with local, scaly thickenings especially in the upper part of the branches.

The form *parvicocca* is nearly connected with the typical form. It differs by its more anastomosing branches, the central portions often forming smaller lobes or coarse and somewhat lobe-like branches, from which issue small bundles of brachlets, or the upper branches bearing more or less numerous smaller and wart-like processes. Pl. 15, fig. 5—8.

Another form probably belonging to the same species is f. *connata*. It often fastens itself to or encompasses small stones. It is less branched and the branches are shorter than in the typical form, much anastomosing especially in the lower part, or it forms a rather solid central portion or smaller lobes. The branches frequently are slightly enlarged towards the tip, fastigate and often furnished with some wart-like process. The ends are as a rule obtuse. Pl. 15, fig. 9—13.

The form *patula* on the one side is closely connected with the typical form in habit, and the limits often nearly impossible to draw, but on the other side showing transition to f. *connata*, also being difficult to distinguish from this form. It forms small spherical or nearly spherical masses about 2 cm. in diameter. The solid central portion is insignificant and the branches more or less spreading, but in general rather straight, fastigate or nearly fastigate, slightly thickened towards the tip, seldom a little tapering, and most frequently with obtuse ends. Pl. 15, fig. 14—19. However, the branches often are more crowded, forming transition to f. *typica*, anastomosing below or even nearly towards the apex, or encompassing small stones, furnished with some wart-like process, and such specimens forming transitions to f. *connata*. The

surface of the frond appears commonly to be smoother than in *f. typica*, and in all less furnished with local, scaly thickenings than the other forms. However, this apparently often depends on the locality where the plant grows, and I met with specimens which in this respect fully coincide with *f. typica*. Also in other species I have seen specimens sometimes quite smooth and rather shining sometimes furnished with numerous scaly thickenings. These thickenings appear in all to be more common in specimens growing in shallow water with somewhat clayish bottom, or in places with rather rapid tides, and wanting or more seldom to be found in specimens growing in deeper water with harder bottom.

With reference to the structure the present plant accords in the main with *L. fruticosum* and other nearly allied species. The cup-shaped layers of tissue are, in a longitudinal section of a branch, more or less regular and rather distinct, and the inner cells are about 8—10 μ long and 5—7 μ thick. Thus they are somewhat shorter in proportion to the thickness than those of the named species, often being nearly squarish. In *f. patula* they are frequently a little coarser than in *f. typica*, but, so far as I have seen, not exceeding 10 μ in length and 7 μ in thickness, and any limit is in this respect impossible to draw, the cells being as a rule rather varying even in one and the same specimen.

The very greatest number of specimens that I have seen have been sterile, only some few ones provided with conceptacles of sporangia or cystocarps. The first named organs are scattered over the whole frond or somewhat crowded below the tip of the branches, convex but slightly prominent, more or less distinctly marked, seen from the surface about 200—250 μ in diameter. In this respect *f. patula* somewhat differs from the other forms, as the conceptacles frequently appear to be a little larger, or up to 300 μ , which, however, now and then also is the case in the other forms. The roof is intersected with about 30—40 muciferous canals, which are rather crowded in the central portion, and especially in the form *patula* it appears apt to fall away. I have seen but some few sporangia. They are four-parted, 90—110 μ long and 35—50 μ broad.

The conceptacles finally grow down into the frond. Overgrown ones are more common in specimens with a more solid central portion or much anastomosing branches than in specimens the branches of which are free, but never to be found in any great number, often, on the contrary, apparently wanting. I occasionally met with grown-in organs of that kind filled with local formations of tissue. In a form of the species standing nearest to *f. connata* I found in overgrown conceptacles rather numerous sporangia, most of which were bisporic, probably not being fully developed before they grew down together with the conceptacles.

Cystocarpic conceptacles are only known in *f. typica* and *f. parvicocca*. They are conical, low and at the summit abruptly passing into a short and thin tip, which easily falls away, 350—450 μ in diameter at the base, scattered or somewhat crowded without any order, sometimes in pairs. I have not seen the carpospores.

Remark on the synonymy. A specimen in Areschoug's herbarium under the name of *L. fasciculatum* I refer to the present species. It is scantily provided with conceptacles of sporangia, collected at Christiansund N. by F. L. Ekman. Cp. Aresch. l. c.

Relation to other species. It appears to be most closely related to *L. fruticosum*, *f. typica* analogous to *f. typica*, *f. connata* analogous to *f. fastigiata*, and *f. patula*, or an intermediate form between this one and *f. connata* analogous to *f. nana* of that species, and on the other hand standing between the named species and the following one, *L. gracilescens*, the form *parvicocca* nearly connected with the latter. The species distinguishes itself from *L. fruticosum* especially by its in general thinner branches and smaller conceptacles of sporangia, shorter cells and different conceptacles of cystocarps. It is in all a much smaller plant than the named one. From *L. gracilescens* it is separated by characters quoted under this species. The form *patula* in its most extreme form reminds one much of certain forms of *L. corralloides*. It is, however, distinguished by its ticker, more straight and more regular branches, a little coarser structure, as well as a little smaller conceptacles of sporangia.

Habitat. The species lives in the upper part of the sublittoral region, on a depth of 3–8 fathom. It chiefly is met with in the fjords, preferring somewhat sheltered places, and is to be found best developed on hard bottom. It partly grows scattered partly forming smaller banks together with other species. Specimens collected in July, September and October have been very scantily provided with conceptacles of sporangia, some of which with apparently ripe sporangia. Specimens bearing cystocarpic conceptacles have been taken in July.

Occurrence. The typical form found at Bejan, local but abundant, and together with it some specimens of f. *parvicocca*. A form closely related to the former has been collected at Munkholmen near Trondhjem, scarce, and at Christiansund, N. (Ekman). The form *connata* is known from Dröbak in the Christiania Fjord (Gran), apparently scarce; Storfosen near Bejan, scarce; and a form most nearly connected with this at Röberg in the Trondhjem Fjord, scarce. Typical specimens of f. *patula* have been collected at Skorpen in Tromsø Amt, Skjörn and Bejan in the Trondhjem Fjord, local but pretty plentiful, and especially at the two last named places together with transitions to f. *typica* and f. *connata*.

Lithothamnion gracilescens Fosl. mscr.

L. fronde libera vel interdum lapidibus affixa, subglobosa, diametro usque 6 cm., obscure rosea, irregulariter ramosa; ramis e centro solido, exiguo, undique egredientibus, teretibus, subcylindricis, superioribus plerumque nodulosis, fasciculos plus minus remotos formantibus, apicibus obtusis; conceptaculis sporangiferis convexiusculis, parum prominentibus, infra apices ramorum crebris, a superficie visis diametro 350–400 μ ; sporangiis quaternas sporas foventibus, 120–150 μ longis, 45–60 μ latis; conceptaculis cystocarpiferis conicis, diametro 300–350 μ . Tab. 15, fig. 20–27.

Syn. *Lithothamnion byssoides* Unger, Leithakalk p. 19, t. 5, fig. 1–8.

Description of the species. The plant forms spheroidal or somewhat irregular masses attaining a diameter of about 6 cm., in general freely developed on the bottom, but now and then fastened to or nearly encompassing small stones. The colour is a dark

pink, most often with a purplish tinge, in winter, however, a brownish pink, but nearly always getting much lighter when dry. The frond is branched in a rather irregular, or sometimes nearly subdichotomous manner. The branches frequently issue in all directions from the centre of the frond, always with short axes, in the lower part more or less bent, in the upper part often rather straight, frequently forming more or less remoted bundles, which are composed of short branches bearing more or less numerous and wart-like processes or short branchlets. They are terete or nearly terete, 1—1.3 mm. thick, sometimes of nearly the same thickness throughout, sometimes a little thicker below, here and there somewhat anastomosing, both never much, often with slightly thickened and frequently nearly obtuse ends. Pl. 15, fig. 20—27. The frond occasionally may be rather compressed, in part corresponding with the form *alcicornis* of *L. tophiforme* and f. *flabelligera* of *L. coralloides*, but the specimens that I have seen of this form are not so distinctly marked as to make it possible to draw any definite limit, and I, therefore, at present do not record it as denominated form of the species.

As to the structure the species coincides with *L. coralloides*. In a longitudinal section of a branch the inner cells of the cup-shaped layers of tissue are about 7—9 μ long and 4—6 μ thick.

I have examined numerous summer- as well as winter specimens, but only one or two met with bearing organs of propagation. The conceptacles of sporangia frequently appear to be rather crowded below the tip or in the upper part of the branches. They are convex, but very little prominent, distinctly marked, seen from the surface 350—400 μ in diameter, sometimes, however, only 300 μ . The roof is traversed by 60—70 muciferous canals. The sporangia that I have seen were not fully developed, sometimes without any partition sometimes two-parted with an apparently well developed wall. However, in some of the latter I found in one or both cells partly a just founded partly a more developed transverse wall issuing from the one side, and once I found one of the two cells parted into two by an entire but rather indistinct wall. Therefore, mature sporangia no doubt are tetrasporic. They

are about 120—150 or up to 160 μ long and 45—60 μ broad, seldom broader.

The conceptacles grow down into the frond, but overgrown ones are very scarce in the specimens that I have examined, and in most cases I did not find such ones. Also in this species the roof appears apt to fall away, leaving a rather deep scar, which sometimes becomes filled with local formations of tissue. Such filled conceptacles now and then are to be seen on a section, in shape and partly also in size fully resembling not filled ones, and distinctly marked.

The organs supposed to be cystocarpic conceptacles I found in other individuals than those bearing conceptacles of sporangia. They are comparatively small, conical and rather acute, about 300—350 μ in diameter at the base, but probably not fully developed. I have not seen the spores.

Remark on the synonymy. As mentioned under *L. fruticosum* I consider *L. byssoides* Unger not referrible to any form of that species. It appears to me most probably being identic with the species in question, and in all agreeing well with typically developed specimens. On the other hand it reminds one of *L. apiculatum* f. *parvicocca* and even certain forms of *L. nodulosum* described below, but the latter is in general a larger and coarser plant.

Relation to other species. This plant forms an intermediate species between *L. apiculatum* and *L. corralloides*. In its typical form it is easily recognised, but it often assumes forms, which in a sterile state are very difficult or nearly impossible to separate from the one or other of the named species. The reproductive organs are, however, different. As to the vegetative parts it distinguishes itself from *L. apiculatum* f. *parvicocca*, the most nearly allied form of that species, by its less anastomosing branches and in general more numerous wart-like nodes, but it sometimes even approaches *L. apiculatum* f. *typica* in habit. Cp. Pl. 15, fig. 27. Now and then it appears to be less densely branched, or the branches even rather spreading, the nodes or short branchlets few in number, and then much approaching *L. corralloides* f. *norvegica*.

Habitat. The species occurs in somewhat sheltered places, on a depth of 5—8 fathom. I met with it on rather hard but somewhat clayish bottom, forming smaller banks in company with *L. coralloides*. A couple of specimens gathered in June and July were provided with reproductive organs in development, or bearing scars after emptied conceptacles of sporangia.

Occurrence. Found at Mandal (Wille), Dröbak (Gran) and at Rotvold near Trondhjem, at the latter place local but in considerable abundance.

Lithothamnion coralloides Crn.

Fl. Finist. p. 151, t. 20, gen. 133, fig. 8—9; Spongites coralloides Alg. mar. Finist. No. 242; excl. syn.

f. *norvegica* (Aresch.) Fosl. mscr.

Lithothamnion calcareum var. *norvegicum* Aresch. Obs. Phyc. 3, p. 4; ex parte.

f. *subglobosa*, diametro circa 3 cm., ramosissima, ramis 1—1.3 mm. crassis, subattenuatis, apicibus plerumque rotundatis. Tab. 16, fig. 1—11.

f. *saxatilis* Fosl. mscr.

f. *lapidibus affixa* vel demum interdum libera, scabriuscula, ramis brevioribus, 1—1.8 mm. crassis, apicibus rotundatis vel subobtusis. Tab. 16, fig. 12—23.

f. *australis* Fosl. mscr.

f. *parce ramosa*, ramis sæpe longioribus, teretibus vel subcompressis, 1.5—2 mm. crassis. Tab. 16, fig. 24—31.

f. *flabelligera* Fosl. mscr.

f. *ramis brevibus, flabellatim dispositis, liberis vel plus minus coalitis, compressis vel subcylindricis.* Tab. 16, fig. 32—37.

f. *subsimplex* Batt.

in Journ. Bot. 1892, p. 8; Grevillea Vol. 21, p. 23.

Descr. *Lithothamnion coralloides* f. *subsimplex* Batt. l. c.

Fig. " " " tab. nostr. 16, fig. 38—42.

Syn. *Apora polymorpha* Gunn. in Act. Nidros. 4, p. 70; ex parte; t. 15, fig. 2. *Nullipora calcarea* Johnst. Brit. Spong. and Lithoph. p. 240; ex parte; pl. 24, fig. 5?

Lithothamnion gracile Phil. in Wieg. Arch. p. 388; Aresch. in J. Ag. Spec. Alg. 2, p. 524?

- Syn.* Lithothamnion rubrum Phil. l. c.; Aresch l. c.
 " norvegicum Kjellm. N. Ish. Algfl. p. 122 (93), pl. 5,
 fig. 9—10.
 " " Fosl. Contrib. II, p. 7; ex parte.
 " coralloides Batt. in Journ. Bot. 1892, p. 7.

Remark on the determination of the species. Through the kindness of Dr. Bornet I have had the opportunity to examine the specimen distributed by Crouan l. c. under the name of *Spongites coralloides*. It is, however, too fragmentary to be determined with certainty, but not unlikely it is identic with the above quoted f. *flabelligera*, and it agrees with this form in regard to the structure. The form of the species delineated in Fl. Finist. l. c., no doubt, is identic with or at least closely related to the above f. *australis*. Specimens of both these forms have been gathered in one of the localities quoted by Crouan and kindly communicated to me by Dr. Bornet. The plant described by Areschoug under the name of *L. calcareum* var. *norvegicum* partly also includes the last named form. Areschoug originally recorded his plant as *L. coralloides* Cr.¹⁾, but later (in Obs. Phyc. l. c.) he considered it a variety of *L. calcareum*. The latter is, however, a coarser plant and in my opinion belonging to *L. tophiforme*, judging from the description by Harvey in Phyc. Brit., but the plant recorded under the same name by Johnston l. c. perhaps in part includes the present species. Cp. Kjellm. l. c. I have not been able to draw any true limit between the quoted forms, and I, therefore, here adopt the name given by Crouan as the older one. However, it may be remarked, that the French and British specimens that I have seen, as well as those which underlie Areschoug's description, gathered at Haugesund, are sterile. Solms-Laubach remarks (Corall. p. 19), considering Areschoug's plant identic with *L. coralloides* Cr., that the species is characterized, besides in habit, by „nicht über die Thallusfläche hervorragenden Conceptacula“. This does not accord with the below mentioned shape of the reproductive organs found in other Norwegian specimens.

1) Akademiske föreläsningar höstterminen 1872. (Unprinted).

Remark on the form of the species. Among the named specimens from Haugesund are some more densely branched, others coarser and more sparsely branched, the former nearly according with the most common form along the Norwegian coast, the above f. *norvegica*, not unlikely being the typical form of the species, and the latter partly agreeing with the form that I have called f. *australis* partly forming intermediate forms. The form *norvegica* is characterized by its much branched frond, frequently forming subspherical masses about 3 cm. in diameter, the branches always rather bent, more or less spreading, about 1–1.3 mm. thick, seldom a little anastomosing below and in general slightly attenuating towards the tip, and the ends frequently rounded. The surface of the frond is most commonly smooth, but now and then rather uneven on account of local, scaly thickenings. Pl. 16, fig. 1–11. This form frequently grows gregarious in considerable abundance.

The form *saxatilis* is nearly connected with the latter. It appears always to grow more or less scattered, never in any great number. It fastens itself to small stones, but in a more advanced stage of development it occasionally detaches itself and lies free on the bottom. It often rather resembles the preceding form in habit, but it never attains the size of that form, being less branched, with shorter axes, but the branches nearly always more or less bent, as in the named form. The branches often also are coarser, up to about 1.8 mm. in thickness, not or slightly attenuating upwards, with rounded or nearly obtuse ends. Pl. 16, fig. 12–23. The surface is rather uneven, finely rugged, with more or less numerous local and scaly thickenings.

Another form also nearly connected with f. *norvegica* is the form that I have named f. *australis*. It frequently is somewhat coarser than f. *norvegica*, sparsely branched, the branches partly short partly and more often rather long, 1.5–2 mm. thick, much spreading, terete or somewhat compressed, cylindrical or slightly attenuating towards the tip, with rounded ends, or now and then with the tips rather compressed and the ends rounded or even nearly truncate. Some specimens that I received from Dr. Borner „drugué à l'embouchure de la rivière de Morlaix (Finistère)“ belong

to this form and in part according well in habit with the cited figure by Crouan. Some other specimens gathered at „Ile Houlavre, dans le Golfe du Morbihan“ are nearly related to *f. australis*, but much smaller, the branches slightly thinner and very short, thus somewhat differing from typical specimens of the form, and ought perhaps to be considered as a separate form of the species. The plant recorded by Batters l. c. as typical *L. coralloides* fully coincides with *f. australis* in the sense here taken, according to specimens kindly communicated to me. Typically developed specimens of this form appear to be scarce with us. I have seen but some few ones, but others partly approaching *f. australis* partly *f. norvegica* have more often been met with. As such an intermediate form I regard the specimens figured by Kjellman l. c. pl. 5, fig. 9—10, however, most nearly related to *f. norvegica*. Cp. pl. 16, fig. 24—31. The figures 24—25 represent the present form from Haugesund, fig. 26 a somewhat differing specimen from Storfosen near Bejan, fig. 27—30 British specimens (from Cumbrae) and fig. 31 a French specimen (from Morlaix).

Of the form *flabelligera* I have not seen typically developed Norwegian specimens, but those represented on pl. 16, fig. 32—37 I got through the kindness of Dr. Bornet „drugué à l'embouchure de la rivière de Morlaix (Finistère)“. It is analogous to the form *aleicornis* of *L. tophiforme*. The branches are rather irregularly divided, with very short axes, spreading almost in one plane, either subcylindrical or compressed, of about the same thickness as those of *f. australis*, with rounded or almost truncate ends. Some other specimens „jeté a la côte de St. Malo (Ille-et-Vilaine)“ at least in part belong to the same form, or forming transitions to *f. australis*.

The form *subsimplex* is closely connected with *f. australis*, distinguished by the entire or almost entire absence of lateral branches, the whole frond being simple or nearly simple, and either straight or angularly bent. Cp. pl. 16, fig. 38—42 (British specimens). Of this form I have not seen any characteristic Norwegian specimen, either, but only transitions to it.

The species is as to the structure characterized by its rather small cells. They are in a longitudinal section of a branch 7—9

μ long and 4—6 μ thick, and often slightly smaller in *f. norvegica* than in the other forms.

I have examined hundreds of specimens from different tracts and seasons, collected in May to October and in January and March, but nearly all of them have been sterile, only a very few ones of *f. norvegica* and *f. saxatilis* bearing organs of propagation. I am, therefore, inclined to suppose, that the plant in all rather seldom develops these organs. The conceptacles of sporangia partly are scattered partly crowded in the upper part of the branches. They are slightly convex and very little prominent, the roof frequently somewhat flattened in the central portion, 300—350 μ in diameter, most commonly about 300 μ , and in general a little larger in *f. saxatilis* than in *f. norvegica*, intersected with rather numerous muciferous canals, of which I have numbered about 50. The sporangia are four-parted, in *f. norvegica* 100—130 μ long and 35—45 μ broad, in *f. saxatilis* frequently a little larger, or 110—140 μ long and 40—55 broad. I, however, have seen but few, especially in *f. norvegica*. Most of the sporangia in *f. saxatilis* were only two-parted, but probably not fully developed, and here I also found bisporic together with tetrasporic overgrown ones.

The conceptacles of sporangia grow down into the frond, but in *f. norvegica* they are extremely scarce. I have examined numerous specimens without finding any trace of overgrown organs of that kind, but in others I found some few ones especially in the peripheral portion of a branch, never in any great number, and I occasionally met with overgrown conceptacles that had been filled with local formations of tissue, as in other species before mentioned. Once I even found a solitary sporangium in such a filled and overgrown conceptacle. In *f. saxatilis* overgrown conceptacles sometimes are not uncommon, sometimes apparently wanting, and nearly always containing not escaped sporangia or such as have not been mature before they as well as the conceptacles grew down into the frond. On the other hand the whole roof appears now and then to fall away, and in such cases the conceptacles apparently not become overgrown, or the scars filled with local formations. In the other forms they have not been found.

What I suppose to be cystocarpic conceptacles have been found in very small numbers in a couple of specimens of *f. norvegica*, in one of these together with some smaller and little developed conceptacles which, not unlikely, are those of antheridia. The former are conical, low, 350—400 μ in diameter at the base, and traversed by a canal about 20 μ in diameter. I have not succeeded in finding the carpospores.

Remark on the synonymy. The *Lithothamnia* that Gunnerus records under the name of *Apora polymorpha* among others probably includes the present species too. Thus the figure on pl. 15, fig. 2 l. c. much resembles *L. coralloides f. saxatilis*. It seems also to be probable, that the form delineated by Johnson l. c. pl. 24, fig. 5 is referrible to this species, and not unlikely identic with or nearly related to *f. flabelligera*. Whether on the other hand the two species described by Philippi l. c. really are identic with *L. coralloides* is impossible to know without having access to the original specimens, but they at least appear to be nearly related to it, *L. gracile* perhaps according with *f. flabelligera* and *L. rubrum* nearly connected with *f. australis*.

Mentioning *L. norvegicum* in Contrib. II, p. 7 I also referred to it specimens, which, as remarked, I now consider partly belong to *L. apiculatum f. patula* partly constitute a separate species, the below described *L. divergens*. On the other hand I have lost the specimens recorded under the same name in Contrib. I, p. 6 from Mehavn in East-Finmarken, and I am not sure whether they belonged to the present species in the sense here taken. So far as I now remember it was not typical *f. norvegica*, but rather a form of *L. apiculatum*. Therefore, I do not adopt this locality in the present paper.

Relation to other species. Cp. under *L. apiculatum*, *L. gracilescens* and *L. divergens*.

Habitat. The species lives in the upper as well as the lower part of the sublitoral region, with us descending to a depth of about 15 fathom, but often also to be found only in 5—6 fathoms water, seldom, however, farther up. On the British coast it occurs on a depth of 6—10 fathom. Cp. Batt. l. c. It prefers harder

bottom and somewhat sheltered places, especially appearing in sounds and fjords. Some specimens bearing conceptacles of sporangia and in part apparently ripe sporangia have been taken in June and July, and a couple of others with cystocarpic conceptacles in June.

Occurrence. Its most northerly and certainly known locality is Skorpen in Kvæningen, scarce (f. *norvegica* and f. *saxatilis*); Lødingen in Nordland; Herø in Helgeland (Schreiner); Frøjen, scarce (f. *norvegica*); Storfosen near Bejan, scattered and apparently scarce (f. *norvegica*, f. *saxatilis*, f. *australis*); at different places in the Trondhjem Fjord, as Inderøen, Tautra, Holmberget, Rotvold, Byberget, Røberg, Skjørn and Bejan, mostly local and sometimes scarce sometimes abundant (f. *norvegica*, f. *saxatilis*); Sulen in Sognefjord (Boye); Haugesund (Wittrock) local but abundant (f. *norvegica*, f. *australis*); Mandal (Wille); and Nesodden in the Christiania Fjord (Schreiner).

Geogr. Distribution. Britain (Batters); France (Crouan, Bornet).

Lithothamnion divergens Fosl. mscr.

L. fronde libera in fundo jacente, roseo-flavescente, irregulariter ramosa; ramis e centro solido, exiguo, vel axi primario egradientibus, omnino liberis vel inferne plus minus coalitis, divergentibus, flexuosis, teretibus, subæqualibus vel apicem versus attenuatis, 1.8—2.2 mm. crassis, apicibus rotundatis; conceptaculis sporangiferis convexiusculis, a superficie visis diametro 300—350 μ ; sporangiis quaternas(?) sporas foventibus, circa 120 μ longis, 40 μ crassis. Tab. 16, fig. 43—50.

Syn. *Lithothamnion norvegicum* f. *distans* Fosl. Contrib. II, p. 7; ex parte.

Description of the species. The more or less irregular frond is in its longest diameter frequently about 2.5—4.5 cm. long. It always develops itself freely on the bottom. The colour is in dried specimens yellowish, or yellowish pink, towards the tip of the branches often somewhat darker, with a violaceous tinge. The solid central mass is insignificant, or forming a somewhat elongated

main-axis, from which the more or less spreading and sparsely divided branches frequently issue in all directions. The branches never are straight, but more or less curved, or angularly bent, terete, either nearly equal in thickness, generally 1.8–2.2 mm., or often rather attenuating towards the tip, with rounded ends, or now and then somewhat rounded-thickened ends. They partly are free everywhere partly in more densely branched specimens more or less anastomosing below, but upwards always spreading. Pl. 16, fig. 43–50. The surface of the frond sometimes is smooth sometimes and more frequently finely rugged and squamellate.

With regard to the structure this plant is in general coarser than the preceding species and most nearly agreeing with that of *L. fruticulosum*. In a longitudinal section of a branch the inner cells of the cup-shaped layers of tissue are 8–12 μ long, frequently about 8–10 μ , and 6–7 μ thick.

The conceptacles of sporangia are crowded in the upper part of the branches without any order, convex, but little prominent, rather reminding one of those in certain forms of *L. fruticulosum*, but frequently larger, seen from the surface 300–350 or occasionally up to 400 μ in diameter and often not distinctly marked. The roof is rather thick and intersected with about 30 muciferous canals. The sporangia most probably are tetrasporic, but I have not seen any with distinct partition, about 120 μ long and 40 μ broad. However, I have seen but a very few. The conceptacles finally grow down into the frond. Overgrown ones sometimes are scarce sometimes rather numerous, chiefly in the peripheral portion of a branch, but they are on the other hand often apparently wanting. I have not seen conceptacles of cystocarps.

Remark on the synonymy. Most of the specimens recorded l. c. under the name of *L. norvegicum* f. *distans* belong to the present species. I then had not the advantage of examining more thoroughly a greater number of specimens of the different forms. *L. norvegicum* was a little known plant, of which only sterile specimens were known, and as this together with the forms now separated often closely approach each other in habit, I considered them to belong to one and the same species.

Relation to other species. Among the species of Lithothamnion that I know *L. divergens* exhibits the greatest resemblance on the one side to *L. fruticosum* f. *curvirostra* and on the other side to *L. coralloides*, forming an intermediate species between these two. It is separated from the former especially by its more spreading and less attenuating branches and larger conceptacles of sporangia. Sometimes it much resembles certain forms of *L. coralloides* in habit, particularly intermediate ones between f. *norvegica* and f. *australis*, but distinguishes itself from these by its in general coarser branches and coarser structure, and also with reference to the conceptacles of sporangia. Occasionally it also reminds one of *L. tophiforme* in habit, but is separated by essential characteristics.

Habitat. This species occurs on a depth of 3—5 fathom in company with other species, as *L. apiculatum* and *L. coralloides*. A few of the specimens collected in the former half of September were provided with conceptacles of sporangia, most of which apparently not fully developed.

Occurrence. Hitherto only found at Skorpen in Kvænangen, north of Tromsö, scattered and scarce.

Lithothamnion flabellatum Rosenv.

Grönl. Havalg, p. 772.

f. *Granii* Fosl. mscr.

f. fronde initio affixa, crustam tenuissimam formante, tuberculis vel ramis instructa, demum crusta evanida, fronde libera in fundo jacente, decomposito subdichotome ramosa; ramis teretibus vel subcompressis, 2 mm. crassis, subattenuatis, apicibus plerumque rotundatis; conceptaculis sporangiferis convexiusculis, parum prominentibus, a superficie visis diametro 350 μ ; sporangiis binas sporas foventibus, 140—180 μ longis, 45—60 μ latis. Tab. 17, fig. 1—7, tab. 22, fig. 1.

f. *Rosenvingii* Fosl. mscr.

Descr. et Fig. Lithothamnion flabellatum Rosenv, l. c. et fig. 1—2.

Syn. Lithothamnion soriferum Rosenv. l. c. p. 772; ex parte sec. spec.

Remark on the species. The plant that Rosenvinge l. c.

describes under the above name is in my opinion the most extreme form of a species, which in some respects rather differs in its development from most other Lithothamnia, so far as these are hitherto known. I have, at least, not been able to draw any limit between this form, which I propose to name f. *Rosenwingii*, and the above f. *Granii*, and it probably includes more forms, the latter perhaps taken in too wide a sense.

Description of the form of the species. The form *Granii* is at first fastened to shells or smaller stones, forming a very thin crust scarcely up to 0.5 mm. in thickness and closely adherent to the substratum. The peripheral portion of this crust is thinner than the internal, feebly zonated, with a whitish brim in specimens not fully encompassing the object, to which it is fastened. Small excrescences appear at an early stage of development, at first in the central portion, later over the whole or nearly the whole crust. At this stage it very much resembles younger individuals of *L. colliculosum*. Afterwards the excrescences arise into erect, straight or somewhat bent knobs or short branches, which are either simple, bifid or trifid above, and at length getting more branched in a rather irregular subdichotomous manner, in old individuals with branch-systems of at least three orders, with rather short axes. Pl. 17, fig. 1—7, pl. 22, fig. 1. At the same time the crust by and by disappears, the plant loosens itself from the substratum and lies free on the bottom, still plainly showing that it has been attacked at first, though not in old and more driven specimens. The branches are in older specimens more or less spreading and seldom straight, terete or slightly compressed, either nearly cylindrical or, more frequently, slightly attenuating towards the apex, with rounded or occasionally obtuse ends, about 2 mm. thick, partly less partly a little more. They are frequently a little anastomosed below, and the surface partly is nearly smooth, occasionally with short, concentric striæ, partly rather uneven on account of numerous local, scaly thickenings. The crust, so far as I have seen, never increases in thickness after the branches are developed, but if much attacked by animals in a younger stage a new crust here and there is formed upon the older, even over short knobs,

but especially between the knobs or short branches of younger specimens so as to cover the animals. This is, however, seldom, and in typically developed specimens not too much attacked I always found only the primary crust. If the crust by and by fully encompasses the object, or this is not of very small size, the plant appears to loosen itself in a later stage of development, sometimes even, not till the branches are much developed, or the plant apparently is nearly full-grown. On the other hand it at length always loosens itself from the substratum; at first a part of the crust disappears or loosens and by and by the whole crust of parts of it together with some branch-system, so that more loosened individuals arise from one fastened. These continue their growth and form at length irregular or subspherical masses, whose longest diameter gets up to about 7 cm. Pl. 17, fig. 6—7. The branches especially of loosened individuals often bear wart-like processes or short branchlets, which in the upper part occasionally may be rather crowded.

I do not know whether the plant also develops freely on the bottom. However, I have seen some younger specimens apparently freely developed and probably belonging to the same form.

An American specimen kindly sent me by Mr. Collins in habit stands between the specimens figured pl. 17, fig. 1—2, and it most probably belongs to f. *Granii*, but it is sterile and, therefore, the determination not quite certain. The crust is very thin, partly disappeared and the plant nearly loosened from the object, a small stone, which it apparently has nearly encompassed. Collins' collection B. „Eagle Island, Maine. In pools at dead low-water.“ The specimen on the other hand somewhat reminds one of certain forms of *L. fruticosum*. Cp. Hauck, Meeresalg. t. 5, fig. 4. However, in overgrown conceptacles I only found bisporic sporangia, but they were smaller than in the named form.

As remarked above I consider f. *Rosenvingii* to be the most extreme form of the species, characterized by its fan-shaped ramification and more or less compressed branches, analogous to *L. tophiforme* f. *alcicornis*, but on the other hand showing the most close affinity to f. *Granii*. A Greenlandic specimen kindly com-

municated to me by Mr. Kolderup Rosenvinge nearly accords with fig. 1 on pl. 17, but smaller, and two others and younger also are so nearly agreeing with f. *Granii*, that they in my opinion must be referred to this form, with not or very slightly compressed knobs or branches. The crust is in the specimens that I have seen as thick or slightly thicker than in f. *Granii*, but Rosenvinge mentions thicker crusts, however, not being sure whether they belong to the same form. Judging from these younger specimens the present form apparently also loosens itself from the substratum, as they, being removed from the substratum, appear to have been but loosely attached. Typical specimens of this form have not been found with us, but only transitions to it.

With reference to the structure both the forms accord with one another. The branches show in a longitudinal section pretty regular cup-shaped layers of tissue, with the inner cells about 10—12 μ long and 5—8 μ thick.

The form *Granii* develops sporangia at a rather young stage, even before the branches are particularly developed. The conceptacles only occur in the upper part of the knobs or branches and especially just below the apices, never in the crust. They are partly somewhat scattered partly and more frequently densely crowded, often so densely that the roofs become angular, or more or less confluent, in this respect rather accordig with those of *L. tophiforme*, seen from the surface about 350 μ in diameter, sometimes less sometimes a little more, convex but little prominent, and now and then somewhat flattened especially in a younger state. The roof is traversed by about 30 muciferous canals. I have examined several sporangia, all of which were bisporic and most of them apparently mature. They are rather straight or only a little bent, 140—180 μ long and 45—60 μ broad.

The conceptacles of sporangia in f. *Rosenvingii* are stated by Rosenvinge l. c. to be only about 250 μ in diameter. I found some few in the above mentioned specimens which are 300—350 μ in diameter seen from the surface, but perhaps they are frequently smaller, or Rosenvinge's measures may be from median

sections, sometimes showing less diameter than from the surface or the roof.

The conceptacles of cystocarps and antheridia are not yet known in any of the forms.

In both the forms the conceptacles of sporangia finally grow down into the frond. Overgrown ones are partly rather numerous, partly very few in number, sometimes even not to be found. Only the central portion of the roof gets dissolved, not seldom though the whole roof and then it partly leaves a nearly cup-shaped partly a deeper scar. Such scars become effaced by local formations of tissue, which, if the scars are not too shallow, rather often are covered by a new thickening layer of the frond and to be seen on a section.

Remark on the synonymy. Among some Greenlandic specimens from Julianehaab referred by Rosenvinge to *L. soriferum* (*L. tophiforme*) is a couple provided with conceptacles of sporangia. These in my opinion really belong to the present species and are closely related to f. *Granii*. I found overgrown conceptacles of sporangia or such ones filled with new-formed tissue, which is never due to *L. tophiforme*. In the superficial conceptacles, coinciding with those of the present species, I also found some few bisporic sporangia, which appeared to be mature. Besides, the specimens differ from *L. tophiforme* by a little thinner branches, shorter axes and somewhat uneven surface, but on the other hand the limits are in this respect often difficult to draw. A couple of others I suppose to be identic with the last named species.

Relation to other species. With regard to the sporangia the present plant is most nearly related to *L. glaciale*, but otherwise it is quite different and cannot be confounded with this species except young individuals. It in some respects shows greater affinity to the following species, *L. colliculosum*. On the other hand it may without closer examination be confounded with certain forms of *L. fruticulosum*, as f. *curvirostra*. However, it is most easily confounded with *L. tophiforme*, and sterile specimens sometimes are difficult to distinguish from smaller and thinner forms of the latter, although typically developed or fertile specimens are sepa-

rated both in structure, the sporangia and other essential characteristics.

Habitat. With us the plant grows in the upper part of the sublittoral region, on a depth of 3—8 fathoms. It apparently prefers protected places, in somewhat exposed localities descending farther down than in the former. On the Greenlandic coast it descends to a depth of 16 fathom. It bears sporangia in July, August, September and December.

Occurrence. Mehavn in East-Finmarken, Bergsfjord in West-Finmarken, scarce; Skorpen in Kvænangen, apparently rare; Rissen in the Trondhjem Fjord, rare; Dröbak (Gran) and Nesodden (Schreiner) in the Christiania Fjord, apparently pretty plentiful.

Geogr. Distribution. Greenland (Rosenvinge); the Atlantic coast of North America (Collins).

Lithothamnion colliculosum Fosl.

Contrib. II, p. 8.

f. *densa* Fosl. mscr.

f. *crusta* 0.5—1.5 mm. crassa; tuberculis usque ad 4 mm. altis, 1—2 mm. crassis, dense dispositis.

Fig. *Lithothamnion colliculosum* Fosl. l. c. t. 3, fig. 1 et tab. nostr. 17, fig. 8—10.

f. *laxa* Fosl. mscr.

f. *crusta* usque 3 mm. crassa; tuberculis tenuioribus, usque ad 2 mm. altis, laxe dispositis. Tab. 17, fig. 11.

f. *rosea* (Batt.) Fosl. mscr.

Descr. *Lithothamnion roseum* Batt. in Grevillea, vol. 22, p. 20.

Fig. " *colliculosum* f. *rosea* tab. nostr. 17, fig. 12—16.

Syn. *Lithothamnion fasciculatum* Farl. New Engl. Alg. p. 182; ex parte sec. spec.

" *colliculosum* Batt. in Grevillea, vol. 21, p. 23; Journ. of Bot. 1892, p. 8; saltem ex parte sec. spec.

Remark on the form of the species. The plant recorded by Batters l. c. under the name of *L. roseum* is supposed by him perhaps to be the tetrasporic form of *L. colliculosum*. It is in fact so closely related to this species, that it in my opinion cannot be considered more than a denominated form, or not unlikely being

the typical form of the species. It even is partly included in the form of *L. colliculosum* mentioned in Contrib. I. c. However, most of the specimens then gathered belong to the form that I have named f. *densa*. Others show transition to f. *rosea*, or being most nearly related to this form, of which I have later collected specimens that fully accord with British ones.

The form *densa* is characterized by its frequently thin crust which apparently seldom attains a thickness of 1.5 mm. It bears numerous and densely crowded knobs up to 4 mm. high, frequently about 2 mm., by a thickness of 1—2 mm. These knobs are cylindrical or slightly tapering, or enlarged towards the tip, simple, or now and then towards the apex provided with one or two wart-like processes, frequently with obtuse apices. Pl. 17, fig. 8—10. In a younger stage the edges of adjacent crusts stumbling each other generally raise themselves against each other, forming more or less elevated ridges. Cp. Contrib. II, pl. 3, fig. 1. These ridges rather seldom are to be seen in fully developed or older individuals, then being covered with knobs. The plant is often accompanied by other species, especially *L. Strömfeltii*, which it, not seldom, by and by covers, and is fastened to stones or occasionally shells.

Two specimens from Spitzbergen kindly communicated to me by Conservator Sparre Schneider fully accord with Norwegian specimens of this form. They are dredged between Amsterdam-øerne and Norskøerne by Capt. Nils Johnsen of Tromsø.

A form apparently nearly related to the latter is f. *laxa*, but on the other hand I have been in doubt whether it might not perhaps be regarded a separate species. I have seen only a solitary specimen bearing a couple of not fully developed conceptacles of sporangia, and this is an American specimen. Pl. 17, fig. 11. Collins' collection D., Rockport, Mass. However, I have Norwegian specimens which closely resemble the latter in habit, but they are sterile. This form rather differs in habit from f. *densa*, and is characterized by its thicker crust, up to 3 mm., but apparently somewhat varying in this respect, as parts of one and the same specimen may be only 1 mm. in thickness, and now and then a new crust partly is formed upon the primary. The crust

bears more or less scattered knobs, which in general are thinner than in f. *densa*, up to about 1.5 mm. thick, but frequently less, and up to about 2 mm. high, subcylindrical, with rounded or occasionally obtuse apices. The colour appears to be a darker pink than in the named form, judging from dried specimens. This form requires closer examination of larger materials than I have at my disposal.

The form *rosea* distinguishes itself by its thicker knobs, about 2—3 mm., which are not so densely crowded as in f. *densa*, cylindrical, cylindrical-conical or occasionally upwards thickened, in the Norwegian specimens not exceeding 5 mm. in height, but in British until 8 mm. according to Batters l. c. In most of the specimens that I have seen the knobs are simple, in others occasionally on the point of dividing, or carrying a small wart-like process, but Batters remarks that they also are bifid or trifid above. The crust is as thick or thicker than in f. *densa*. Pl. 17, fig. 12—13 represents Norwegian specimens, fig. 15—16 British, and fig. 14 an American specimen from Rockport, Mass. (Collins' collection F.).

The above quoted forms accord with each other as to the structure. The knobs show in a longitudinal section more or less regular cup-shaped layers of tissue, with the inner cells frequently longer in proportion to the thickness than those in a section of the upper thickening-layers of the crust, 8—12 μ long and 5—8 μ thick, with rather thin walls.

The conceptacles of sporangia in f. *densa* are scattered or somewhat crowded in or between the knobs, seen from the surface 300—350 μ in diameter, very little prominent and as a rule rather flattened. The roof is intersected with 30—40 muciferous canals. The sporangia are two-parted, much varying in shape and size, convex-concave and frequently with the rounded or now and then rather attenuating ends somewhat bent together, occasionally nearly half-moon shaped, and large in proportion to the height of the conceptacles, in general about 180—220 μ long and 60—100 μ broad, or more. I have, however, seen but few conceptacles and sporangia of this form.

In the above quoted specimen of f. *laxa* I found only two conceptacles in the crust, which are probably not fully developed, hardly perceptibly raised above the surface of the frond and much flattened, and of about the same diameter as in the preceding form. Some sporangia found in overgrown conceptacles were about 180 μ long and 60—90 μ broad.

In f. *rosea* the named conceptacles are frequently rather densely crowded in the crust and knobs, the roofs occasionally confluent or nearly confluent, also here about 300—350 μ in diameter, and partly much partly less flattened. In a British specimen kindly sent me by Mr. Batters I found them not or scarcely raised above the surface of the frond, indistinct and much flattened, but they were probably not fully developed, although the sporangia appeared to be mature. In another British specimen from the same locality they fully accord with those in Norwegian specimens, distinctly marked, slightly prominent and more or less flattened. In the above quoted American specimen of this form (pl. 17, fig. 14) the conceptacles are of the same size, but much flattened and in part nearly disc-shaped, though very little prominent. The sporangia are of about the same size as in f. *densa*, or a little smaller. Cp. Batt. l. c.

The above named conceptacles finally grow down into the frond. Overgrown ones sometimes are numerous sometimes very few in number, or apparently even wanting, which not unlikely may be connected with the fact, that the cystocarpic and antheridial conceptacles appear not to occur in the same individuals as those bearing sporangia. However, sometimes the whole roof falls away and leaves a rather shallow scar, and now and then I found such scars covered with a new, local formation of tissue; the conceptacles being densely crowded this new formation even stretched over more ones.

Cystocarpic conceptacles have with certainty only been found in f. *densa*. They are scattered or crowded over the crust or knobs without any order, conical, about 500—600 μ in diameter at the base, with a single orifice, and a little above the middle or towards the apex nearly always more or less constricted, the upper portion partly acute partly rather blunt. This portion or a part

of it easily falls away, or perhaps always towards maturity, and then the conceptacles are depressed-conical or nearly hemispherical. Later the whole roof disappears, leaving a cup-shaped scar with somewhat elevated edges, as in most other species. They are in a median vertical section inwards about $400\ \mu$ in diameter at the base, $200\ \mu$ high and the upper portion of the roof also about $200\ \mu$ high, the canal intersecting this portion $50\text{--}60\ \mu$ in diameter except towards the tip, where it is thinner. These measures are, however, from the largest conceptacles. The frequently appear to be lower. The carpospores are broadly cuneate, occasionally elliptical or elongated obovate, $120\text{--}160\ \mu$ long and $50\text{--}70\ \mu$ broad in the broadest part.¹⁾

The conceptacles of antheridia are very numerous in some of the specimens collected, scattered or crowded especially between the knobs, and appear in the same individuals bearing conceptacles of cystocarps. They are of the same shape as the last named organs, but smaller, about $200\text{--}300\ \mu$ in diameter at the base and traversed by a canal at the tip. The spermatia are very much varying in shape, however, apparently most frequently rounded-angular and much compressed, about $50\text{--}60\ \mu$ in diameter.

Remark on the synonymy. Prof. Farlow has had the kindness to send me two specimens of his *L. fasciculatum*. Another one is mentioned under *L. fruticulosum*. These specimens I without any doubt refer to the present species, and represent a form closely related to f. *densa*. It only differs by its in part a little thicker crust, and the numerous knobs are more or less anastomosing below and above more often furnished with wart-like processes than in Norwegian specimens. The conceptacles of sporangia accord with those of the named form. One of the specimens is accompanied by and partly anastomosed with *L. compactum*.

The plant that Mr. Batters records l. c. as *L. colliculosum* at least in part appears to belong to this species, according to

1) The shape and size quoted in Contrib. II, p. 10 partly refers to the spermatia partly depending thereon, that the carpospores have not been removed from the conceptacle and thereby mostly not seen fully from the side. They really are much thinner than broad, frequently somewhat convex-concave, and in the conceptacles especially the upper portion more or less bent.

specimens kindly communicated to me. One of these, fastened to a fragment of a shell, coincides well in habit with *f. rosea*, and is provided with conceptacles of sporangia also similar to this form, the roof intersected with about 40 canals, but I have not seen the sporangia. A couple of other specimens fastened to or encompassing small stones partly nearly approach *f. densa* in habit partly and especially one of them nearly destitute of knobs may not unlikely belong to another species, perhaps being a young *L. incrustans*. I have not succeeded in finding organs of propagation. However, Batters remarks¹⁾ that „the tetraspores are formed in prominent hemispherical or conical conceptacles with a single naked orifice“. If so really is the case, this form is quite different from the present species and most probably belongs to an undescribed one. I never met with any species in which the conceptacles of sporangia are conical, resembling those common to the superficial cystocarpic ones, with a single orifice.

Relation to other species. This plant is more nearly related to *L. glaciale* than the preceding, but is, however, plainly separated, except sometimes in a sterile stage from young individuals of that species. Young individuals much resemble young ones of *L. flabellatum f. Granii*, and *f. rosea* even in an older stage sometimes rather approaches younger and attached individuals of the latter. On the other hand, especially *f. rosea* encompassing stones, or forms standing between this and *f. densa* on the one side, and *L. fruticosum f. intermedia* on the other side sometimes are difficult to distinguish without closer examination. Besides *f. rosea* now and then reminds one in habit of *L. polymorphum f. tuberculata*, but it is separated from this even as to the colour, if they are not too bleached.

Habitat. At the first place I found this species (Skorpen in Kvaenangen) it grew on a depth of 10—15 fathom. Later I met with it in more shallow water, 5—10 fathom on the coast of Finmarken, but on the whole it appears to descend farther down along the northern part of the coast than in more southern tracts, or in exposed localities. It prefers sheltered places. In the Trondhjem Fjord I have taken it on a depth of only 1—2 fathom. On the

¹⁾ Grevillea, Vol. 22, p. 20.

British coast it even occurs in the litoral region, here, however, only in deep pools, which also sometimes seems to be the case on the Atlantic coast of North America, but apparently never laid dry, as for inst. often is the case with *L. polymorphum*. Cp. Batters l. c. On the northern Norwegian coast it has been found sparingly provided with sporangia, but more richly with apparently ripe carpospores and spermatia in July, the former half of August and September, and on the southern coast in July and August. On the British coast it bears sporangia in February and August. Thus it appears as if *L. colliculosum* develops reproductive organs nearly all the year, although in this as well as in most other species the greatest number of the gathered specimens have been sterile.¹⁾

Occurrence. Found at Kjelmo (f. *densa*) and Mehavn (f. *rosea*) in East-Finmarken, scattered and very scarce; Kistrand (f. *densa*), Kvalsund (f. *rosea*) and Sopnes in West-Finmarken; Skorpen in Tromsö Amt (chiefly f. *densa*), local but abundant; and at several places in the Trondhjem Fjord (f. *densa*, and f. *laxa*?), as Vanvik, Rissen and Kongensvold, scattered and very scarce.

Geogr. Distribution. Spitzbergen; Britain (Batters); the Atlantic coast of North America (Farlow, Collins).²⁾

Lithothamnion varians Fosl. mscr.

L. fronde crustacea, plus minusve lobata, crustis superimpositis demum sat crassa, tuberculis striisque brevibus instructa; conceptaculis sporangiferis convexiusculis, at parum prominentibus, a superficie visis diametro 300—350 μ ; sporangiis binas(?) sporas foventibus, 100—130 μ longis, 25—35 μ latis; conceptaculis cystocarpiferis conicis, subapiculatis, diametro circa 500 μ .

f. *verrucosa* Fosl. mscr.

f. *crusta irregulariter lobata, tuberculis usque ad 2 mm. altis, 0.5—2 mm. crassis, dense dispositis.* Tab. 18, fig. 1—5.

1) After this was in the hands of the printer I met with a form of the species at Ytteröen in the Trondhjem Fjord, growing in a rock-pool at low-water mark, which partly coincides with f. *rosea* partly somewhat approaches the above mentioned North American.

2) Cp. the remarks under *L. Strömfeltii* as to *L. Lenormandi* Gobi from the White Sea, which probably also includes the present species.

f. *irregularis* Fosl. mscr.

f. *tuberculis* fere hemisphaericis vel irregularibus, plus minusve laxe dispositis. Tab. 18, fig. 6—9.

Syn. Lithothamnion polymorphum Kjellm. N. Ish. Algfl. p. 134 (102); ex parte.
 sec. spec. ab auct. determ.
 " " Kleen, Nordl. Alg. p. 11; ex parte?
 " " Fosl. Contrib. I, p. 9.

Description of the species. As remarked below under *L. polymorphum* I consider the present plant an independent species. It forms incrustations on rocks. The form of the crust partly depends on that of the substratum, to which it clings closely and at first firmly, but when older at least often is easily separated from it. In f. *verrucosa* the crust puts forth more or less clumsy protuberances or lobes, or such are formed by covering up extraneous objects, and bearing, like the rest of the crust, numerous wartlike knobs up to about 2 mm. high and 0.5—2 mm. thick, with in general blunt apices. Pl. 18, fig. 1—5. In the form *irregularis* the crust is more or less irregular, and it is furnished with less numerous or few wart-like knobs, but more often smaller or larger subhemispherical or irregular processes. Pl. 18, fig. 5—9. Upon the primary crust new crusts are formed partly clinging to the subjacent one partly rather elevated and here and there free, or covering extraneous objects, or new, local crusts are formed so as to cover the numerous animals frequently living on or penetrating the plant, and the marginal portion of these new formations may sometimes be more or less free, or they form lamels, or ridges, or in all very irregular processes. Pl. 18, fig. 7 shows a specimen with in part small lamels. The crust attains a thickness of up to nearly 1 cm., frequently, however, less. Old individuals occasionally are to be found nearly free on the bottom, or become loosened by external causes. Such loosened individuals continue their growth and new formations are partly formed on the lower side turned towards the bottom, which, however, is also the case in fastened but nearly free individuals. Younger specimens are feebly shining, older ones often finely rugged on the surface. The plant is furnished with short and very fine striæ in

the crust as well as the knobs, but they are more or less indistinct and partly wanting in old specimens.

The colour is much fugitive. I have not noted that of fresh specimens, but dried ones partly are yellowish-white partly yellowish-brown and occasionally with a purplish tinge.

The structure is rather varying, as in most other Lithothamnia. However, the cells of the inner layers of tissue are in a longitudinal section of a knob frequently longer in proportion to the thickness than for inst. in *L. polymorphum*, and the walls apparently thinner, about 10—17 μ long and 6—10 μ thick in the specimens that I have examined.

The organs of propagation are as a rule very scarce and apparently seldom attain fully development. They are often attacked by animals, and in most of the conceptacles of sporangia that I have examined I did not succeed in finding spores, or I met with small animals or animal substance fully filling the cavity. The named conceptacles are irregularly scattered over the crust or knobs and never so numerous as in *L. polymorphum*, very nearly related to those of *L. glaciale* in appearance as well as development, though less distinctly marked, convex but very little prominent, and seen from the surface 300—350 μ in diameter, sometimes a little more sometimes less. The roof is intersected with 30—40 canals, which are crowded in the central portion of the roof. These canals are larger than those in *L. glaciale*. The central portion often gets somewhat depressed when nearly dissolved, and then it looks, in a certain stage, as if the conceptacles were surrounded by an annular border, as in *L. glaciale*. Most of the certainly few sporangia that I have seen were bisporic, about 100—130 μ long and 25—35 μ broad, but probably attaining larger size, nearly linear, or a little broader in the middle than towards the ends. However, in another specimen certainly somewhat differing from typical f. *irregularis* in habit, but most probably belonging to this form I found a conceptacle containing irregularly two- three- and four-parted sporangia. It may, therefore, be, that the sporangia have not been fully developed and mature ones in fact are tetrasporic.

In a specimen from Borgevær in Lofoten partly according with f. *verrucosa* partly furnished with some crowded, short and rather coarse branches reminding one of those in certain forms of *L. glaciale* I found well developed and apparently mature bisporic sporangia about $180\ \mu$ long and $80\ \mu$ broad. The part of the plant agreeing with the present species was sterile. It may be that spores of *L. glaciale* have germinated on the named form of *L. varians*, or both are grown together, though any limit between the crusts of the two supposed species is not to be detected, and the crust in all most nearly resembles that of the last named species.

The named conceptacles finally grow down into the frond, but overgrown ones appear seldom to be found in any great number.

In one of my specimens of f. *verrucosa* I found a few conceptacles of cystocarps. Pl. 18, fig. 5. They are conical, often rather low, $450\text{--}500\ \mu$ in diameter at the base, with a rather acute tip and traversed by a single orifice, on the one side approaching those of *L. apiculatum* in appearance, but not so abruptly passing into this tip as in that species, and on the other side rather more resembling those in *L. colliculosum*, but lower and so far as I have seen never constricted farther down, as often is the case in the last named species. This tip easily falls away and then the conceptacles look depressed-conical or subhemispherical. I have not succeeded in finding the spores.

Some few other conceptacles on the same individual and apparently similar in shape probably are those of antheridia. The greater part of the roof is in most of them fallen away, and always the uppermost part. They, however, seem to have been rather low, and are about $200\text{--}250\ \mu$ in diameter at the base.

I do not know which of the quoted forms might be considered the typical form of the species. They certainly are not well defined, although a limit frequently may be drawn, and they are often even considerably differing, and in my opinion ought to be regarded as denominated forms. Along the coast of Finmarken most of the specimens gathered belong to f. *irregularis* or forms

which are most nearly related to this, but also specimens fully according with typical f. *verrucosa* were apparently not uncommon. The best developed individuals of the latter I met with at Balstad in Lofoten. However, as I formerly regarded the species identical with *L. polymorphum* I did not take any greater notice of it at the different places.

Remark on the synonymy. This species is included in *L. polymorphum* recorded by Kjellman l. c., according to specimens determined by him. All the specimens that I now possess from East-Finmarken referred to under that name in Contrib. l. c. also belong to *L. varians*, except, perhaps, a specimen from Berlevaag. Still the plant mentioned by Kleen l. c. under the name of *L. polymorphum*, not unlikely, in part includes the present species.

Relation to other species. The plant rather approaches smaller individuals of *L. glaciale*, and it, in some respects, appears to form an intermediate link between this species and *L. polymorphum*, although the conceptacles of sporangia as well as the sporangia themselves are different in both the named species. On the one side it shows great affinity to the former, and is not always easily to be distinguished, as remarked under this, even the conceptacles of sporangia nearly approaching one another. But on the other side it occasionally assumes forms, especially such ones growing on a plain substratum in somewhat sheltered localities, which in a sterile state are very difficult or nearly impossible to separate from the latter. It probably is most closely related to *L. glaciale*, but its nearest relationship cannot be made out before the organs of propagation are better known.

Habitat. On the coast of Finmarken it frequently lives in the upper part of the sublitoral region, on a depth of about 2—5 fathom, but it also descends farther down, to about 10 fathoms water, and on the other hand it also occurs in rock-pools in the lowest part of the litoral region. Farther to the south I only met with it in the sublitoral zone. It prefers exposed localities, but also appearing in somewhat sheltered places. The plant is nearly always much attacked by animals, which it, if possible, by and by covers in its existence struggle, being rich in cavities produced

by boring-muscles, which particularly destroy the lower part of the crust, and always in very numerous passages made by worms. It grows over younger individuals of *Mytilus*, shells of *Balanidæ*, tubes of *Serpula* and numerous other animals fastened to or living on it. It also serves as a substratum for *Alaria*, *Laminaria* and other algæ, often widely extending over the rocks, and, not seldom, growing over the root and the lowest part of the stem of those large algæ. Specimens bearing conceptacles of sporangia have been taken in June, July, August and September, but in very small numbers and few of them containing sporangia. A solitary specimen collected in the later half of September was, as above mentioned, provided with some few conceptacles of cystocarps and probably also antheridia.

Occurrence. I here only record the localities from which I have specimens left, viz. Havningberg and Berlevaag in East-Finmarken, Honningsvaag, Havösund, Gjesvær and Ingö in West-Finmarken. A specimen from Kjelvik, picked up from a depth of about 15 fathom, perhaps also belongs to the same species. Besides it has been gathered at Skorpen in Kvænangen, and at Balstad and Borgevær in Lofoten.

Geogr. Distribution. Some specimens from Greenland that I have seen, determined by Kjellman as *L. polymorphum*, not unlikely, at least in part, belong to this species. Cp. Kjellm. l. c.

Lithothamnion polymorphum (L.) Aresch.

in J. Ag. Spec. Alg. 2, p. 524; *Millepora polymorpha* L. Syst. Nat. p. 1285; ex parte.

Descr. *Lithothamnion polymorphum* Strömf. Algveg. Isl. p. 19, t. 1, fig. 1—3.

Exsicc. " " Aresch. Alg. Scand. exsicc. No. 302.

f. *tuberculata* Fosl. mscr.

f. *crusta tenuiore*; tuberculis 2—3 mm. altis, 2—5 mm. crassis, obtusis vel truncatis plus minusve dense dispositis. Tab 17, fig. 17—19.

f. *valida* Fosl. mscr.

f. *crusta crassiore*; tuberculis fere hemisphæricis, diametro 5—20 mm., altitudine 2—6 mm. Tab. 17, fig. 20—21.

f. *papillata* Fosl. mscr.

f. crusta tenuiore, sublævi vel tuberculis minutis instructa.
Tab. 17, fig. 22—23.

- Syn.* Millepora polymorpha Mohr, Isl. Naturh. p. 141; ex parte.
Spongites crustacea Kütz. Spec. Alg. p. 689; Tab. Phyc. 19, t. 97?
Lithothamnion purpureum Cr. Fl. Finist. p. 150; sec. spec.
" polymorphum Kleen, Nordl. Alg. p. 11; ex parte.
" " Aresch. Obs. Phyc. 3, p. 5; ex parte.
" " Hauck, Meeresalg. p. 271; ex parte.
" " Kjellm. N. Ish. Algfl. p. 134 (102); ex parte.
" " Batt. Mar. Alg. Berw. p. 139; sec. spec.;
excl. syn.

Remark on the limits of the species. Some forms formerly referred to this species were removed by Kjellman l. c. It was taken in the same sense by me in Contrib. I, most of the specimens there referred to kindly determined by Kjellman and partly recorded by him l. c. However, regarding the plant distributed by Areschoug in Alg. Scand. exsicc. No. 302 as the type, I am now of opinion, that the species must still be limited and a form removed from it, which in fact appears to be rather more nearly related to *L. glaciale*. This I consider an independent species, the before mentioned *L. varians*. I here record the present species as defined by Strömfelt l. c. in regard to the vegetative parts, his specimens, as he remarks, also compared with Areschoug's type specimen, and the below quoted shape and development of the organs of propagation.

Remark on the form of the species. This species seems to be less varying than several other Lithothamnia, although there is a rather considerable difference between the most extreme forms. It perhaps includes more than the above quoted ones. They are, however, not well defined, as transitions often appear to occur. I do not know which of them might be considered the typical form, nor have I seen any great number of specimens, as the plant has been rather scarce in the tracts where I have collected Lithothamnia myself.

The form *tuberculata* is characterized by its rather thin crust, about 1—3 mm. in thickness, which bears more or less numerous

knobs, that frequently are about 2—3 mm. high and 2—5 mm. thick, either thickened towards the tip, with obtuse or truncate ends, or occasionally forming wart-like, subconical or subhemispherical processes. New crusts are formed, one upon the other, which cling more or less closely to the older one and its knobs, and thereby also the knobs become thicker, but not always stretched over the tip of the latter, or here the edges now and then form somewhat irregular excrescences by trumbling each other. Pl. 17, fig. 17—19. Especially in younger crusts a smaller or greater part of the peripheral portion often is free, and this portion is more or less distinctly zoned, with a whitish brim, and the downwards turned part of such a free portion frequently forms rather distinct concentric ridges. This also now and then is due to new crusts overlapping extraneous objects.

In *f. valida* the crust is thicker than in the preceding, up to 5 mm. or more, with larger and subhemispherical processes, which in general are 5—20 mm. in diameter and 2—6 mm. high. Pl. 17, fig. 20—21. This form reminds one much in habit of *L. loculosum* Kjellm. Beringh. Algfl. p. 21, t. 1, fig. 1—2. It often grows over shells of *Balanidæ* and *Mytilus*, and the new crusts are rather closely united to one another, if not covering extraneous objects.

The form *papillata* appears to be less independent than any of the other forms, and often passing into the one or other, but, on the other hand, in its most extreme form it is rather differing. The crust is of about the same thickness as in *f. tuberculata*, partly, however, nearly even, partly more or less uneven and provided with small processes, particularly in a younger stage with concentric zoned peripheral portion and whitish brim. Pl. 17, fig. 22—23. The surface of the frond is in younger individuals of this as well as the other forms rather smooth and often even shining. Magnifying shows, however, the surface to be uneven in consequence of concentric and radiating striæ. These striæ are not, or seldom, to be seen in older individuals, and in such ones the surface never is quite smooth.

On a radial section the cells of the upper thickening layers

are rectangular, occasionally nearly squarish, about 10—14 μ long and 6—8 μ thick, with most often rather thick walls.

The conceptacles of sporangia, which I also found in Areschoug's above mentioned type, are more or less densely crowded over the whole frond without any order. I have not seen younger, but fully or nearly fully developed, or emptied ones. They are always immersed, seen from the surface depressed-globular or oblong, not cup-shaped, as in the below mentioned conceptacles, about 100—150 μ in diameter, at least towards maturity surrounded by an annular or oblong border, partly rather indistinct, but visible by its a little lighter colour, partly distinct, but not or very slightly raised above the surface of the frond, including this border 200—300 μ in diameter. The roof is intersected with 20—30 muciferous and rather coarse canals, which towards maturity often are about 8—10 μ in diameter. By and by the roof gets nearly dissolved, the surrounding parts continue their growth and the conceptacles become overgrown. Occasionally the whole roof as well as the greater part of the border falls away, leaving a rather deep hole. The tetrasporic sporangia are in general 90—110 μ long and 25—40 or 45 μ broad, by a thickness of about $\frac{1}{2}$ — $\frac{1}{3}$ of the breadth.

Overgrown conceptacles frequently are numerous, spherical or flattened-spherical, about 200—300 μ in diameter, and now and then having been filled with local formations of tissue, probably corresponding with the mentioned falling away of the roof and border.

The conceptacles of cystocarps and antheridia appear to occur in other individuals than those bearing sporangia. Once I have seen them in an individual growing on the same substratum as, and in part confluent with another individual bearing sporangia. However, I am not sure whether the below described organs include the one or other, or, as I am most inclined to suppose, both the named ones. I found them in two small specimens from Mandal and a couple of others from Helgoland, the former kindly sent me by Prof. Wille and the latter by Dr. Kuckuck.

In the named specimens from Mandal the conceptacles are from the surface of the frond at first visible as globular points,

which are imperceptible to the naked eye, 150—250 μ in diameter. These points are slightly lighter than the surrounding parts, in the middle intersected with a single and rather indistinct canal, and the periphery forming a more or less light and very narrow annular border, not, however, raised above the surface of the frond. By and by the roof becomes slightly convex, seldom nearly hemispherical or depressed-conical, rather thick, but in all very little prominent, of the same diameter as above quoted, with the orifice more distinct, but, so far as I have seen, not yet any spores formed. Later the central portion of the roof gets thinly decorticated, but the conceptacles apparently not yet fully developed, nor did I find any distinct spores in the, however, very few conceptacles that I have seen in this state of development.

In the specimens from Helgoland I found some few conceptacles very nearly resembling the named convex ones, and in others a smaller or greater part of the central portion decorticated, seen from the surface apparently by and by assuming a cup-shaped or depressed-oblong form, with not or very slightly elevated edges, successively depressed towards the centre, and the not much depressed central portion traversed by a single canal. Conceptacles in the last named state were numerous and appeared to be fully developed, at least some of them containing apparently mature spermatia, and others not unlikely carpospores, the former flattened and rounded or rounded-angulate, about 60 μ in diameter, the latter broadly cuneate or oblong, but in all rather irregular, about 70 μ long and 40—50 μ broad. At maturity the orifice becomes larger, a smaller or greater part of the roof gets dissolved, or the whole roof falls away, leaving a rather deep hole.

From the rather scanty materials at my disposal, with the conceptacles in the specimens from Mandal in one and the same state of development, and so also in those from Helgoland, I have not been able to decide with certainty whether the first named really bear cystocarpic conceptacles in development, or both these and the antheridian ones. And I am not sure whether the last named specimens only were provided with spermatia, and if so, the latter are extremely varying, or if in fact are both the named

organs, so that the convex conceptacles are cystocarpic ones in development. There is a slight difference between the convex conceptacles in the specimens from Mandal and the convex in those from Helgoland, as the latter appear frequently to be even less prominent and, especially those cup-shaped, in general a little larger than the former, although I, on the other hand, have not seen any true limit between the convex, in part decorticated, and the cup-shaped and fully developed conceptacles.

There can be but little doubt that the here mentioned specimens belong to one and the same species, or to the present one.

Also these conceptacles apparently grow down into the frond, but are on the other hand often effaced by local formations of tissue. In one specimen with all the conceptacles emptied I found numerous such formations forming even disc-shaped, light and slightly projecting processes, which I, however, have occasionally seen also in other species.

Remark on the synonymy. Most of the authors from the former century did not refer crust-like Lithothamnia to this species, or all the forms known were apprehended as one and the same species, *L. polymorphum*. Among these probably was Linné, Gunnerus, Esper, Ellis et Solander, Moñr, and others. The latter refers l. c. to *Apora polymorpha* Gunn. in Act. Nidros. 4, p. 70, which includes the forms mentioned under *L. boreale*, *L. fruticulosum* and *L. coralloides*, and he adds: „I Fiöru-Maalet træffes den almindelig, men under en anden Skikkelse, nemlig ikke anderledes end en kalk, der har beklædt Stene, Snekker og Skaller, oftest kurlakrød, uden Grene eller Knorter“. Here probably is included the present species, as well as *L. circumscriptum* and *L. Strömfeltii*. Also in the former half of this century the species often has been taken nearly in the same sense (cp. Johnston and Kützing l. c.), or it has been very differently understood, until Areschoug defined it as a true crust-like plant, but later, and even by Areschoug himself, it has been the general practice to refer all or nearly all such forms to the present species. Cp. Kjellm. l. c.

Of *L. purpureum* Cr. I have seen 4 small fragments from

Crouan's collection in Museum d'Histoire Naturelle. One of these is provided with newly emptied conceptacles of sporangia coinciding with those of the species in question, and Crouan quotes the sporangia to be tetrasporic, and it in all accords well with *L. polymorphum*. It is only about 1.5 mm. thick, but overgrown conceptacles are visible from the side of the fragment. The roofs of the emptied conceptacles are fully dissolved, but not any part of the border, the holes 150—180 μ in diameter, and including the border the conceptacles have been 200—300 μ in diameter seen from the surface. Two of the other fragments destitute of conceptacles perhaps or probably also are referrible to the same species. The fourth on the other hand seems to be somewhat differing, but it is too small and fragmentary to be determined, as it only forms a part of the peripheral portion of a larger specimen.

Relation to other species. As remarked under *L. varians* these two species may easily be confounded in a sterile stage. So also in regard to the following species, *L. incrustans*. They are, however, distinguished by characters quoted under the latter. The species on the other hand sometimes approaches in habit certain forms of *L. papillosum* Zanard.

A specimen that I got from Dr. Bornet, gathered at „Le Croisic (Loire Inférieure)“, rather resembles in habit *L. papillosum* Zanard. in Hauck, Meeresalg. t. 2, fig. 4, with smaller or larger processes. I, however, found some few conceptacles of sporangia, which fully accord with those in *L. polymorphum*, and, no doubt, being a form of this species most nearly related to *f. papillata*. Overgrown conceptacles are numerous, but I have not seen the sporangia.

A British specimen gathered at Swanage by Mr. Batters is nearly related to the latter in habit, however, with more numerous, a little larger and more irregular knobs. It not unlikely is also a form of *L. polymorphum*, but it is sterile and, therefore, the determination not certain.

Of *L. papillosum* Mad. A. Weber van Bosse kindly sent me 3 specimens from Hauck's herbarium for examination. Two of these fully coincide with Hauck's description l. c., and it probably

is a well defined species. They are about 4—6 mm. thick. Upon the primary crust new crusts are formed, sometimes closely united to one another, sometimes and more often, in one and the same specimen, rather loosely connected, with in part visible interwalls, or covering extraneous objects. Together with the wart-like and small prominences small lamels often are formed, with the edges free and bent downwards, or gripe over and older prominence, or at length form hollow prominences. These lamels are frequently concentric zonated. The conceptacles grow down into the frond. They are in a median section about 100 μ high and 200—250 in diameter. I have not seen superficial conceptacles of sporangia, nor do the sporangia appear to be known. I, however, found some few other superficial conceptacles, which apparently are cystocarpic ones, and probably those mentioned by Hauck l. c. p. 272. They are nearly subhemispherical, with a single orifice and about 300—400 μ in diameter. The third specimen rather differs from the other two. It is of about the same thickness as these, but the frond appears to be composed of minute lamels more or less densely united. Seen from the surface these lamels are very small and horizontally extended, seldom slightly raised, giving the surface a rugged and squamellate appearance. It is sterile, and I have not examined the structure, nor do I know whether it really is a form of *L. papillosum*, or, more probably, belongs to another species, not unlikely even of the subgenus *Lithophyllum*. It grows together with a very small fragment of typical *L. papillosum*.

Habitat. On the northern part of the coast the plant lives in rockpools, or on nearly perpendicular rocks in the lower part of the litoral region. It also occurs a little below extreme low-water mark, to about 1 fathom, but I do not know whether it descends farther down in the sublitoral region. On the south-western coast I met with it in 2—3 fathoms water, as at Hvitingsø near Hauge-sund, and in the Christiania-Fjord it has been taken on a depth of about 5 fathom. It appears in sheltered places as well as in rather exposed localities, and it apparently develops organs of propagation nearly all the year at least in more southern waters. Thus it is found near Tromsø with ripe sporangia in the middle of June

and with conceptacles (of sporangia?) in development in the former half of September. On the southern coast it bears reproductive organs, especially sporangia, in July and December, partly mature partly in development. Summer- and winter-specimens from Helgoland are partly furnished with sporangia partly with spermatia (and carpospores?). On the coast of Britain it develops reproductive organs in February and on the coast of France in May, but probably also at other seasons of the year.

Occurrence. In the sense here taken the species has not with certainty been found farther to the north than Honningsvaag in West-Finmarken, and here apparently rare; Skorpen in Kvænangen, local and scarce (f. *tuberculata*); Lyngö near Tromsö, local but pretty plentiful (f. *valida*); the coast of Nordland, common, according to Kleen l. c.; Sulen in Sogn (Boye); Hvitingsø; Mandal (Wille); and Nesodden in the Christiania-Fjord, a solitary specimen (Schreiner). It probably is more commonly dispersed along the western and south-western coast.

Geogr. Distribution. The Bahusian coast of Sweden (Areschoug); Iceland (Strömfelt); Britain (Batters); Helgoland (Kuckuck); France (Crouan, Bornet). The form quoted by Hauck l. c. from the Adriatic Sea very likely is *L. incrustans* Phil. Cp. under this species.

Lithothamnion incrustans (Phil.) Fosl. mscr.

Lithophyllum incrustans Phil. in Wieg. Arch. p. 388; Solms Laub. Corall. p. 16.

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

Lithothamnion depressum Crn. Fl. Finist. p. 151.

Descr. Lithophyllum incrustans Solms Laub. l. c.

Fig. Lithothamnion incrustans f. *depressa* tab. nostr. 18, fig. 10—11.

f. *Harveyi* Fosl. mscr.

Descr. et Fig. Melobesia polymorpha Harv. Phyc. Brit. pl. 345,

Fig. Lithothamnion incrustans f. *Harveyi* tab. nostr. 18, fig. 12—15.

Syn. Nullipora polymorpha Johnst. Brit. Spong. and Lithoph. p. 238; ex parte; pl. 25, fig. 2—3?

Melobesia polymorpha Harv. Man. p. 108; ex parte.

Spongites confluens Kütz. Spec. Alg. p. 698; Tab. Phyc. 19, t. 97;

Aresch in J. Ag. Spec. Alg. 2, p. 519.

- Syn.* Spongites incrustans Kütz. Spec. Alg. p. 698.
 " racemosa Kütz. Phyc. gen. 386; Phyc. germ. p. 296; Spec.
 Alg. p. 698? Cfr. Tab. Phyc. 19. p. 35.
 Lithophyllum incrustans Aresch in J. Ag. Spec. Alg. 2. p. 519.
 Lithothamnion crassum Unger, Leithakalk p.. 21, t. 5, fig. 9?
 " polymorphum Crn. Fl. Finist. p. 151.
 " " Le Jol. Liste Alg. Cherb. p. 151; saltem
 ex parte.
 " " Rosan. Melob. p. 99; saltem ex parte.
 " " Hauck, Meeresalg. p. 271; saltem ex parte.

Remark on the determination of the species. I have not the advantage to decide with certainty what Philippi has meant by his *L. incrustans*. He refers to *Corallina cretaceum lichenoides* Ell. Corall. p. 84, t. 27, fig. d. D., one of which is probably not a *Lithothamnion*, the other not unlikely represents the species in question, although the figure does not give any good idea of the plant. Solms Laubach l. c. declares *L. incrustans* in its typical development to be easily recognized from the nearly allied *L. polymorphum* Aresch., but it is on the other hand not quite evident whether it really may be the same plant that I apprehend as *L. incrustans*. Thus he remarks, that „die Conceptacula sind ausserlich nicht sichtbar“ and that the surface is often sprinkled „mit nadelstichartigen Löchern“, which by Kützing is quoted as a character of his *Spongites confluens*, the latter being considered by Solms Laubach identical with *L. incrustans*, and these holes he states to be „nur die Mündungen zahlreicher, von Thieren gebohrter Gänge“. In this respect the plant in the sense here taken quite differs from that of Solms Laubach. The conceptacles of sporangia are, as below mentioned, visible from the surface of the frond just as small pin-holes, but they are, on the other hand, particularly when emptied, easily confounded with passages made by worms, which certainly are often to be found in this as well as in all or nearly all other species. He records as a well marked character, that *L. incrustans* distinguishes itself by the colour of a fracture of the frond. „Auf dem Querbruch ist er schmutzigweiss Normal entwickelte Individuen beider Arten gleichen sich vollkommen, lassen sich aber in frischen Zustand sofort an

der Farbe des Querbruchs unterscheiden, welcher nämlich hier (*L. polymorphum*) nicht trübweiss, sondern schön gelb erscheint“. I have not seen fresh specimens of *L. incrustans*, but judging from *L. polymorphum* and dried specimens of both, this character is, in my opinion, of less value, as the colour of the surface as well as that of the fracture is also rather varying and often depends on the locality where the plants grow and relations connected with this. However, there can be but little doubt, that the species is, in the sense here taken, identic with that considered by Solms-Laubach to be *L. incrustans* Phil. He refers to an Adriatic specimen, that he got from Dr. Hauck under the name of *L. polymorphum*. Also of this form Mad. A. Weber van Bosse kindly sent me two specimens from Hauck's herbarium for examination, which are mentioned below. If not, the name *L. depressum* Crn. has the priority.

Remark on the form and addition to the description of the species. Of *L. depressum* Crn. I have seen three authentic but small fragments from the collection in Museum d'Histoire Naturelle, all of which are provided with conceptacles of sporangia, and the one also with those of cystocarps. The crust is about 1—2 mm. thick, and the surface is partly nearly even, smooth and somewhat shining, partly irregular, with some few, small and irregular excrescences. The conceptacles of sporangia are irregularly scattered or crowded over the whole frond, seen from the surface strikingly reminding one of small and shallow pin-holes, about 50—80 μ in diameter. They at first appear as indistinct depressed-circular points. Later the deepenings get a little larger, the central part deepest, darker and more distinct, the bottom of which forms a part of the roof of the conceptacle. The surrounding part is also slightly depressed and gradually passing into the surface of the frond. I have not seen more than a single canal traversing the centre of the roof, which is to be found also in younger conceptacles, about 15—20 μ in diameter. Towards maturity this canal becomes larger, or at length the greater part of the roof falls away, leaving a hole about 80—120 μ in diameter, sometimes a little smaller sometimes larger. These holes much resemble passages made by

worms. Crouan l. c. quotes the sporangia to be bisporic. However, this may probably depend thereon, that he has examined not fully developed ones. Judging from a solitary conceptacle examined they appear in fact to be tetrasporic. I also found some bisporic, but neither the former nor the latter appeared to be mature. The cystocarpic conceptacles are convex or nearly hemispherical, 150—200 μ in diameter, most frequently very little prominent and furnished with a rather coarse orifice, in appearance rather resembling a certain stage of those mentioned under *L. polymorphum*. I have not seen the spores.

A specimen that I got from Dr. Bornet under the name of *L. polymorphum* „cum tetrasporis“, gathered at Cherbourg, is nearly related to the above mentioned in habit. The crust is about 2 mm. thick, the surface rather irregular, with subhemispherical or irregular but small processes, smooth and rather shining. Pl. 18, fig. 10. Seen from the surface the conceptacles of sporangia form in a younger stage very small, shallow depressed-circular points about 20—30 μ in diameter, owing to the dark bottom, a part of the roof, looking as deeper holes, with not or scarcely not depressed edges. Later the edges or a slightly larger part of the surrounding portion than in Crouan's specimens get depressed, and thereby the points are more easily perceptible and even look a little larger than in the latter, but still gradually passing into the surface of the frond. Also the central portion by and by becomes a little larger, as a part of the edges get dissolved, though frequently smaller than in the named specimens, or not more than about 50 μ in diameter, but probably not yet fully developed.

Another but smaller and younger specimen „cum disporis“ that I also got from Dr. Bornet under the same name and from the same place nearly accords in habit with the former, but partly with an indistinct whitish brim. It bears some few conceptacles of sporangia nearly coinciding with the above mentioned and most developed ones, but the edges less depressed. I also found but bisporic sporangia, about 120 μ long and 50 μ broad, and some of them even with an apparently fully developed wall, but they were probably not mature. As before mentioned the parti-

tion of the sporangia in immersed conceptacles apparently takes place in a more slow succession and, therefore, the middle wall may perhaps be even fully developed before the other walls are founded. The specimen also bears conceptacles of cystocarps in development.

The named specimens from the Adriatic Sea (Hauck's coll. No. 72) belongs to the same series of forms, and so also most probably that represented in Hauck, Meeresalg. t. 1, fig. 5. The other figure (4) not unlikely is identic with the below mentioned f. *Harveyi*. The one specimen has a rather even and smooth surface, with a couple of smaller and rather clumsy protuberances. In the other some individuals originally have fastened themselves to one and the same substratum, in their farther growth anastomosing, and the edges trumbling each other form coarse ridges. Otherwise it is partly even and smooth partly with some few irregular processes. In both I found some few conceptacles of sporangia fully according with those in *L. depressum* Crn., seen from the surface 60—80 μ in diameter. In a few others the whole roof has by some reason disappeared, the emptied conceptacle forming a hole about 200 μ in diameter.

Another and younger specimen from Hauck's herbarium, gathered at Miramar and labelled *L. Lenormandi* nearly covers an individual perhaps being the latter, which specimen probably also belongs to the same series of forms as the above mentioned. It is richly provided with in part even confluent cystocarpic conceptacles, that very nearly accord with those mentioned under *L. depressum* Crn., about 150—200 μ in diameter.

The here mentioned specimens without any doubt belong to one and the same species, *L. depressum* Crn., which I adopt as a form of *L. incrustans* Phil., very likely being the typical form of this species. This form is, besides, as to the reproductive organs, characterized by its crust either being in part even, or bearing more or less numerous subhemispherical or irregular, but frequently small processes. The peripheral portion is in general and especially in older individuals not much thinner than the internal, never, so far as I have seen concentric zonated and not even in

younger specimens with any distinct whitish brim. Old specimens appear to be more vaulted, which probably sometimes also is the case in younger, as Solms Laubach remarks l. c. „In der Jugend ist er kreisförmig und in Folge des in der Mitte rasch voranschreitenden Dickenwachsthums ziemlich stark convex“. The crust attains a thickness of at least 1 cm. New crusts formed upon the primary one are closely united to each other, and the limits are difficult to detect, except when covering extraneous objects, which, however, apparently not often infest this form. The surface is frequently smooth, more seldom with local, scaly thickenings or other local new formations, partly rather shining partly not. The four-parted sporangia, of which I have seen but few, appear to be about 100—120 μ long and 30—50 μ broad. Overgrown conceptacles sometimes are numerous sometimes very few, almost spherical and about 200 μ in diameter. Some specimens gathered at Mandal on the south coast, also bearing conceptacles of sporangia, most of which are emptied and the whole roof having disappeared, partly accord with this form (cp. pl. 18, fig. 11) partly form transitions to f. *Harveyi*.

The plant recorded by *Harvey* l. c. under the name of *Melobesia polymorpha* also has been one of the doubtful forms, which by *Areschoug* as well as some recent authors is referred to *L. polymorphum*. As before remarked there is no authentic specimen of *Harvey's* *Lithothamnia* in existence. I got, however, some specimens from Mr. *Batters*, gathered at *Cumbræ* and considered by him to be identic with *Harvey's* plant, which without any doubt really is the case. However, *Harvey* referred all the crust-like forms known to him to the same species, as he remarks himself, and among these probably also the true *L. polymorphum*. Cp. *Phyc. Brit. and Man.* l. c. But, on the other hand, the figures in *Phyc. Brit.* as well as the description of the reproductive organs refer to the form in question. He describes the conceptacles such: „*Ceramidia* minute, dot-like, sunk deeply in the outer layers of cells, extremely numerous and often punctuating over the whole surface of fertile fronds as if they had been closely marked with pin-holes“. There can be no doubt that this refers to the con-

ceptacles of sporangia and agrees perfectly with the specimens that I have seen. In this respect Harvey's plant fully coincides with the above quoted f. *depressa*, only the conceptacles frequently a little larger. The point-like deepenings are, in the named specimens, at first 40—50 μ in diameter, in a more advanced state getting larger, about 70—80 μ in diameter, and, so far as I have seen, always with a single orifice, which towards maturity becomes larger, or the whole bottom, a part of the roof, as well as the lower part of the depressed edges of these deepenings get dissolved, especially in dead specimens even the whole roof, and then forming distinct holes about 200—300 μ in diameter. I found numerous sporangia, but at least most of them appeared not to be fully developed, unparted or bisporic and among the latter some few with apparently a fully developed wall, as in the above mentioned French specimen of f. *depressa*. I, however, also found a couple of tetrasporic ones and two others with indistinct partition of the one or both just formed cells. I, therefore, consider mature and normally developed sporangia to be tetrasporic. They are very much varying in shape and size. Sometimes I found them 120—150 μ long and even up to 65 μ broad, sometimes and apparently in the same state of development only about 90 μ long and 30—40 μ broad. Overgrown conceptacles partly are very numerous partly few. In one of the specimens bearing conceptacles of sporangia I also found a couple of other conceptacles, which probably are those of cystocarps. They nearly agree in shape with those in f. *depressa*, but are a little larger, or up to 250 μ in diameter at the base.

This form, which I propose to name f. *Harveyi*, can hardly be considered a separate species. It is nearly connected with f. *depressa*, and especially the above mentioned specimens from Mandal show complete transition. On the other hand it is, in its most extreme form, much differing, and a specimen from the west coast probably belonging to the present form even somewhat approaches *L. crispatum* Hauck l. c. t. 2, fig. 3 in habit, and Mr. Batters informs me, that it often comes near *L. expansum* in appearance. It seems to be extremely varying, the primary crust often nearly

disappearing, and the more or less anastomosing and irregular knobs now and then divided in a very irregular manner, or bearing irregular processes. Pl. 18, fig. 12—15, which represents British specimens. It is nearly always much attacked by animals, new formations are formed so as to cover these as well as other extraneous objects, the edges often being free, or the overlapping flaps nearly in contact with each other bend downwards and form a deepening over the overlapping object, which, however, also may be a knob or a short branch, or not closed at the summit, that sometimes may be more or less compressed or wavy, and in all assuming peculiar forms, most of which probably are raised in its struggle for existence, as specimens not much attacked by animals more or less approach f. *depressa* also in habit.

Besides the above mentioned specimen from the west coast I have seen another from the same locality (Sulen in Sogn), that most probably belongs to f. *Harveyi*, but it is sterile and the lower or older parts nearly destroyed, the upper and younger ones covering tubes of *Serpula*, shells and other objects.

A British specimen from Chapman's Porl. Dorset, referred by Batters to the same form, rather reminds one of certain forms of *L. polymorphum* and especially f. *tuberculata* in habit. The crust is about 2 mm. thick, with rather densely crowded and in part anastomosing knobs up to 7 mm. high and 5 mm. in diameter, but more or less irregular in shape, and here and there with some wart-like processes. It on the other hand seems to be nearly related to f. *Harveyi* and not unlikely belonging to this, but it is sterile and cannot, therefore, be determined with certainty.

As to the structure the species appears often to be rather varying. In the form *depressa* I frequently found the cells of the upper thickening layers to be about 10—12 μ long and 5—6 μ thick on a radial section, and pretty uniform, but especially in f. *Harveyi* the named cells sometimes are of about the same size sometimes much larger even in one and the same specimen. Here I found them up to 18 μ long and 9 μ broad, nearly always elongated, with rather thin walls. Occasionally the cell-rows are in vertical

direction of the frond so loosely connected, that they after decalcifying are easily separated by pressure.

With reference to colour it also appears to be subject to much variation. Crouan quotes the colour in *f. depressa* to be „rosée“. The named fragments that I have seen are much faded, partly, however, with a faint purplish tinge. The specimen from Dr. Bornet's collection with tetrasporic sporangia (pl. 18, fig. 10) is yellowish-brown and partly with a purplish tinge. Another specimen from Cherbourg is feebly wine-coloured. Solms Laubach remarks l. c., that the colour „schwankt zwischen trübroth und bräunlichviolet; an üppig wachsenden Exemplaren ist seine Oberfläche bläulich bereift“. In *f. Harveyi* the colour of living specimens is according to Mr. Batters „a purplish pink very much like that of *L. polymorphum* but fainter and more fugitive“. Dried specimens of both forms often closely resemble each other in colour.

Remark on the synonymy. Besides the above mentioned synonymes is to be remarked, that *L. polymorphum* Crn. no doubt also belongs to the present species and stands nearest to *f. Harveyi*. I have seen three authentic but fragmentary specimens, which are up to 1 cm. in thickness, with rather coarse and irregular processes. The conceptacles of sporangia accord with those of the present species, and the sporangia are tetrasporic, of about the same size as the above quoted smaller ones in *f. Harveyi*.

So also with regard to *L. polymorphum* Le Jol., of which I have seen a smaller specimen (Herb. Le Jol. No. 1745). It is about 1 mm. thick, confluent crusts form ridges, but otherwise being nearly even and smooth, with conceptacles of sporangia and cystocarps in development, and most probably identic with *f. depressa*. In an overgrown conceptacle I found tetrasporic sporangia. Whether it, however, is identic with the form distributed in Alg. mar. Cherb. No. 11 is unknown to me.

As mentioned under *L. fruticulosum* and *L. crassum* Johnston's *Null. polymorpha* probably includes both these species as well as the present. Thus pl. 25, fig. 2–3 l. c. represent forms, that seem to be most nearly related to *f. Harveyi*, the one, fig. 2, however, perhaps being a form of *L. crassum*.

Relation to other species. This plant in some respects corresponds with the northern *L. varians*, the form *Harveyi* nearly connected in habit with certain forms of that species, but it is in fact most nearly allied to *L. polymorphum*, and sterile specimens especially of f. *depressa* easily may be confounded with the latter. The colour, however, is frequently lighter and more fugitive, the marginal portion in general comparatively thicker and, so far as I have seen, never concentric zonated, nor that of new-formed crusts overlapping extraneous objects, and the surface appears not to be furnished with concentric or radiating striae, as often is the case particularly in younger individuals of *L. polymorphum*, although not always. Fertile specimens are on the other hand easily distinguished, and it cannot then be confounded with any form of the latter.

Habitat. With us it apparently grows in the upper part of the sublitoral region. It appears to prefer protected places. Specimens collected in the former half of August were provided with partly emptied partly not fully developed conceptacles of sporangia. On the coast of Britain it bears the named organs as well as conceptacles of cystocarps in August, and on the coast of France in April, September and November, in most cases with not mature sporangia and carpospores, but also emptied conceptacles.

Occurrence. Only found at Mandal (Wille), apparently scarce (f. *depressa* and transitions to f. *Harveyi*), and two not quite certain specimens of f. *Harveyi* at Sulen in Sogn (Boye).

Geogr. Distribution. Britain (Harvey, Batters); the Atlantic coast of France (Crouan, Le Jolis, Bornet); the Mediterranean Sea (Philippi, Solms-Laubach); the Adriatic Sea (Kützing, Hauck).

Lithothamnion compactum Kjellm.

N. Ish. Algfl. p. 132 (101).

Descr. et Fig. Lithothamnion compactum Kjellm. l. c. et t. 6., fig. 8—12.

Fig. " " tab. nostr. 19, fig. 1—4.

Syn. Lithothamnion polymorphum Farl. New Engl. Alg. p. 182; saltem ex parte.

" " Kjellm. Algenv. Murm. Meer. p. 8.

" circumscriptum β validum Rosenv. Grönl. Havalg. p. 775.

Addition to the description of the species. Most of the specimens of this species that I have seen are thinner and younger than those mentioned by Kjellman l. c., the crust only 1—2 mm. in thickness, but bearing conceptacles of sporangia, a couple, however, even up to 2.5 cm. thick, with numerous new crusts formed upon the primary. The surface of younger individuals is even and smooth, in older it often becomes somewhat uneven, and once I even found a couple of very small excrescences. It partly is feebly shining partly not, and especially old individuals appear frequently to be dull or nearly dull. Pl. 19, fig. 1—4.

The conceptacles of sporangia are rather densely crowded over the whole frond without any order, occasionally so densely that they become angular, and even close to the margin of the crust. They appear from the surface at first as small and lighter points, which soon become a little larger and by and by depressed, towards maturity forming nearly cup-shaped but shallow deepening about 150—200 μ in diameter, a smaller central portion frequently gets more depressed, about 100 μ in diameter, and this portion is intersected with 10—20 rather coarse muciferous canals. Occasionally they somewhat approach those of *L. incrustans* in appearance. At maturity the named central portion of the roof falls away, and the surrounding parts sometimes become lighter and easily dissolvable sometimes not, the peripheral portion or thickening layer of the frond continues its growth and the conceptacles become overgrown. Now and then the whole roof falls away, probably on account of external causes, or if the conceptacles are very densely crowded, and then the emptied conceptacles form distinct and rather deep holes about 200—250 μ in diameter. These holes often get effaced by new local formations of tissue, and such filled conceptacles are to be seen on a section. Overgrown conceptacles partly are numerous partly very few, on a radial section forming more or less regular rows parallel to the surface of the frond. I have seen but some few sporangia, which were bisporic, but I do not know whether they were quite mature, 120—160 μ long and 50—80 μ broad. Cp. Rosenv. l. c. The cell-rows of

the upper thickening layers are after decalcifying easily separated by pressure.

Remark on the synonymy. According to kindly communication of Prof. Farlow he considers his *L. polymorphum* to be most nearly related to *L. compactum*. On the same substratum as a specimen of his *L. fasciculatum*, mentioned under *L. colliculosum*, I found a small crust with sporangia in development, which belongs to the present species, and the named plant most probably at least in the main includes *L. compactum*. Besides, I got a well developed, sporangia-bearing specimen from Mr. Collins, which also is identic with this species. Pl. 19, fig. 4. Collins' coll. 2136. „Eagle Island, Maine. Apparently thrown up from deep water“.

I cannot agree with Kolderup Rosenvinge, that his *L. circumscriptum* β *validum* belongs to the species, to which it is referred by him. He had the kindness to send me specimens of this form, and, in my opinion, it is not a form of *L. circumscriptum*, but accords well with *L. compactum*. He remarks that it is not impossible, that the plant may be identic with the latter¹⁾, but has on the other hand seen every transition to *L. circumscriptum*, and, therefore, he thinks it referrible to this. However, if it may be considered a specific character whether the conceptacles of sporangia grow down into the frond, or not, *L. circumscriptum* must only with regard to this character be regarded a species different from the older *L. compactum*. In the former the conceptacles never grow down into the frond according to Strömfelt.²⁾ I have, too, collected rather numerous specimens of this species fully coinciding with Strömfelt's description, and the immersed conceptacles do not become overgrown. On the other hand, in *L. circumscriptum* β *validum*, as Rosenvinge remarks l. c. „afkastes kun Laaget, men ikke hele Konzeptaklets Loft, og idet dette og de mellem Konzeptaklerne liggende Partier fortsætte Væksten, bliver Konzeptaklerne overvoxede“. The conceptacles of sporangia

1) „Det er ikke umuligt, at denne form kan være identisk med *L. compactum* Kjellm.“

2) Algveg. Isl. p. 20.

mentioned by Kjellman l. c. appear to have been younger and those mentioned by Rosenvinge fully developed or emptied. Greenlandic specimens accord in this respect with specimens that I got from Spitzbergen (pl. 19, fig. 3), American (pl. 19, fig. 4) and Norwegian (pl. 19, fig. 1—2), in which I also found younger conceptacles agreeing with younger ones in an authentic specimen from Kjellman's collection, gathered at Novaya Zemlya. The named organs are different in both species, although they, in certain states of development, may be rather easily confounded. The above mentioned falling away of the whole roof in *L. compactum* does not take place successively and in the same manner as in *L. circumscriptum*, and even in this case the conceptacles may be overgrown. If, however, the holes become filled with new local formations of tissue, as apparently often being the case, such filled conceptacles frequently are to be seen on a section, which, so far as my experience goes, never is the case in *L. circumscriptum*, showing that the thickening meristema in *L. compactum* is superficial, overlapping this new formations, but in *L. circumscriptum* lying below the basal surface of the conceptacles. I have even seen the greater part of a new crust upon an older being rubbed or dissolved together with the conceptacles. Pl. 19, fig. 2. I, therefore, suppose it to be specimens in which the whole roof of the conceptacles is fallen away, that Rosenvinge regards as transitions to *L. circumscriptum*, and such specimens occasionally rather remind one of the latter. However, the last named species never attains the thickness of *L. compactum*, scarcely up to 1 mm., and the peripheral portions always are thinner than the internal, while in *L. compactum* the former sometimes may be even thicker than the latter and the plant slightly concave. Besides, the conceptacles in *L. circumscriptum* occupy a sharply defined zone, developed successively from the centre towards the periphery, so that the inner frequently are emptied before the outer are founded, but always with a sterile peripheral portion. In *L. compactum*, on the other hand, they are contemporary developed over the whole frond and frequently even close to the margin.

Relation to other species. As remarked by Prof. Kjellman

himself, this species appears to show greatest affinity to *L. incrustans*, from which it, however, is distinguished especially with regard to the shape and size of the conceptacles of sporangia, as well as the sporangia themselves.

Habitat. On the Norwegian coast it lives in the upper part of the sublittoral region, on about 5—6 fathoms water, both on open coast and in sheltered places. Specimens collected in June to September were provided with conceptacles of sporangia in development. I, however, did not succeed to find the sporangia. On the coast of Novaya Zemlya it bears young conceptacles at the end of June and July. Specimens from Spitzbergen probably taken in July or August were furnished with well developed sporangia, and on the coast of Greenland in the later half of June. In American specimens collected in July and September I partly found apparently mature sporangia partly in development. Cystocarpic and antheridian conceptacles still are unknown.

Occurrence. Found at Kjelmö (Sydvaranger) and Mehavn in East-Finmarken, Kistrand and Kvalsund in West-Finmarken, at Skorpen in Kvænangen, and at Tromsö, everywhere apparently rare.

Geogr. Distribution. Novaya Zemlya (Kjellman); Spitzbergen; Greenland (Rosenvinge); the Atlantic coast of North America (Farlow, Collins).

Lithothamnion testaceum Fosl. mscr.

L. fronde crustacea, crustis superimpositis demum usque ad 1 cm. crassa, pallida rosea, superficie inæquali, tuberculis subsemiglobosis vel irregularibus instructa; conceptaculis sporangiferis sub foveola leviter excavata immersis, diametro 100—140 μ ; sporangiis quaternas sporas foventibus, 90—120 μ longis, 25—50 μ latis. Tab. 19, fig. 5—9.

Description of the species. The plant forms irregular crusts of a rose pink colour, older sometimes with a yellowish tinge. The form of the crust partly depends on that of the substratum. New crusts are formed upon the primary, sometimes rather closely clinging to the subjacent sometimes loosely covering extraneous objects, or partly nearly free, with concentric striæ in the part

turning downwards, at length attaining a thickness of about 1 cm. It is more or less uneven, which, however, often depends on the substratum, as it frequently covers shells of Balanidæ and other animals fastened to the rock, or grows over animals fastened to younger crusts of the plant itself. But it also is provided with subhemispherical or irregular processes, or new local and irregular crusts are formed upon the older. Pl. 19, fig. 5—9. It is extremely traversed by worms especially in the lower layers, so that it here often rather resembles a mesh-work. The surface appears perfectly smooth to the naked eye, as if it were polished, but magnified shows here and there rather indistinct concentric and radiating striæ, sterile crusts feebly shining but fertile not. The peripheral portion is rather thin, but not concentric zoned, nor is the brim whitish.

The conceptacles of sporangia are irregularly scattered nearly over the whole frond, or here and there crowded, but on the whole scarce in the specimens gathered. They are at first visible from the surface of the frond as minute lighter points, imperceptible to the naked eye, about 100—130 μ in diameter, the roof of the conceptacles. The latter by and by gets thinly decorticated at first in the centre, later the whole roof, intersected with about 10—15 muciferous canals, and at length forming depressed-circular points of the named size. At maturity the whole roof gets dissolved, frequently at first the central portion, the surrounding parts continue their growth and the conceptacles become overgrown. They are in a median section spherical or nearly spherical, about 100—140 μ in diameter. The sporangia are four-parted, 90—120 μ long and 25—50 μ broad.

Overgrown conceptacles frequently appear to be numerous. In most of those examined I found all or nearly all the sporangia not escaped, many of which have been apparently mature when they together with the conceptacles grew down into the frond.

The cells of the upper thickening-layer are seen on a radial section to be arranged in straight, well-marked rows, rectangular or sometimes nearly square, about 10 μ long and 7—8 μ thick, with not or scarcely not rounded corners.

Relation to other species. The plant on the one side reminds one of *L. compactum* and on the other side it rather approaches *L. incrustans* f. *depressa* in habit, and appears to be most nearly related to this. It, however, distinguishes itself especially with reference to the conceptacles of sporangia, which are smaller and differ in several particulars. The structure also seems in general to be coarser.

Habitat. In the only locality hitherto known it appeared in a shallow rock-pool at low-water mark of neap tide in a fjord, but a rather exposed place. It bears mature sporangia in the later half of August, partly also with such ones in development partly emptied conceptacles.

Occurrence. Only found in the neighbourhood of Bergsfjord in West-Finmarken, local and very scarce.

Lithothamnion foecundum Kjellm.

N. Ish. Algfl. p. 131 (99).

Descr. et Fig. *Lithothamnion foecundum* Kjellm. l. c. et t. 5, fig. 11—19.

Syn. *Lithothamnion polymorphum* Kjellm. Kariska hafvets Alg. p. 15.

Remark on the determination of the species. It scarcely admits of any doubt, that some few specimens gathered in East-Finmarken belong to this species, although I have not succeeded to find the sporangia. One of them, however, bears conceptacles of sporangia, which at least in part are almost fully developed and exactly coincide with a couple in a fragment of an authentic specimen from the Kara Sea. However, it appears as if they are rather differing in the different states of development, and the border is often to be seen only in a certain state, but I have not been able to get any clear idea of their development in the scanty materials at my disposal. Emptied conceptacles apparently not seldom get filled by new local formations of tissue, judging from such ones seen on a radial section together with overgrown conceptacles. The specimens otherwise also agree well with the description and the named fragment. The peripheral portion of the crust is feebly concentric zonated, and the whitish brim rather indistinct.

The species seems to have been taken in a rather wide sense by Kjellman. Some specimens from Greenland, that I have seen, are considered by him to belong to this species, but at least a couple are identic with *L. Strömfeltii*, bearing mature sporangia as well as newly emptied conceptacles. Cp. Kjellm. l. c.

Relation to other species. The plant appears to be most nearly related to *L. varians*, from which it, however, is separated by essential characteristics.

Habitat. In the locality known with us it grew in a rock-pool between tides, on a much exposed coast, and is collected in the middle of July.

Occurrence. Found at Berlevaag in East-Finmarken, rare. A sterile and younger specimen picked up from a depth of about 5—6 fathom at Mehavn in East-Finmarken probably belongs to the same species.

Geogr. Distribution. The Kara Sea (Kjellman).

Lithothamnion flavescens Kjellm.

N. Ish. Algfl. p. 129 (98).

Descr. et Fig. *Lithothamnion flavescens* Kjellm. l. c. t. 6, fig. 1—7. Cfr. tab. nostr. 8, fig. 1.

Syn. *Lithothamnion flavescens* Fosl. Contrib. I, p. 8.

Remark on the species. This species fastens itself to quite different substrata, as for inst. other crustaceous or branched *Lithothamnia*, stones or shells of *Balanidæ*, and thereby it also assumes much varying forms as to the shape of the crust. Thus I met with it surrounding the lower branches of *L. tophiforme* and *L. fruticosum*, giving to these plants a coarse and often peculiar appearance, and in a sterile stage easily to be considered, without closer examination, as if the host not really was infested with any epiphyte. Cp. *L. fruticosum* f. *flexuosa* pl. 8, fig. 1 and two of the specimens of *L. tophiforme* (*L. soriferum*) represented in Contrib. II, pl. 3, fig. 2. The form I met with on smaller stones, occasionally together with or in part covered by *L. colliculosum*, most probably also belongs to the same species. It is, like the epiphytic form, closely adherent to the substratum and

resembles this, richly provided with reproductive organs, only the crust being more regular owing to the substratum, often with smoother surface, and the colour is a somewhat darker pink, sometimes with a purplish tinge. The species probably includes two or three forms, but the material at my disposal is rather scarce, and I have not been able to draw any limit between them.

The conceptacles of sporangia I nearly always found to be flattened hemispherical, occasionally nearly disc-shaped, but strongly prominent, now and then nearly superficial, about 500—700 μ in diameter, most often rather crowded and sometimes so densely that the roofs become angular. The tetraporic sporangia get up to 300 μ in length, however, rather varying both in length and breadth. Cp. Kjellm. l. c.

The conceptacles of cystocarps I met with in the greatest number on specimens fastened to stones, more seldom and in less numbers on epiphytic ones, conical or depressed-conical, 500—600 μ in diameter at the base, now and then, however, even up to 800 μ . They are not acute, but at least often rather high and somewhat constricted towards the summit. This upper portion falls away earlier than the lower, or a part of the lower, and then the conceptacles look very low. The carpospores are nearly rectangular, with more or less rounded corners, or slightly narrower towards the base, or, apparently more seldom, broadly cuneate, in general 150—180 μ long and 60—80 μ broad.

Together with the last named conceptacles there occur some smaller, in shape nearly resembling the former, but only 250—300 μ in diameter at the base. These I suppose to be the conceptacles of antheridia, but I have not seen certain spermatia.

At maturity the whole roof of the conceptacles of sporangia often falls away, leaving a cup-shaped scar with more or less elevated edges, which is gradually effaced by local formations of tissue, and thereby the surface becomes more irregular. This seems especially to be the case if the conceptacles are nearly superficial, otherwise they appear to grow down even if the whole roof gets quite dissolved. However, overgrown conceptacles often are scarce even in older crusts. On the other hand also the cystocarpic con-

ceptacles occasionally become overgrown thereby, that only a smaller or greater portion of the roof falls away, and the rest gets covered by a new thickening layer of the frond or a local new formation.

Relation to other species. I do not know any species of this section, to which *L. flavescens* shows any greater affinity. However, it in habit occasionally somewhat approaches *L. foecundum*, but even sterile specimens appear as a rule to be easily distinguished. On the other hand the below mentioned *L. ocellatum*, *L. Strömfeltii* and *L. investiens* may be confounded with it, partly in a sterile partly even in a fertile state. Cp. under these species.

Habitat. The present plant seems with us to prefer rather sheltered places and penetrates far up the fjords, frequently occurring in the upper part of the sublittoral region, but it descends also to the lower limit of this region, fastened to other Lithothamnia, as *L. glaciale*, *L. tophiforme* and *L. fruticosum*, or to stones and shells of Balanidæ. It is richly provided with organs of propagation in July and August, especially sporangia.

Occurrence. Found at Kjelmo, scarce, Kirkenes (Sydvaranger), scarce, and Lebesby in East-Finmarken, local but pretty plentiful; at Kistrand, Magerø (Kjellman) and Kvalsund in West-Finmarken, scarce; and within Tromsø Amt at Skorpen, Karlsö (Kjellman) and Tromsö, at the latter place apparently not uncommon on other Lithothamnia.

Geogr. Distribution. The west coast of Novaya Zemlya (Kjellman); and the west coast of Spitzbergen (between Amsterdam and Norsköerne).¹⁾

Lithothamnion ocellatum Fosl. mscr.

L. fronde crustacea, arcte adnata; crusta 0.5–1 mm. crassa, purpurea, scabriuscula, limbo obsolete concentric striato; conceptaculis sporangiferis sub foveola leviter excavata annulo vix elevato circumdata 150–200 μ lata immersis, diametro 300–350 μ ; con-

¹⁾ Cp. what is quoted under *L. Strömfeltii* as to *L. Lenormandi* Gobi from the White Sea, which probably in part also includes a form of *L. flavescens*.

ceptaculis cystocarpiferis convexiusculis vel fere hemisphaericis, diametro 250—300 μ ; sporangiis quaternas sporas foventibus, 120—135 μ longis, 45—60 μ latis. Tab. 19, fig. 10.

Description of the species. The plant forms incrustations on other and branched Lithothamnia. The crust clings closely and firmly to its substratum, and is about 0.5—1 mm. thick, frequently surrounding nearly all the branches of the host plant. The nature of the surface is determined by that of the substratum. If this is smooth, the crust is also smooth and feebly shining especially when young. Older crusts partly are very finely rugged and squamellate by growing over small extraneous objects, or on account of the shape of the conceptacles, or scaly thickenings; partly nearly smooth, with indistinct concentric and radiating striae. The brim is thin, feebly concentric zonated, and the margin shallowly crenate with rounded lobes. The colour is a purplish pink very much like that of *L. polymorphum*, only lighter than is usual in the latter.

The lower, co-axil system of the frond is feebly developed and in the fragment examined scarcely perceptible on a section. In the upper thickening-layer the cells are smaller than those of the nearly allied *L. polymorphum*, nearly squarish or rectangular, 7—9 μ long and 5—7 μ thick. Overgrown conceptacles are more or less numerous, occasionally having been filled with local formations of tissue.

The conceptacles of sporangia in their development and even as to the appearance closely resemble those in *L. polymorphum*. They, however, are frequently larger, the visible part of the roof itself about 150—200 μ in diameter, including the border 300—350 μ , and is intersected with 40—50 muciferous canals, which are smaller than those in the named species. At maturity the roof gets more frequently fully dissolved than in the latter, seldom also a part of the border, leaving a distinct hole. The sporangia are four-parted, 120—135 μ long and 45—60 μ broad.

What I think to be the conceptacles of cystocarps appear on the same individual bearing those of sporangia. They also resemble the probably similar organs in *L. polymorphum*, in a certain state,

or those in the mentioned specimen of the latter from Mandal, but a little larger, convex or nearly hemispherical, with a single orifice, about 250—300 μ in diameter. They are apparently not yet fully developed, nor did I succeed in finding the spores.

Relation to other species. As remarked, the present species is closely related to *L. polymorphum* with regard to the colour and the shape of the conceptacles of sporangia, and it, perhaps, is nothing more than an epiphytic form of this species, analogous to the same form of *L. flavescens*. However, it on the other side differs especially by its surface being smoother than in any form of *L. polymorphum*, not provided with excrescences, frequently larger conceptacles, the roof of which is intersected with smaller and more numerous muciferous canals, and so also with reference to the structure. I, therefore, at least for the present consider it an independent species. Sterile and somewhat faded specimens appear more easily to be confounded with *L. flavescens* than with any other known species.

Habitat. It has hitherto been met with only on a single specimen of another Lithothamnion, which seems to belong to *L. fruticulosum* f. *flexuosa*, or perhaps is a form of *L. tophiforme*, taken on a depth of 5—6 fathom, on hard bottom in an exposed locality. It bears mature sporangia in the middle of June. The formation of carpospores appears to set in later.

Occurrence. Only found at Lyngö in the neighbourhood of Tromsö, rare.

Sectio II. **Evanidæ** Fosl. mscr.

Conceptaculis sporangiferis superficialibus vel immersis, nunquam -nnatis.

Lithothamnion congregatum Fosl. mscr.

L. fronde libera in fundo jacente, subglobosa, demum fornicata, diametro usque ad 15 cm., roseo-purpurea, irregulariter subdichotome ramosa; ramis brevissimis, confertis, inferne plus minusve coalitis, teretibus, subcylindricis, circa 1 mm. crassis, fastigiatis, apicibus obtusis. Tab. 20.

Description of the species. The plant accords with *L. dehiscens* in its development, and the colour is nearly the same, only a little darker and apparently less varying. The frond is at first subspherical or nearly hemispherical, at length assuming a cup-shaped form like the named species, but frequently even less vaulted, or occasionally plane or nearly plane. Pl. 20, fig. 1—3. In the latter stage it is much rubbed in the part that has turned towards the bottom, with the interwalls between the branch-systems visible from this side. Pl. 20, fig. 4. Afterwards new formations of tissue often cover the rubbing parts of these older and partly denuded branch-systems, from which then new branches here and there are developed (pl. 20, fig. 5), or even covering the whole lower side of the plant. Pl. 20, fig. 6. Cup-shaped specimens go up to about 15 cm. in diameter and 1.5—2 cm. in thickness. It is branched in an irregular subdichotomous manner, and the branches are densely crowded, in the lower part more or less anastomosing and below the apex often furnished with small wart-like or short branch-like processes, occasionally showing a tendency to form very small bundles. They are frequently rather straight and fastigate, terete and nearly cylindrical, with obtuse or slightly spherically thickened ends, about 1 mm. thick, partly less partly a little more.

In a longitudinal section of a branch the inner cells of the more or less distinct cup-shaped layers of tissue are rectangular, or often nearly square, about 9—12 μ long and 6—8 μ thick.

The organs of propagation are unknown. I found some conceptacles of cystocarps in a younger specimen, and these rather resemble those in *L. dehiscens*, though frequently larger and more acute and apparently not yet fully developed, but I do not know whether this specimen really belongs to the present species. Nor did I find overgrown conceptacles of sporangia in the specimens examined and I, therefore, refer it to the section *Evanidæ*; however, on the other hand it appears rather probably, that these organs in fact grow down into the frond, but the not unlikely are seldom developed in older individuals, or not occurring in the same indi-

viduals bearing conceptacles of cystocarps and, therefore, seldom to be found on a section.

Relation to other species. On the one side it closely approaches certain forms of *L. dehiscens* and the limits are very difficult to draw, although typically developed specimens of both are easily recognized. It scarcely can be considered only a form of that species. On the other side younger or not opened and cup-shaped specimens often are nearly impossible to distinguish from certain forms of the following species, *L. nodulosum*, from which, however, it is quite different in an older stage.

Habitat. The species grows gregarious on rather hard bottom in 5—10 fathoms water in protected places. Specimens collected in the later half of July were sterile.

Occurrence. Only known from Sörfjorden in the Skjörn Fjord (a branch of the Trondhjem Fjord), local but abundant.

Lithothamnion nodulosum Fosl. mscr.

L. fronde libera in fundo jacente, subglobosa, diametro usque ad 10 cm., roseo-purpurea, decomposito-subdichotome ramosissima; ramis e centro solido, exiguo, undique egredientibus, subbrevibus, inferne sæpe plus minusve coalitis, teretibus, subcylindricis, circa 1.5 mm. crassis, extremis plerumque ramulos breves vel verrucæ-formes fasciculatos emittentibus; conceptaculis sporangiferis convexiusculis, parum prominentibus, a superficie visis diametro 300—350 μ , conceptaculis cystocarpiferis depresso-conicis, apiculatis, diametro 500—600 μ ; sporangiis quaternas sporas foventibus, 130—180 μ longis, 50—80 μ latis. Tab. 21, fig. 1—6.

Description of the species. This plant always develops freely on the bottom, forming subspherical masses, that attain a diameter of up to 10 cm., frequently, however, less, or about 7 cm. Pl. 21, fig. 1—6. The solid central mass is insignificant, and in older specimens a smaller or larger part of the central portion is frequently destroyed by boring-muscles or other animals. The frond is repeatedly but rather irregularly subdichotomously branched. The branches are frequently more or less curved, with short axes, in the upper portions occasionally rather straight, terete and nearly

cylindrical, or slightly tapering, about 1.5 mm. thick, seldom a little more, with rounded or slightly spherically thickened ends, which in old specimens often are somewhat denuded. Pl. 21, fig. 4. Especially the branches of the last order frequently bear numerous wart-like processes or short branchlets, which often are very densely crowded at the apex, forming smaller and denser or larger and more remoted bundles. These bundles are rather irregular, often subglobose, occasionally obpyramidal and nearly truncate. Pl. 21, fig. 2. The branch-systems are often more or less anastomosing, particularly if much attacked by animals.

In structure it very nearly agrees with the preceding species, frequently with rather more distinct cup-shaped layers of tissue, and the cells are of the same size as in the latter.

The conceptacles of sporangia I have seen only in two specimens (pl. 21, fig. 3 and 6) and in small numbers, most of which apparently not fully developed and others emptied. They are rather crowded in the upper part of the branches, convex but very little prominent, seen from the surface 300—350 μ in diameter. The muciferous canals appear not to be very numerous. The sporangia are tetrasporic, 130—180 μ long and 50—80 μ thick.

The cystocarpic conceptacles occur in other individuals than the first named organs. I, however, have seen but very few in a solitary specimen (pl. 21, fig. 5), and in another, but rather uncertain one, that apparently is anastomosed with *L. congregatum*. They are conical but rather low, abruptly ending in a short and thin tip; but apparently now and then somewhat approaching those of the named species in shape, about 500—600 μ in diameter at the base. I have not seen the carpospores.

Nor did I in this species meet with overgrown conceptacles of sporangia, but I am not sure whether they in fact do not grow down into the frond, as the conceptacles of cystocarps are superficial and both organs do not appear in one and the same individual. Scars after emptied conceptacles of sporangia I found effaced by local formations of tissue, but on the other hand I have not seen such on a section overlapped by a new thickening layer of the frond.

Relation to other species. As remarked under *L. congregatum* these species are often very difficult to distinguish in a not full-grown stage, and even older specimens of the present species may be confounded with not full-grown ones of the former. On the other hand it in some respects shows rather close affinity to other species, as *L. gracilescens*, *L. apiculatum* and even *L. fruticulosum*, and sterile specimens are easily confounded with the one or other, though rather seldom with *L. fruticulosum*. It requires closer examination of a number of fertile specimens, and it probably includes more forms, but must on the other hand be considered an independent species.

Habitat. The plant lives on a depth of 3—10 fathom, and it prefers rather hard bottom; though also occurring on looser and somewhat clayish bottom, partly in protected partly in somewhat exposed localities, but not on the open coast. It sometimes forms isolated banks sometimes grows in company with other species. The species is very scantily provided with organs of propagation in the later half of July.

Occurrence. Found in Sörfjorden in Skjörn, rather local but abundant, partly together with *L. congregatum*; Brækstad (Örlandet), local but abundant; at Bejan, local and rather scarce together with other species; and at Fröjen together with *L. topiforme*, rare.

Lithothamnion byssoides (Lam.) Phil.

in Wieg. Arch. p. 388; *Millepora byssoides* Lam. Hist. Anim. 2, p. 312.

Descr. et Fig. *Lithothamnion byssoides* Hauck, Meeresalg. p. 275, t. II, fig. 1.

Fig. Spongites " Kütz. Tab. Phyc. 19, t. 99.

Syn. *Lithoth. byssoides* Aresch. in J. Ag. Spec. Alg. 2, p. 522; excl. syn. plur.

Remark on the determination of the species. With some doubt I refer a couple of fragmentary specimens to this species, agreeing well with the description and the cited figures, only larger, or of subspherical specimens that have been about 10 cm. in diameter. They are, however, sterile, and I have not seen any authentic specimen of *L. byssoides*, nor do I know whether the conceptacles of sporangia become overgrown in the latter. I have not found such in the named fragments.

The only other form that I know, to which these show greater affinity and might perhaps be referrible is that mentioned under and for the present referred to *L. dehiscens*, but the fragments are of old specimens differing in development from the latter. They also differ from the named form especially by a little thinner, more regularly divided branches and longer axes. I am, therefore, most inclined to consider them identic with *L. byssoides* and not unlikely representing a northern and larger form of the species than the typical. I provisionally name it f. *major*.

Habitat. Unknown to me. Specimens taken in the later half of July were sterile.

Occurrence. Only found on the most southern part of the coast, at Mandal (Wille).

Geogr. Distribution. The Mediterranean Sea (Lamarck, Philippi); the Adriatic Sea (Hauck).

Lithothamnion tophiforme Unger

Leithakalk p. 21. *Lithothamnion soriferum* Kjellm. N. Ish. Algfl. p. 117 (88)

f. *globosa* Fosl.

Lithothamnion soriferum f. *globosa* Fosl. Contrib. II, p. 6.

f. *globosa* vel *subglobosa*, ramis strictis, fastigiatis.

Fig. l. c. t. 3, fig. 3.

f. *typica* Fosl. mscr.

Lithothamnion soriferum f. *divaricata* Fosl. l. c.; ex parte.

f. *subglobosa*, ramis plus minusve patentibus, plerumque curvatis vel interdum hamatis. Tab. nostr. 21, fig. 7, 10.

f. *squarrosa* Fosl. mscr.

Lithothamnion soriferum f. *divaricata* Fosl. l. c.; ex parte.

f. ramis squarrosis, plus minusve flexuosis vel hamatis, extremis plerumque elongatis. Tab. nostr. 21, fig. 8—9.

f. *alcicornis* (Kjellm.) Fosl.

l. c.; *Lithothamnion alcicorne* Kjellm. l. c. p. 121 (91).

Descr. et Fig. *Lithothamnion alcicorne* Kjellm. l. c. et t. 5, fig. 1—8.

Fig. " " *soriferum* f. *alcicornis* Fosl. l. c. t. 3, fig. 4.

Syn. *Corallium pumilum* Ellis, Corall. p. 83, p. 27, fig. C, No. 1?

Millepora polymorpha Mohr, Isl. Naturhist. p. 141, 148; ex parte; t. 6, fig. b.

- Syn.* *Millepora polymorpha* Ell. et Sol. Zooph. p. 130?
 " " var. *globosa* Esper, Pflanzenth. I, p. 214, t. 13?
 " *calcarea* Lam. Hist. Anim. 2, p. 312?
Nullipora calcarea Johnst. Brit. Spong. and Lithoph. p. 240; ex parte
 pl. 24, fig. 4?
Spongites polymorpha Kütz. Spec. Alg. p. 699?
Melobesia calcarea Harv. Phyc. Brit. pl. 291; Man. p. 108?. Nec
Millepora calcarea Ell. et Sol. p. 129, t. 23, fig. 13.
 " *compressa* M'Calla, sec. Harv. Man. p. 108?
Lithothamnion calcareum Aresch. in J. Ag. Spec. Alg. 2, p. 523?
 " *fasciculatum* Solms Laub. Corall. p. 20; saltem ex parte.
 " " Kleen, Nordl. Alg. p. 11.
 " " Aresch. Obs. Phyc. 3, p. 5; ex parte.
 " " Gobi, Algenfl. Weiss. Meer. p. 22; ex parte.
 " *soriferum* Fosl. Contrib. I, p. 6; II, p. 6.
 " " Strömf. Algveg. Isl. p. 18.
 " " Rosenv. Grönl. Havalg. p. 772; ex parte.

Remark on the determination of the species. It scarcely admits of any doubt at all, that the plant recorded by Unger under the above name and delineated l. c. t. 5, fig. 14 is the same that Kjellman l. c. calls *L. soriferum*, and formerly appears to have been recorded under different names. It is described from a specimen from Greenland, and the quoted figure accords well with certain forms of the above f. *squarrosa*. I, therefore, adopt this name as the oldest one. Unger remarks l. c.: „Es scheint mir der *Millepora polymorpha* var. *tophiiformis* Esper zu sein“. However, the latter in my opinion is not any Lithothamnion, but probably a coral, and Esper himself appears to have been doubtful whether it really was referrible to his *M. polymorpha*. Cp. Esper, Pflanzenth. I, p. 221, t. 15.

Remark on the form of the species. The above forms are not well defined, not even f. *alcicornis*, as transitions are often to be found, but they on the other hand deserve to be specially mentioned.

The form that I recorded l. c. under the name of f. *divariata* I now consider to include both the typical form of the species as well as one of its most extreme forms, f. *squarrosa*, although they pass rather gradually into one another, but that is

in fact also the case with the other forms. Pl. 17, fig. 7 and 10 represents what I apprehend as the typical form, characterized by its subspherical or rather irregular frond, with the branches being partly rather erect partly and more frequently somewhat spreading and seldom straight, but most often rather bent or even curved, on the one side passing into f. *globosa* and on the other side into f. *squarrosa* and f. *alcicornis*. The branches are up to 3 mm. thick, frequently about 2—2.5 mm., and they are never so regularly fastigiate as in typical specimens of f. *globosa*, often bearing more or less numerous wart-like processes or short branchlets. It gets up to about 12 cm. in diameter, frequently, however, less.

The form *globosa* is generally smaller than the preceding, spherical or nearly spherical, and the branches are erect, straight and fastigiate, more densely branched and the branches more seldom bearing wartlike processes. The apices occasionally are truncate or nearly truncate. Cp. Contrib. II, pl. 3, fig. 3.

The form *squarrosa* is very irregular in shape, in all much varying and little independent, although in its typical development rather differing from f. *typica* and easily recognized. The branches are much spreading, frequently rather flexuous and curved, less branched than the other forms, and the ultimate most often rather elongated. Pl. 21, fig. 8—9. The surface of this form is nearly always quite smooth, which, however, frequently also is due to the other forms, though these are less seldom here and there furnished with scaly thickenings, very seldom nearly over the whole frond.

As remarked l. c. *L. alcicorne* cannot be considered more than a form of the present species. It is very characteristic in its most extreme form, but far from being independent, and it especially is nearly related to f. *typica*. Two specimens represented l. c. pl. 3, fig. 4 plainly show transitions to this form. Specimens of the last named form, or forms standing between this and f. *globosa*, often bear here and there compressed branch-systems, and those separated much resemble small specimens of f. *alcicornis*.

The conceptacles of sporangia are quoted by Kjellman l. c. to be „small, scarcely perceptible to the naked eye“, and the

sporangia „generally, after the formation of spores has begun, about $95\ \mu$ long and $20\ \mu$ thick“. As I possess some specimens determined by Kjellman himself there can be no doubt as to the identity, but I found the conceptacles to be larger than in most other of the northern *Lithothamnia*, or of about the same size as those mentioned by him under *L. alcorni*, $400-500\ \mu$ in diameter seen from the surface, though rather varying and partly even a little more. However, I also met with smaller, but they appeared not to be fully developed, and they are then easily confounded with those of *L. flabellatum*, but they may perhaps be more varying than I have seen. They are frequently very densely crowded, and then the roofs being angular, occasionally almost fully confluent, sometimes over the greater part of a branch, and not only to be found in the upper branches, but nearly everywhere and even in the central portions of not too densely branched specimens both of f. *typica* and f. *globosa*. The roof is intersected with $70-80$ muciferous canals, and the four-parted sporangia are up to about $200\ \mu$ long and $80\ \mu$ broad.

The cystocarpic conceptacles sometimes appear in the same individual bearing those of sporangia sometimes and most frequently in other individuals, scattered and in great numbers nearly everywhere, though especially in the upper part of the branches, occasionally in pairs, fully anastomosed, with two orifices nearly approaching to one another. They are commonly about $600\ \mu$ in diameter at the base, conical, rather high, towards the apex more or less constricted and traversed by a rather coarse canal. The carpospores are much varying in shape, frequently, however, elliptical or broadly cuneate, $70-100\ \mu$ long and $40-50\ \mu$ broad in the broadest part.

Some few other conceptacles that I found in the same individuals bearing the latter are smaller, about $300\ \mu$ in diameter at the base, and probably those of antheridia. I, however, have not seen the spermatia.

Remark on the synonymy. The plant recorded by Ellis l. c. from Falmouth and the Isle of Man as „*Corallium pumilum album, fere lapideum, ramosum*“ is by different older authors

referred to rather different species, mostly, however, to *L. polymorphum* (L.). Crouan refers it to *L. coralloides* and Lamarck to his *Millepora informis*, the latter referred by Crouan to his *L. polymorphum*. The figure that Ellis gives of this plant somewhat reminds one of certain forms of the present species, but it looks coarser and more clumsy. It on the other hand rather approaches in habit a Lithothamnion that I got from Mr. Batters, gathered at Cum brae, which will be described in a separate paper under the name of *L. Battersii*, but the latter is a much smaller plant, the longest diameter only 1.3—2 cm., if, however, Ellis' figure has not been magnified.

The figure that Mohr l. c. gives of one of the forms of his *Millepora polymorpha* from Iceland is evidently f. *squarrosa* of the present species.

It seems as if *Mill. polymorpha* var. *globosa* Esper might be referrible to this species. Fig. 1 l. c. reminds one much of *L. tophiforme* f. *globosa*, and fig. 2 represents the upper part of a branch-system apparently with conceptacles of sporangia and cystocarps, supposed by Esper to be „die ersten Anlagen, oder Schichten neuer Aeste“, and also in this respect the plant rather resembles *L. tophiforme*. However, it looks coarser and larger than the last named f. *globosa* frequently appears to be, and is fastened to another object. Lamarck, Philippi and Areschoug refer this plant to *L. byssoides*, but the figure and description make it little explicable that it can be any form of that species.

One of the specimens figured by Johnston l. c. (fig. 4) as *Nullipora calcarea* most probably belongs to the species in question, and appears to be nearly related to or identical with f. *squarrosa*. The other is mentioned under *L. coralloides*.

It cannot with certainty be made out what *Melobesia calcarea* Harv. really is. The figures in Phyc. Brit. l. c. on the one side much resemble certain forms of the present species, but on the other side fig. 1 differs by its coarse main-axes. However, as mentioned under *L. flavescens* the present plant is often infested in the lower parts with other Lithothamnia, and then it sometimes looks very coarse, especially if the branches also are somewhat

anastomosed before being infested with the epiphyte. Mr. Batters kindly sent me a specimen gathered many years ago at Roundstone, and given to him by Dr. Paniter as *Melob. calcarea* of Harvey. He remarks: „I have little doubt that it is correctly named“. This specimen is sterile and much bleached, and it is small and far slender than the cited figure by Harvey, but much resembling *L. tophiforme* in habit, standing between f. *typica* and f. *squarrosa*. It is, however, also more slender than the latter frequently use to be, and, therefore, it perhaps belongs to *L. flabellatum* f. *Granii*. I am of opinion, that *Melob. calcarea* Harv. in the main includes the present species, but not unlikely also other species. Cp. Harv. and Johnst. l. c.

The form of *Melob. calcarea* mentioned by Harvey in Manual p. 108 under the name of *M. compressa* M'Calla, not unlikely, is identic with f. *alcicornis* or perhaps *L. flabellatum* f. *Rosenvingii*. „It differs from *M. calcarea* in having a compressed frond, with flat branches broader towards the tip.“ Harv. l. c.

I on the contrary do not think *Millepora calcarea* Ell. et Sol. l. c. identic with the species in question, referred to by Lamarck, Johnston and Harvey l. c., but more likely *M. polymorpha* Ell. et Sol. l. c. The former not even seems to be any Lithothamnion, but most probably a true coral. Cp. l. c. t. 23, fig. 13. It is described and figured from a specimen from the Mediterranean Sea, and at any rate it cannot be the same species that Harvey and Johnston record under the same name.

One of the specimens of *L. fasciculatum* Aresch., that I have seen probably belongs to this species, and is most nearly related to f. *typica*. It is, however, sterile.

Also *L. fasciculatum* Gobi partly includes this species. After a part of the present paper was printed I got, through the kindness of Prof. Chr. Gobi and Mr. C. Deckenbach, a specimen from the White Sea for examination, determined as *L. fasciculatum* and probably being one of those quoted by Gobi l. c. This specimen belongs to *L. tophiforme* f. *typica*, provided with conceptacles of sporangia, most of which, however, emptied. As Gobi mentions specimens which fully accord with *L. glaciale* (*L. fasci-*

culatum Kjellm. Spetsb. Thall. 1, p. 3) from Spitzbergen that he has seen from Kjellman's collection also the last named species is probably included in his *L. fasciculatum*, but not only this, as quoted above under *L. glaciale* p. 13 (41).

With regard to *L. soriferum* Rosenv. I refer to what is remarked under *L. flabellatum*.

Relation to other species. The present species appears to be more sharply defined than several other Lithothamnia. As the conceptacles never grow down into the frond and the thickening meristema apparently lies below the basal surface of the conceptacles, it really is most nearly allied to *L. nodulosum*, so far as the latter hitherto is known, but it cannot be confounded with any form of that species. However, on the other hand it in a sterile stage may be confounded with more species of the section *Innatae*, in which overgrown conceptacles are not always to be found. Thus as mentioned under *L. fruticulosum* f. *flexuosa* the typical form sometimes is very difficult to separate from that, and f. *globosa* occasionally rather approaches *L. dimorphum* in habit. Besides, sterile and slender specimens are easily confounded with *L. flabellatum* f. *Granii*, and even such ones with younger conceptacles of sporangia, although these species are quite different in their typical development.

Habitat. This species in general lives on sandy and shingly bottom, frequently forming banks, and it appears to prefer somewhat sheltered places, here often growing on a depth of only 4—8 fathom, but in more exposed localities descending farther down, to a depth of 10—15 or even 20 fathom, and it on the whole descends farther down than other Lithothamnia, perhaps with exception of *L. glaciale* and *L. boreale*. It nearly always develops freely on the bottom. I never met with certain specimens fastened to any other object, but according to Kjellman l. c. some specimens of f. *alcicornis* plainly show that they have been at first attached to some harder object. However, at Kvalsund I found a younger specimen fastened to *L. glaciale* which most probably belongs to f. *squarrosa*. The plant bears sporangia in July, Au-

August and September, carpospores (and spermatia?) in August and September.

Occurrence. The species appears to be dispersed along the whole coast of Finmarken and in several places abundant, as Lebesby in East-Finmarken, Magerö (Kjellman), Repvaag and Kistrand in West-Finmarken. Cp. Kjellm. and Fosl. l. c. Within Tromsö Amt for inst. at Skorpen, Karlsö (Kjellman) and Tromsö, plentiful. In Nordlands Amt it is common and abundant according to Kleen l. c. Within Nordre Trondhjems Amt I met with it at Fröjen and Froöerne, at the latter place local but plentiful. It has probably also been found at Christiansund, N. (Ekman).

Geogr. Distribution. The White Sea (Gobi); Iceland (Ström-felt); Greenland (Rosenvinge); Britain (Johnston, Harvey)?

Lithothamnion uncinatum Fosl. mscr.

L. fronde initio affixa(?), demum libera in fundo jacente, pulchre rosea, circa 5 cm. alta, irregulariter ramosa; ramis e axi primario brevissimo egredientibus, plus minusve patentibus, inferne usque ad 3 mm. crassis, valde attenuatis, ramulos plerumque flexuosos vel hamatos, 1—1.5 mm. crassos undique emittentibus. Tab. 19, fig. 11—14.

Syn. *Millepora polymorpha* var. *divaricata* Esper, Pflanzenth. vol. I, p. 218, t. 14, fig. 2?

Description of the species. This species is rather puzzling. I have seen but a solitary, somewhat fragmentary and sterile specimen. It most probably has been attached at first to some hard object and afterwards detached itself. The frond has the appearance of a low bush, about 5 cm. high, with a very short main-stem, and from this issue irregularly divided branches, which in the lower part attain a thickness of up to about 3 mm., much attenuating upwards and the ultimate ones only 1—1.5 mm. thick. They are more or less patent and bent, or flexuous, or in the upper parts of the frond curved, terete or nearly terete, and put forth nearly everywhere rather numerous branchlets, which are frequently thinner than their main-axes, not seldom only one half or even one third, either simple or irregularly divided, spreading,

flexuous or curved, 1—1.5 mm. thick, or occasionally less. Cp. pl. 19, fig. 11—14, of which fig. 12—14 are fragments of the specimen fig. 11. In the lowest part of the plant the branches are somewhat anastomosed, and this anastomose also here and there takes place farther up, and occasionally the tip of a branch bends itself towards another branch and anastomoses with this. The surface is smooth; magnifying shows, however, in the lower part of the plant numerous short striae.

In a longitudinal section of a branch the cup-shaped layers of tissue are pretty regular and distinct, with the inner cells nearly square or rectangular, about 9—12 μ long and 6—8 μ thick.

Remark on the synonymy. The plant somewhat reminds one in habit of that described by Esper under the above quoted name, which is said also to occur „in den norwegischen Meeren“. However, the latter is much larger than the present species, and it appears to differ in several particulars, not unlikely even being a coral.

Relation to other species. On the one side it approaches *L. coralloides* in habit, but is larger and differs especially by its branches being coarser in the lower part and much attenuating upwards. On the other it appears to be rather more nearly allied to *L. flabellatum* f. *Granii*, but distinguishes itself by its curved, irregular and attenuating branches. I have not found overgrown conceptacles of sporangia, and it probably is separated from both the named species and, not unlikely, in fact most closely connected with *L. tophiforme*, from which, however, it also appears to be specifically distinguished.

Habitat. Unknown to me; is found washed ashore.

Occurrence. A solitary specimen gathered at Kragerö on the south coast.

Lithothamnion Sonderi Hauck.

Meeresalg., p. 273.

Descr. et Fig. Lithothamnion Sonderi Hauck l. c. et t. 3. fig. 5.

Remark on the species and addition to the description. Of this species Mad. A. Weber van Bosse also kindly sent me an

authentic specimen from Hauck's herbarium for examination. Besides, in a collection of *Lithothamnium* from Helgoland, that Dr. Kuckuck had the kindness to send me, I found several fertile specimens of the plant. I have seen but a solitary Norwegian specimen which is not quite typical and ought, perhaps, to be considered a denominated form of the species. Two small British specimens, gathered at Cumbrae by Mr. Batters, fully accord with Helgolandian ones, the one being sterile but the other provided with some few conceptacles of sporangia.

There is some difference between younger but sporangia-bearing and older individuals. The former rather approach *L. Strömfeltii* and *L. Lenormandi* in habit, and sometimes closely resemble the figure of the last named species by Hauck l. c. t. 3, fig. 4, partly with nearly smooth surface partly with scaly thickenings or minute excrescences. Some younger specimens from Helgoland that I got under the name of *L. Lenormandi* belong to the present species. Old specimens resemble the quoted figure (5) by Hauck l. c. and are easily recognized and even in a sterile stage rather characteristic.

The conceptacles of sporangia are scattered over the whole frond in great numbers, and often two or three quite confluent. They are circular or nearly circular in circumference, very little prominent and nearly always flattened, often disc-shaped or nearly disc-shaped, frequently 350—400 μ in diameter seen from the surface. Towards maturity the central portion becomes more or less depressed, by and by falling away, and at length the whole roof gets dissolved, leaving a rather shallow scar, sometimes, however, with the exception of a small peripheral portion. The scars get effaced partly by a new thickening layer of the frond partly by new local formations, which contribute to the unevenness of the surface. The roof is intersected with 80—100 muciferous canals. The sporangia are four-parted, 100—140 μ long and 35—60 μ broad.

The conceptacles of cystocarps sometimes occur in the same individual bearing those of sporangia sometimes and most frequently in other individuals, and are scattered in great num-

bers like the latter. They are conical, rather low, generally 400—450 μ in diameter at the base, with a single orifice. The carpospores are nearly elliptical, elongated-obovate or broadly cuneate, 50—80 μ long and 35—40 μ broad in the broadest part.

Conceptacles of antheridia appear in the same individual as the last named organ, resembling this in shape but only 250—300 μ in diameter at the base. Some few spermatia that I have seen were roundish or rounded angular, compressed, and about 40 μ in diameter.

Relation to other species. It is rather independent and cannot in an older and fertile state be confounded with any other known species. However, as remarked above, it shows greater affinity to *L. Lenormandi* and *L. Strömfeltii*, and younger specimens are not always easily distinguished from the latter. Older specimens somewhat remind one of *L. polymorphum* except with regard to the colour, which is a darker or lighter pink, sometimes with a lilaceous tinge.

Habitat. It appears to grow in the upper part of the sublittoral region, fastened to smaller stones. At Helgoland it apparently develops reproductive organs all the year, at least in January, March, June and October, on the Norwegian and British coast in the former half of August.

Occurrence. Only found at Mandal (Wille), a solitary specimen.

Geogr. Distribution. Helgoland (Sonder, Kuckuck); Britain (Batters).

Lithothamnion investiens Fosl. mscri.

L. fronde crustacea, substrato plus minusve adnata, parte marginali plerumque soluta, undulato-lobata, zonata vel parte inferiore subconcentrice jugosa; crusta 0.5—1.5 mm. crassa, subnitida, demum superimposita, scabriuscula, striis brevibus instructa; conceptaculis cystocarpiferis(?) depresso-conicis, diametro circa 300 μ . Tab. 22, fig. 2—5.

Syn. *Lithophyllum zonatum* Fosl. Contrib. I, p. 10.

Description of the species. In the quoted paper I recorded a

solitary and fragmentous specimen of an alga, which I supposed to be referrible to *Lithophyllum* and considered nearly connected with *L. arcticum* (Kjellm.)¹⁾, a species showing close affinity to *L. lichenoides*. It in fact belongs to *Eulithothamnion*. Young specimens certainly rather remind one of younger specimens of that species, but older, which I have later collected, are quite different and really most closely related to certain forms of *L. flavescens*. However, with reference to structure it sometimes nearly approaches the subgenus *Lithophyllum*.

The plant forms incrustations on other Lithothamnina, partly dead specimens, as *L. glaciale*, *L. fruticosum* and *L. tophiforme*. Young individuals are nearly orbicular (pl. 22, fig. 2), older ones of irregular shape and rather extended. The frond clings more or less closely to the substratum; more closely to little or coarse-branched hosts as certain forms of *L. glaciale*, but is frequently only here and there adherent, more free in a host with much spreading branches as *L. tophiforme* f. *squarrosa*, or stretched over the branches of densely branched specimens of *L. fruticosum* (pl. 22, fig. 5), however, it also closely clings over and between the upper branches, though frequently even then but here and there attached. The peripheral portion or sometimes even a larger part of the crust partly and most frequently is quite free, undulate-lobate, bent a little upwards or irregularly bent, partly, however, attached to the substratum, though not closely. The upper side of this portion is most often rather feebly concentric zonated or in thin crusts provided with subconcentric furrows, which also occur in the lower part, but here narrower and more sharply defined, or in the latter part it even forms small ridges. Pl. 22, fig. 3—4. Sometimes the upwards turned part of a free peripheral portion is in thicker crusts nearly smooth or not zonated, but the lower part either concentric zonated or provided with small ridges. Now and then the crust puts forth a peripheral, free, disc-like or somewhat convex-concave and nearly reniform lobe. It is frequently feebly shining, older specimens with a more or less uneven surface, finely rugged and squamellate, or often.

¹⁾ Kariska hafvets Algveg. p. 16.

apparently provided with wart-like or short branch-like processes. This unevenness is, however, at least partly caused by the substratum, and the excrescences are either also caused by the substratum, by growing over short branches or covering up small extraneous objects, or, if not, they are concave in the lower part, or the short branch-like processes occasionally formed are partly hollow. Besides, the crust is furnished with very fine striæ partly radiating partly concentric not visible to the naked eye, which are to be found in young as well as old individuals, in the latter, however, more indistinct and partly wanting. New crusts are formed upon the primary, I have seen up to three, partly rather clinging to the subjacent, but seldom closely, partly more or less free and but here and there adherent.

The crust has a faint rosy colour, which by older individuals frequently passes into faint brownish-yellow. Fractures of the crust are rose-coloured or whitish with a rose-coloured tinge outwards.

With regard to structure the species appears to be rather varying and in general agreeing with that of *Eulithothamnion*, sometimes, however, nearly approaching *Lithophyllum*. Thus the basal, co-axil layer may in a thin crust be as thick or thicker than the upper thickening layer, frequently, however, much thinner especially in thicker crusts, and is composed of rounded or somewhat elongated cells about 8—12 μ thick. The cells of the upper layer are square or rectangular with more or less rounded corners, about 6 μ thick and up to $1\frac{1}{2}$ times longer than thick. The surface cells are rounded or rounded-angular, 4—8 μ in diameter.

I have seen but a couple of not well developed conceptacles, which apparently are those of cystocarps. They are conical, low, with a single orifice and about 300 μ in diameter at the base. I, however, have not seen the spores.

Relation to other species. As mentioned above the present species is nearly related to *L. flavescens*, apparently often being easily confounded with this, but the conceptacles do not grow down into the frond, and it also differs in other particulars. On the other side it seems to show closer affinity to *L. expansum* or occasionally even to coarser forms of *L. lichenoides*. Cp. Hauck,

Meeresalg. t. III, fig. 7. However, it may even be confounded with new local crusts in *L. varians* and other Lithothamnia much attacked by animals, which are formed so as to cover the animals or other objects and partly being free. It, on the other hand, most probably is a well characterized species, but it wants closer examination of larger fertile materials.

Habitat. The plant occurs in the upper part of the sublittoral region, descending to a depth of about 10 fathom, and appears to prefer somewhat exposed localities. A specimen taken in the middle of June, fastened to *L. tophiforme* f. *squarrosa*, was provided with a couple of not well developed conceptacles probably being those of cystocarps.

Occurrence. Found at Kjelmö in East-Finmarken, rare, and at Lyngö a little north off Tromsö, rare.

Lithothamnion circumscriptum Strömf.

Alveg. Isl. p. 20.

Descr. Lithothamnion circumscriptum Strömf. l. c.

Fig. " " " " t. 1, fig. 4—8; Fosl. Contrib. II, t. 3, fig. 8.

Syn. Lithothamnion circumscriptum Fosl. Contrib. I, p. 9, II, p. 10.

" " *α* areolatum Rosenv. Grönl. Havalg. p. 774.

Remark on the species and addition to the description. This species is one of the most characteristic of the arctic crustaceous Lithothamnia. It is most often easily recognized even in a sterile stage. The frond attains a thickness of about 1 mm., frequently however, about 0.6—0.8 mm. The limits between adjacent crusts stumbling each other are always to be seen at least before the plant bears sporangia a second time. Sometimes new crusts here and there are formed upon primary crusts stumbling each other, and, together with new formations effacing the scars after the first developed sporangia, more or less efface the limits between the primary crusts especially in richly sporangia-bearing specimens.

The conceptacles of sporangia are very densely crowded and occupy a sharply defined zone in the central portions of the frond, developed from the centre towards the periphery, but a broader

or narrower part of the peripheral portion is always sterile, and the first developed conceptacles in the centre frequently are emptied before the others are developed. Bearing sporangia for the second time or more, this development is less regular, or the named organs are developed from the centre of smaller and new-formed crusts upon the older.

The conceptacles are shown from the surface of the frond at first as faintly light circular and not depressed points about 200—300 μ in diameter. Later the central portion of these points gets decorticated, by and by forming a globular and very shallow deepening about 100—150 μ in diameter, a part of the roof of the conceptacles, and this part is intersected with about 20—30 rather coarse muciferous canals, or the roof is not to be distinguished from the other parts of the surface of the frond before the named central portion gets decorticated. At maturity this central portion at first gets dissolved, and at the same time the surrounding parts of the roof become lighter and by and by disappear, leaving, owing to the densely crowded conceptacles, frequently six-angular holes, the emptied conceptacles, looking as a mesh-work, with thin walls. By and by a smaller or greater part of the dissepiments also gets dissolved. The scars are effaced by a new thickening layer of the frond, and when replenished it often looks, as if the surface was areolate, but the effacing also takes place by new local formations of tissue stretched over more scars, and then the surface becomes rather irregular.¹⁾ The bisporic sporangia are rather varying, 200—300 μ long and 70—100 μ broad.

Relation to other species. It in some respects shows greater affinity to *L. compactum* and may in a sterile state occasionally be confounded with that. However, it differs both in regard to the conceptacles of sporangia as well as the structure and other characters. Cp. under the latter. It is more easily confounded with a couple of the below described species.

Habitat. The plant lives both in the litoral and sublitoral

¹⁾ Rosenvinge mentions l. c. such areolating to be recognized by densely crowded conceptacles also before they are opened.

region. In the former I mostly met with it fastened to *Mytilus* shells or occasionally stones in deeper rock-pools, but apparently not to the rock itself. In the latter region it also most frequently fastens itself to smaller or larger stones, more seldom to rocks, and, so far as I have seen, nearly always to be found only on stony bottom. It prefers exposed places, and here it grows in rock-pools or on a depth of 1—2 fathom, but in more sheltered localities it always appears to descend farther down, to a depth of about 10 fathom, seldom more, and to be found in by far smaller numbers than in the former. However, it does not penetrate far up the fjords. The development of sporangia probably takes place nearly all the year. Thus I have collected specimens from the middle of May to the middle of September with partly emptied conceptacles or scars after older ones nearly effaced by new-formed tissue partly with ripe sporangia or such being in development.

Occurrence. It appears to be commonly dispersed along the whole coast of Finmarken and is found eastward to Kjelmø in Sydvaranger, at several places abundant, for inst. Mehavn and Kjøllefjord in East-Finmarken, Helnes, Kjølvik, Skarsvaag and Lopen in West-Finmarken. It has not with certainty been found farther to the south than Skorpen (Kvænangen) in Tromsø Amt.

Geogr. Distribution. Iceland (Strömfelt), Grønland (Rosenvinge).

Lithothamnion coalescens Fosl. mscr.

L. fronde crustacea, subarcte adnata, superficie plus minusve inæquali, striis brevibus, densis, radiatim et concentricè dispositis, 1—1.5 mm. crassa, dilute vinoso-purpurea; crustis plerumque compluribus demum confluentibus, margine crenato-lobato; conceptaculis sporangiferis sub foveola leviter excavata 80—100 μ lata immersis, diametro 200—300 μ ; sporangiis binas sporas foventibus, 150—200 μ longis, 60—80 μ latis. Tab. 19, fig. 15—20.

Description of the species. The plant forms more or less irregular crusts on smaller stones. Several crusts frequently are founded on one and the same substratum, but in their farther

growth get fully confluent, so that especially when older it looks as if it had been a solitary crust from the beginning. The crust is at first fastened closely to the substratum, and often even in a more advanced stage, but when older it most frequently is rather easily separated. It attains a thickness of 1.5 mm., frequently about 1 mm. The central part is commonly a little thicker than the peripheral, but the latter on the other hand less decreasing than in the nearly allied *L. circumscriptum*, and the margin shallowly crenate with more or less rounded lobes. The surface nearly always is more or less uneven. Pl. 19, fig. 15—20. This unevenness is partly caused by that of the substratum, partly by covering up small extraneous objects but most often also by small and irregular excrescences, and besides also by an irregular effacing of the deep scars after the emptied and irregularly scattered or here and there crowded conceptacles of sporangia. The surface is also provided with numerous radiating and concentric striae. It is feebly wine-coloured, frequently lighter than in *L. circumscriptum*, rather dull or faintly shining, but gets darker and often rather violaceous when dry. I have never seen new crusts formed upon the primary.

The lower, co-axil system is more vigorously developed than in *L. circumscriptum*. The upper thickening layer is composed of cells which are seen on a radial section to be arranged in rather straight and well-marked rows, the upper ones more loosely united, so that they after decalcifying are rather easily separated by pressure. The cells of these layers are up to $1\frac{1}{2}$ times the diameter in length, or about 7—8 μ long and 5—6 μ thick.

The conceptacles of sporangia, the only reproductive organs hitherto known, are partly scattered partly densely crowded here and there in the frond, even close to the periphery, as in *L. compactum*, and not forming a sharply defined zone as in *L. circumscriptum*. They are at first seen from the surface of the frond as slightly depressed-circular points about 80—100 μ in diameter. Later these points get by and by decorticated and then forming rather shallow holes frequently with not sharply marked edges, the bottom of which forms a part of the roof, intersected with

15—20 six-angular muciferous canals. At maturity this portion gets dissolved, afterwards the whole roof, then leaving a distinct and deep circular hole of about the same diameter as in *L. circumscriptum*, or 200—300 μ . If the conceptacles are densely crowded also a part of the dissepiments get dissolved, though less than in the named species, but I have not seen them being angular. The sporangia are bisporic, about 150—200 μ long, 60—80 μ broad and 20—25 μ thick.

*Relation to other species.** This species is closely related to *L. circumscriptum*, and it ought, perhaps, to be regarded a southern form of the latter. However, I have not seen any true transition, and it differs in several particulars partly quoted above. The surface is also in a younger stage more uneven than in older crusts of that species, more irregular in outline, the peripheral portion frequently thicker, adjacent crusts getting fully confluent, the striæ coarser, and also somewhat differing as to the structure. So far as I have seen *L. circumscriptum* never produces excrescences. Besides, the conceptacles of sporangia are irregularly scattered in every part of the crust, in certain states rather resembling those of the named species, but on the other hand in the same state of development somewhat differing, although I have seen these organs only in some few specimens, most of which in one and the same state, and I, therefore, do not know whether they in this respect sometimes perhaps more approach the named species.

Habitat. Contrary to *L. circumscriptum* the present plant apparently prefers sheltered places. I found it best developed in a lagoon or streamlet with rather rapid tides, between half tide level and high water mark in the innermost part of the Trondhjem Fjord. Farther out the Fjord I met with it on a depth of 3—5 fathom, descending to about 10 fathom. Specimens collected in the middle of August and October were furnished with ripe sporangia, though very scantily, and some few of the conceptacles were emptied.

Occurrence. Hitherto only found in the Trondhjem Fjord, at

Strømmen (Inderöen), local but pretty plentiful, and at Munkholmen and Röberg, scarce.¹⁾

Lithothamnion evanescens Fosl. mscr. ,

L. fronde crustacea, subarcte adnata, superficie plus minusve inæquali, rosaceo-violacea vel glaucescente, 1—2 mm. crassa, margine leviter crenato; conceptaculis sporangiferis sub foveola leviter excavata 100—120 μ lata demum annulo distincto rotundato-angulato circumdata immersis, diametro 200—250 μ ; sporangiis binas sporas foventibus, 130—160 μ longis, 40—55 μ latis. Tab. 22, fig. 6—8.

Description of the species. Of this plant I have seen but two specimens, a Norwegian (fig. 7) and an American (fig. 6), the latter gathered at Marblehead, Mass. Collin's coll. C.

The crust is 1—2 mm. thick, rather irregular in outline and not much decreasing in thickness towards the margin, and the latter shallowly and irregularly crenate. In an older stage it is rather easily loosened from the substratum. The surface is more or less uneven, which partly is caused by covering up small extraneous objects, here and there, however, bearing small and irregular excrescences, and the unevenness is also caused by the scars after emptied conceptacles of sporangia being irregularly effaced. A small part of one of the named crusts is provided with some few but rather coarse, short and radiating striæ, and the surface appears in younger crusts to be feebly shining, in older, however, dull. The colour is here and there a light rose pink with a violaceous tinge, otherwise glouceous or yellowish. I have not seen new crusts formed upon the primary.

On a vertical section of the crust the cells of the upper thickening layer form straight or nearly straight rows, after decalcifying,

¹⁾ After this was ready for the press I met with a sterile *Lithothamnion* in a rather sheltered locality at Ytteröen in the inner part of the Trondhjem Fjord, growing on stones or rocks just below low-water mark, which, no doubt, also belongs to this species. It forms more extended crusts than the above mentioned, but also here the surface is frequently somewhat uneven, here and there with very small and irregular excrescences, and occasionally I found new, smaller crusts formed upon the primary.

upwards at least, sometimes separable by pressure. They are square or most frequently rectangular, 8—10 μ long and 6—8 μ thick including the walls, which, however, are rather thin.

The conceptacles of sporangia are very densely crowded nearly over the whole frond, not forming any defined zone, and are here and there emptied before the adjacent are fully developed. They are immersed, in the earliest stage of development that I have seen at first perceptible from the surface of the frond as minute, indistinct and slightly depressed-circular points. By and by these points by decortication become more distinct and rather sharply defined, at length forming shallow deepenings, the bottom of which forms a part of the roof about 100—120 μ in diameter, and then intersected with about 15—20 rather coarse and six-angular muciferous canals. At the same time is shown a very indistinct border around this part of the roof, not raised above the surface of the frond, but visible by its colour being a little lighter. Towards maturity the part of the surface between the densely crowded borders gets by and by thinly decorticated, and at length also the latter are sharply defined, looking a little elevated, frequently six-angular or rounded-angular, surrounding the above named part of the roof, about 60—80 μ broad and rather flattened, and the whole roof including the border about 200—250 μ in diameter. Pl. 22, fig. 8. At maturity the whole roof, including the border which also forms a part of the roof, falls away, leaving angular, often regularly six-angular, holes of the named diameter with thin walls, like a mesh-work. Also a smaller or greater part of the walls disappears, and the remaining scars by and by become effaced by new formed tissue. The certainly not numerous sporangia that I have examined quite likely were mature, bisporic and 130—160, seldom up to 200 μ long and 40—55, now and then up to 60 μ broad.

Relation to other species. It seems to be closely related in habit to *L. durum* Kjellm.¹⁾, the surface, however, being more uneven. Also the conceptacles of sporangia apparently much resemble the similar organs in that species. I have not seen any

¹⁾ Beringh. Algfl. p. 22, t. 1. fig. 3—5.

specimen of the latter, but according to Kjellman l. c. the conceptacles appear to be of about the same size in both, in the named species „märkbara på krustans yta genom en deras tak omgifvande, svagt upphöjd kant“, but I do not know whether this border is formed in the same manner as in the present species, in which it has not been raised above the original surface of the frond. The structure appears to be somewhat differing, and the sporangia are tetrasporic in *L. durum*, but in *L. evanescens* they most probably are bisporic.

Sterile and especially younger specimens appear to be easily confounded with *L. coalescens* or *L. circumscriptum*.

Habitat. The named specimen found with us was fastened to a *Mytilus* shell together with *L. colliculosum* and *L. Strömfeltii* on a depth of 5—6 fathom in the inner part of a fjord. It is gathered in the later half of September and has been rather richly provided with conceptacles of sporangia, nearly all of them, however, emptied, and the scars partly effaced. On the American coast the plant has been taken „just below low water mark“, nearly encompassing a small stone, in April partly richly provided with sporangia partly with emptied conceptacles.

Occurrence. Found at Mestervik in Malangen, not far from Tromsö, a solitary specimen.

Geogr. Distribution. The Atlantic coast of North America (Collins).

Lithothamnion lævigatum Fosl. mscr.

L. fronde crustacea, subarcte adnata, 0.3—0.8 mm. crassa, lævissima, subnitida, violaceo-purpurea, livida vel flavescens; conceptaculis sporangiferis sub foveola demum fere hemisphaerico-concava annulo vix elevato circumdata immersis, diametro 150—200 μ ; sporangiis binas sporas foventibus, 120—150 μ longis, 40—60 μ latis. Tab. 19, fig. 21—23.

Syn. *Lithothamnion* crustaceum Batt. herb.

Remark on the species. I have seen but a couple of fully developed Norwegian specimens and some other young ones probably belonging to the same species, but several from abroad. It

appears not to be uncommon on the British coast, and at Helgoland it apparently is one of the most common Lithothamnia. An American specimen is gathered at Kennebunkport, Maine. Collin's coll. E. Pl. 19, fig. 21 and 23 represent fragments of specimens from Helgoland, and fig. 22 is a younger Norwegian one.

Description of the species. The plant forms more or less extended crusts on stones and rocks. Several crusts founded on one and the same substratum get fully confluent. It is at first closely adherent to the substratum, but when older it frequently is more or less easily detached from it. The frond is in the central portions 0.3–0.8 mm. thick, frequently about 0.5 mm., plainly decreasing in thickness towards the margin, and the latter is entire or shallowly crenate or lobed, in a younger stage sometimes with a whitish brim. The peripheral portion is frequently more or less indistinctly zonated. The surface otherwise is smooth and most often feebly shining, never with excrescences, but now and then covering up small extraneous objects, and often provided with very small, scaly thickenings not visible to the naked eye, or sometimes getting slightly uneven when emptied conceptacles become irregularly effaced by local formations of tissue. Besides, the surface occasionally here and there is provided with short striæ. I have not seen new crusts formed upon the primary. The colour is much varying, partly nearly according with that of *L. polymorphum* partly and most frequently a lighter and more violaceous-purplish shade, or bluish brown, or yellowish brown, American and British specimens frequently being darker than Norwegian and Helgolandian ones.

The lower, co-axil system of the frond in general is vigorously developed, so far as I have seen occupying about one third of the thickness, partly less partly, however, even more, and its anticlinals partly converge gradually partly more strongly towards the matrix. The cells of the upper thickening layer are on a vertical section arranged in straight rows, and are square or rectangular, including the walls 5–8 μ long and 4–6 μ thick.

The conceptacles of sporangia are scattered in great numbers over the whole frond, partly nearly confluent, except a rather narrow

peripheral portion always being sterile. They are immersed, and at first appear from the surface of the frond as minute, lighter points, which soon become decorticated, at first in the centre, forming depressed-circular points not perceptible to the naked eye, later getting larger and at length forming sharply defined cup-shaped deepenings, the roof of the conceptacles, about 150—200 μ in diameter and intersected with 40—55 muciferous canals. The edge of the roof forms a not or scarcely not elevated, narrow border. In this state the conceptacles much resemble in shape the conceptacles of antheridia in *L. polymorphum*, but are smaller, and those only traversed by a single canal. At maturity the roof gets thinly decorticated and the border disappears, by and by dissolved or settling more or less down into the conceptacle. When emptied the conceptacles leave globular and rather deep, distinct holes of the same diameter as above quoted. So far as I have seen the conceptacles never grow down into the frond and the holes become frequently effaced by a new thickening layer of the frond. On the other hand the roof apparently does not always get fully dissolved and also local formations partly efface the holes partly are formed upon the settled roof and even raised above the surface of the frond as small, convex excrescences reminding one of conceptacles, but very easily falling away. Such formations sometimes even appear to be formed upon the roof of not fully developed conceptacles, but I do not know whether they then perhaps prevent the farther development of the reproductive organs.

I have examined rather numerous sporangia, most of which appeared to be mature and were two-parted. I, however, found two irregularly three-parted sporangia, but never four-parted, so that I suppose mature and typically developed ones always to be bisporic. They are 120—150 μ long, 40—60 μ broad and about 15—20 μ thick. Occasionally may be found very broad ones, or up to 100 μ .

Habitat. With us this species has been found fastened to smaller stones on a depth of 5—6 fathom. Otherwise it fastens itself to rocks, stones and other hard objects. It apparently develops sporangia all the year. In specimens collected in the middle

of July the conceptacles recently were emptied, and in the middle of December provided with sporangia. On the British coast it bears such ones in February. Specimens collected at Helgoland in January, March, June and July partly bear sporangia partly emptied conceptacles.

Relation to other species. The plant appears to show greatest affinity to *L. circumscriptum*, from which it, however, is easily distinguished by essential characteristics. It sometimes approaches *L. polymorphum* f. *papillata* in habit (cp. pl. 17, fig. 23), but the latter is never smooth or only a part of the crust.

Occurrence. Found at Dröbak (Gran) and Nesodden (Schreiner) in the Christiania Fjord, apparently rare.

Geogr. Distribution. Helgoland (Kuckuck); Britain (Batters); the Atlantic coast of North America (Collins).

Lithothamnion scabriusculum Fosl. mscr.

L. fronde crustacea, 0.1–0.3 mm. crassa, scabriuscula, arcte adnata, vinacea. Tab. 22, fig. 9.

Remark on the species. Some years ago I collected in the most eastern part of Finmarken a sterile specimen of a *Lithothamnion* which seems to represent the type of an undescribed species. I then sent it to Prof. Kjellman if he might have seen a similar one. However, he declared it to be a species unknown to him, and together with some other doubtful algæ I left it unrecorded in Contrib. I. Although sterile, there can be but little doubt that it forms a separate species, if not, perhaps, by closer examination of larger and fertile materials proving to be a form of *L. lævigatum*.

Description of the species. The plant forms a thin, scarcely more than 300 μ , partly only 100 μ thick and somewhat extended crust on a stone, composed of some confluent primary crusts, with the limits sometimes visible sometimes not. It clings closely and very firmly to its substratum, plainly decreasing in thickness towards the periphery, and the very thin peripheral portion scarcely perceptibly zoned. The margin is shallowly and irregularly crenate and lobed. The surface is somewhat uneven partly in consequence of small, scaly thickenings, which are a little larger than in *L. lævigatum* partly also by growing over small extra-

neous objects. Besides, it is furnished with numerous and shallow little holes, that I suppose to be scars after emptied conceptacles of sporangia. Some of them are effaced by local formations of tissue. These scars are rather more numerous, smaller and more shallow than the holes after the emptied conceptacles in *L. lævigatum*, and, therefore, it seems as if the conceptacles have been less, or, perhaps, not immersed. The colour is vinaceous or pinkish vinaceous, partly with a yellowish tinge.

I do not exactly know the structure. The cells of the upper layers of tissue appear on a vertical section to be about $8\ \mu$ long and $6\ \mu$ thick.

Relation to other species. As remarked, it shows greatest affinity to *L. lævigatum*. However, it differs in some particulars, and if the above named scars really are those after conceptacles of sporangia, it probably is a well defined species.

Habitat. The specimen was found in a much exposed locality on a depth of about 6 fathom. It was taken in the beginning of August, probably bearing sporangia earlier in the summer.

Occurrence. Only found on the outer side of Kjelmö (Syd varanger) in East-Finmarken, a solitary specimen.

Lithothamnion orbiculatum Fosl. mscr.

L. fronde crustacea; crusta orbiculari vel suborbiculari, diametro 3—6 mm., arcte adnata, sublævi, in media parte circa 0.2 mm. crassa, limbo tenuissimo, margine leviter undulato-crenato; conceptaculis sporangiferis convexiusculis, parum prominentibus, diametro a superficie visis circa $250\ \mu$; sporangiis circa $80\ \mu$ longis, $20\ \mu$ latis. Tab. 22, fig. 10—11.

Syn. *Lithothamnion polymorphum* Aresch. Obs. Phyc. 3, p. 5; ex parte?

Remark on the species. In I. E. Areschoug's herbarium in the Riksmuseum at Stockholm is a piece of a stone, to which some specimens of an undescribed and characteristic *Lithothamnion* are fastened, the above *L. orbiculatum*, collected about 40 years ago at Christiansund, N. by F. L. Ekman. It has probably been referred to *L. polymorphum*, as it in the named herbarium was

placed together with specimens of the last named species, of which, on the other hand, no specimen is to be found from that locality.¹⁾

Description of the species. The named specimens are much bleached, with a faint yellowish tinge, orbicular or nearly orbicular, 3—6 mm. in diameter, occasionally somewhat confluent, and closely adherent to the substratum. They are in the central portion scarcely more than 0.2 mm. thick. The nature of the surface appears to be determined by that of the substratum, most often nearly smooth, or the unevenness partly caused by scars after emptied conceptacles, which are gradually filled with new formed tissue, but the latter not always regularly effacing the scars. A broader or narrower part of the peripheral portion is very thin, shallowly undulate-crenate, and is frequently rather distinctly marked from the internal and thicker part of the crust. Pl. 22, fig. 10.

The cells of the upper thickening layer are, so far as I have seen, rectangular with rounded corners, about 7—10 μ long and 5—6 μ thick with thin walls.

The conceptacles of sporangia never grow down into the frond, so far as may be judged from the scanty materials at my disposal. They are small and somewhat crowded in the central portion of the frond, seen from the surface about 250 μ in diameter, and the circular, slightly convex roof very little prominent, partly and more often not or scarcely not raised above the surface of the frond, but distinct and nearly always surrounded by an annular, shallow deepening. Pl. 22, fig. 11. The roof falling away a shallow or deeper scar after the emptied conceptacles appears on the surface of the frond, which by and by becomes filled by new formed tissue. The only conceptacle examined was not provided with mature sporangia, a solitary one nearly linear, about 80 μ long and 20 μ broad, with a founded but very indistinct partition from the periphery towards the middle of the cell. I, therefore, cannot decide whether the sporangia are bisporic or tetrasporic.

I got a *Lithothamnion* from Mr. Batters, gathered at Arran,

¹⁾ Cp. Aresch. l. c. and Ekman, Bidr. p. 5.

which closely resembles this species in habit, of the same size, but partly less regular in outline, the crusts here and there confluent, with the limits sometimes visible sometimes not, and the peripheral portion slightly thicker, fully or almost fully passing into the central portions. It bears scars after emptied conceptacles, some of which are nearly effaced, or only the central portion of the roof dissolved, showing that they are of the same size as in the present species, but less distinctly marked. The colour is a faint purplish pink. It hardly admits of doubt that this plant is identic with the species in question, although the sporangia are unknown.

Relation to other species. It is plainly distinct from any other species that I know, perhaps most nearly allied with *L. Strömfeltii*, but easily recognized and separated by essential characteristics.

Habitat. The species probably grows on rocks in the litoral region, supposing it has been referred to *Melobesia polymorpha* recorded by Ekman l. c. It appears to be furnished with sporangia in summer. The above quoted British specimen has been collected in August.

Occurrence. Hitherto only met with at Christiansund, N. (Ekman).

Geogr. Distribution. Britain (Batters).

Lithothamnion Strömfeltii Fosl. mscr.

Lithothamnion tenue Rosenv. Grönl. Havalg. p. 778.

f. *macrospora* Fosl. mscr.

f. *plerumque nitida*, concentrice zonata, margine lobato vel crenato; conceptaculis sporangiferis diametro 600–900 μ ; sporangiis 250–600 μ longis, 100–200 μ latis. Tab. 22, fig. 12.

f. *tenuissima* Fosl. mscr.

f. *subnitida*, non vel parce zonata, margine sæpe irregulariter crenato-lobato; conceptaculis sporangiferis diametro 400–600 μ ; sporangiis 150–200 μ longis, 50–80 μ latis.

Fig. Lithophyllum Lenormandi f. læve Fosl. Contrib. II, pl. 3, fig. 6.

Syn. Melobesia Lenormandi Farl. Mar. Alg. New Engl. p. 181 ex parte?

Lithophyllum Lenormandi Gobi, Algenfl. Weiss. Meer. p. 21; ex parte.

” ” Fosl. Contrib. I, p. 9; ex parte.

Syn. Lithophyllum læve Strömf. Algveg. Isl. p. 21.

" " Fosl. l. c. p. 10.

" Lenormandi f. læve Fosl. Contrib. II, p. 10.

Remark on the species and description of the form. Through the kindness of Kolderup Rosenvinge I have had the opportunity to examine some specimens of his *Lithothamnion tenue*. This species includes the plant that I have referred to *Lithophyllum læve* Strömf. and in Contrib. l. c. subsumed as a form of *L. Lenormandi* (Aresch.). Besides, it includes another, coarser form which I also met with along the northern part of the coast. However, being uncertain where this form really ought to be placed I then left it unrecorded, though some specimens were with doubt referred to the named f. *læve*.

Strömfelt l. c. quotes his *L. læve* to be closely related to *L. Lenormandi*. Judging from his description and supposing the sporangia not to have been fully developed in the specimens examined by him, but mature ones being tetrasporic, as in my specimens, I considered them identic.¹⁾ Although I am still of opinion, that the present species is identic with or includes *L. læve* Strömf., there is, however, nothing to prove, that this in fact is the case. No specimen of the plant is to be found in Strömfelt's collection in the Riksmuseum at Stockholm, and, perhaps, it may have been another but nearly allied species. I, therefore, here do not adopt this name.

On the other hand, the name *tenue* has already been applied to a species of the subgenus *Lithophyllum*, viz. *L. tenue* (Kjellm.)²⁾. I, therefore propose the species in question to be named after the late H. F. G. Strömfelt.

1) Rosenvinge mentions bisporic sporangia occasionally found by him, and I have also seen such ones, but they have probably not been fully developed. The measures given by Strömfelt apparently show narrow sporangia. These organs are in fact much varying, and small sporangia may, not seldom, be found together with very large ones in one and the same conceptacle. I want, however, to remark, that the sporangia being bent somewhat inwards and thereby often lying more or less on the side when removed from the conceptacle look narrower than they really are.

2) Be'ingh. Algfl. p. 22.

The plant forms in the sense here taken an intermediate link between *Eulithothamnion* and *Lithophyllum*, the above f. *macrospora* most nearly related to the former, and f. *tenuissima* as to the structure forming transitions to the latter and occasionally not easily separated from *L. Lenormandi*. Some of the specimens that I in Contrib. 1 referred to *L. Lenormandi* really belong to *L. Strömfeltii*. Owing to this confusion I lay no stress on my notes as to the distribution of these species especially along the coast of East-Finmarken, but refer only to the specimens that I now possess. Later I met with rather numerous fertile specimens of the last named species, and, through the kindness of Prof. Wittrock, I have examined authentic specimens of *L. Lenormandi* in Areschoug's herbarium in the Riksmuseum at Stockholm.

The named forms *macrospora* and *tenuissima* are certainly not well defined, as transitions very often are to be found, but they are, on the other hand, in their most extreme forms rather differing, so that I hold it most suitable to regard them as denominated forms of the species. Nor are they apparently the only ones.

The form *macrospora* is characterized by its more distinctly zoned peripheral portion, having tendency to become orbicular when freely developed on a plain substratum, and the margin more regular. It is in general rather shining, sometimes even much, the crust gets up to 400 μ in thickness, and the conceptacles of sporangia are very large, 600—900 μ in diameter or more, and are more or less flattened, low, or nearly disc-shaped. The tetrasporic sporangia also are proportionally large, but very much varying in shape as well as in size even within one and the same conceptacle. However, they are frequently about 250—600 μ long and 100—200 μ broad.

The form *tenuissima* sometimes is only 50 μ thick sometimes attaining a thickness of 200 μ or even more, but specimens from the more southern part of the coast seem in general to be thinner than those from the northern. It has a more irregular outline, being composed of smaller and more irregularly confluent crusts than in f. *macrospora*. It is less shining, sometimes even rather

dull, and not or only a little zonate. The conceptacles of sporangia as well as the sporangia themselves are frequently smaller than in the named form, the former 400—600 μ in diameter seen from the surface and the latter 150—200 μ long and 50—80 μ broad.

The roof of the named conceptacles is in both forms traversed with 80—120 muciferous canals. The roof being dissolved a cup-shaped scar with somewhat elevated edges appears on the surface of the frond. These scars become by and by filled frequently with new, local formations of tissue, and these local thickenings may sometimes be small, only effacing the scar, sometimes rather extended, now and then crowded or partly imbricated, forming small lamels, which, however, are larger than those in *L. Lenormandi*.

The conceptacles of cystocarps are in the present species conical and frequently rather acute, 600—800 μ in diameter at the base and at maturity upwards traversed by a distinct canal often visible to the naked eye. They appear in the same individual as those of sporangia. The carpospores are much varying in regard to the shape as well as size, frequently broadly cuneate, 150—250 μ long and 80—130 μ broad in the broadest part.¹⁾

Conceptacles of antheridia generally also appear in the same individual as the latter. They most often are only one half or one third the size of the conceptacles of cystocarps, or 300—400 μ in diameter at the base, but otherwise resembling the last named organs. The spermatia are very irregular in shape and size, most frequently rounded or rounded-angular, compressed, thin, and about 80—100 μ in diameter.

The colour of the plant is not much varying, partly, however, apparently depending on the locality where it grows. Along the northern part of the coast it agrees with Greenlandic specimens and a Spitzbergian one that I have seen, the latter gathered between Amsterdam- and Norskøerne, sometimes, however, a lighter sometimes even a darker pink, but in all getting somewhat darker in the lower part of the sublitoral region than farther up. In the

¹⁾ With reference to the shape and measures quoted in Contrib. II, p. 12 cp. the note under *L. colliculosum*.

Trondhjem Fjord I occasionally met with specimens of a rather dark brownish pink colour.

Remark on the synonymy. The plant that Farlow records l. c. by the name of *Melobesia Lenormandi* most probably at least in part includes the present species. „The tetrasporic conceptacles are large but very much flattened“ and the crust „rose-colored“, which does not correspond with *L. Lenormandi* (Aresch.), but on the contrary appears to accord well with the present species.

Of *L. Lenormandi* Gobi l. c. I have seen three authentic specimens from the White Sea. Two of these, which are fertile, agree fully with the present species, the one growing together with a young individual of another species, probably *L. colliculosum*. The third specimen on the other hand is quite likely a form of *L. flavescens*, but the conceptacles of sporangia are a little smaller than in the latter, and I have not examined the sporangia, nor the structure.

Relation to other species. As remarked, it is closely allied with *L. Lenormandi*, but distinguishes itself partly in colour partly and especially with reference to the reproductive organs, and in typically developed specimens also by its smoother surface. The cystocarpic conceptacles are different both in shape and size, and those of sporangia are frequently much larger, more flattened, never so densely crowded as common in *L. Lenormandi*, and the muciferous canals are more numerous. With regard to the difference in structure cp. Rosenvinge l. c.

The species seems in some respects also to show greater affinity to *L. tenue* (Kjellm.)¹⁾.

It is on the other side now and then difficult to separate it from certain forms of *L. flavescens*, and even sporangia-bearing specimens, without closer examination, can be confounded with such of the latter, in which the conceptacles have not yet grown down into the frond, although the superficial ones are more prominent in the named species.

Besides, younger individuals are easily confounded with young ones of other species.

¹⁾ Beringh. Algfl. p. 22.

Habitat. The present plant lives in the upper as well as lower part of the sublitoral region, fastened to smaller stones or to shells, sometimes on a depth of 2—4 fathom sometimes and more frequently on greater depths, until 15 fathom, or occasionally more. It appears to prefer protected places and descends deepest in exposed localities. It often grows together with other Lithothamnia, in such cases frequently at length being covered with the latter. Specimens collected in July to October were provided with ripe sporangia, in August and September with carpospores and spermatia.

Occurrence. It is probably more commonly dispersed along the northern and western part of the coast than hitherto known, in several places being pretty plentiful. I have taken it at Kjelmö, Kirkenes and Mehavn in East-Finmarken; Kistrand, Kjelvik, Kvalsund, Sopnes (Altenfjord) in West-Finmarken; Skorpen, the outer part of Balsfjord and at Mestervik in Tromsö Amt. I also met with it at Strömmen, Ytteröen, Tautra, Öxningen, Munkholmen, Vanvik, Röberg and Rissen in the Trondhjem Fjord. One or two small specimens have been gathered at Sulen in Sogn (Boye) and Espevær (Gran) on the south-western coast.

Geogr. Distribution. The White Sea (Gobi); Spitzbergen; Greenland (Rosenvinge); Iceland (Strömfelt)? The Atlantic coast of North America (Farlow)?

Subgen. **Lithophyllum** (Phil.) Fosl. mscr.¹⁾

Gen. Lithophyllum Phil. l. c.; Aresch. l. c.; Rosan l. c.

Lithothamnion Lenormandi (Aresch.) Fosl. mscr.

Melobesia Lenormandi Aresch. l. c.

Descr. Lithophyllum Lenormandi Rosan. l. c. p. 85.

Fig. " " " " " t. 5, fig. 16—17, t. 6, fig. 1—3
Hauck, Meeresalg. t. III, fig. 4;
Strömf. Algveg. Isl. t. 1, fig. 9—10.

1) After a part of the present paper was printed I have had the opportunity to see a note by Mr. P. Hariot in Journ. Bot. 9, p. 113, where he proposes to change the name *Lithophyllum* Phil. for *Tenarea* Bory. He

f. *typica* Fosl. mscr.

f. conceptaculis sporangiferis hemisphaericis vel fere hemisphaericis, creberrimis, diametro a superficie visis 250—350 μ .

f. *sublaevis* Fosl. mscr.

f. superficie laeviore; conceptaculis sporangiferis depresso-hemisphaericis, subcrebris, diametro a superficie visis 300—400 μ .

Syn. Melobesia Lenormandi Le Jol. Alg. Mar. Cherb. p. 151; sec. spec.

„ „ Kleen, Nordl. Alg. p. 11.

„ „ Farl. Mar. Alg. New Engl. p. 181; ex parte?

„ „ Batt. Mar. Alg. Berw. p. 139; sec. spec.

Lithophyllum „ Solms-Laub. Corall. p. 15.

„ „ Hauck l. c. p. 267; saltem ex parte sec. spec.

„ „ Kjellm. N. Ish. Algfl. p. 136 (103).

„ „ Holm. et Batt. in Annals of Bot. p. 102.

„ „ Rke. Algenfl. p. 32.

„ „ Fosl. Contrib. I, p. 9; ex parte.

Remark on the form of the species. The form that I apprehend as the typical is characterized by its conceptacles of sporangia being very densely crowded over the whole frond except a broader or narrower part of the peripheral portion, often so densely that the roofs become angular, now and then two or three confluent. They are hemispherical or subhemispherical, 250—350 μ in diameter, and the upper part of the roof intersected with 25—35 muciferous canals, which partly are somewhat crowded, never densely, partly and most frequently rather scattered. Towards

remarks: „Bory de Saint-Vincent recueillit pendant l'expédition de Morée, sur les rochers du Cap Ténare, une production calcifiée qu'il considéra comme un Polypier et qu'il signala comme tel dans une *Notice sur les Polypiers de la Grèce*. Cette Notice, assez courte d'ailleurs, est insérée dans la partie consacrée à la Zoologie de l'expédition scientifique de Morée“. It is written five years before Dr. Philippi published his well-known paper on the true nature of the Nullipores of older authors. Mr. Hariot has examined the original specimen recorded by the name of *Tenarea (undulosa)* Bory, and considers it the type of a species including *L. cristatum* (Menegh.) and *L. crassum* (Lloyd) as varieties. He farther remarks: „Bory a encore décrit, dans le même Mémoire, un *Nullipora Trochanter* qui n'est autre que le *Lithothamnium byssoïdes* créé par Philippi pour le *Nullipora byssoïdes* de Lamarck“.

I cannot agree with Mr. Hariot to strike the name *Lithophyllum*. Before Philippi proved the Nullipores really to be plants, they were ap-

maturity the central portion of the roof often gets a little flattened or even depressed. This portion at first becomes dissolved, later the greater part of the roof, but so far as I have seen, always leaving a smaller or larger border. These borders contribute to the unevenness of the frond, and the rest of the emptied conceptacles get effaced by local formations of tissue. The tetrasporic sporangia are about 60—80 μ long and 20—35 μ broad. I have, however, examined but some few of the latter.

In f. *sublævis* the conceptacles frequently are a little larger than in f. *typica*, the roof 300—400 μ in diameter, and more flattened, sometimes in this respect rather approaching those of *L. Strömfeltii* and not densely crowded. I have seen only one or two specimens of this form from Helgoland and from Berwick on the British coast, and a small one from the Christiania Fjord only provided with cystocarpic conceptacles probably belongs to the same form. The surface appears to be smoother and the colour darker than frequently in f. *typica*. However, it is possible that this form perhaps constitutes a separate species, although the limits seem to be very difficult to draw.

prehended partly as such partly as animals, and often referred to various genera. Cp. Gumbel, Die sogen. Nullip. p. 17. The name *Nullipora* was constituted by Lamarck l. c. as genus-name, and by him it comprehends calcareous algæ principally of the later genus *Lithothamnion* Phil. The oldest genus-name applied only to species of the latter is *Apora*, recorded by Gunnerus, which could be adopted for *Lithothamnion* with the same pretension as *Tenarea* for *Lithophyllum*. Thus Gunnerus remarks with regard to his *Apora polymorpha* in Act. Nidros. 4 (1768), p. 21, t. 8: „Man finder ei, paa disse, Stierner eller Porer (hverken Milleporarum eller Celleporarum); hvorfor de Orme, som beboe denne Corall, maa søges imellem dens Grene eller de smaa Rum, som flere sammengroede, af denne Art, forårsage, eller og i de Hull, som Ormene selv paa adskillige Maader bore igjennem dens Grene. Af denne Aarsag synes mig, at den udgjør et nyt Genus, som jeg kalder *Apora*“. Cp. above under *L. fruticosum* and *L. coralloides*. However, I find no reason to replace neither the denomination *Lithothamnion* nor *Lithophyllum* for any other previous to those of Philippi, which have been maintained for nearly 60 years.

On the other hand I agree with Mr. Hariot that the species-name *undulosa* ought, perhaps, to be adopted for *L. cristatum*, if the latter in the sense taken by Solms-Laubach and Hauck l. c. does not include more than one species.

The conceptacles of sporangia are quoted by Hauck l. c. to be „sehr flach“. This is not the case in a specimen from his herbarium that I have seen, but fully according with those of the typical form. Another specimen from his herbarium perhaps belonging to this species and most nearly related to the below mentioned specimen from the Black Sea is nearly covered with another Lithothamnion, that I suppose to be a younger *L. incrustans* f. *depressa* and mentioned under this. On the other hand Hauck's plant probably also includes the above f. *sublævis*.

As remarked by Rosanoff l. c. the cystocarpic conceptacles appear frequently in the same individual as those of sporangia, but either most often in the greatest number. They are of about the same size as the latter, hemispherical or sometimes between hemispherical and low conical, with a rather large orifice. This is due to both forms. But in the above quoted not quite certain specimen of f. *sublævis* from the Christiania Fjord they are nearly conical, though never acute. Also here only the greater part of the roof falls away. Some small conceptacles in company with the latter, about 200 μ in diameter or less, are probably those of antheridia. I have not seen the carpospores, nor the spermatia.

The colour of the plant is quoted by Areschoug l. c. to be „nunc purpureo-rubri nunc cretaceo-albidi“, by Rosanoff „rose-violacée“, by Solms-Laubach „hell-violett“ and by Hauck „rötlich-lila“. Authentic specimens in Areschoug's herbarium from the Bahusian coast of Sweden are lilac, almost fully according with no. 48 in Saccardo, Chromotaxia. Helgolandian specimens partly are light lilac partly and especially f. *sublævis* approaching that of *L. polymorphum*, or with a more violaceous tinge and more often nearly coinciding with that of *L. lævigatum*. British specimens that I have seen most nearly accord with the darker Helgolandian. A specimen from Cherbourg has a very light violaceous shade. Specimens with us that I have gathered in Nordland accord with Bahusian, partly, however, a little darker partly with a yellowish-violaceous shade. At Berlevaag, the most northern locality known, it sometimes is yellowish, here and there with a very faint violaceous tinge, sometimes bluish violet.

Remark on the synonymy. Those of the above quoted synonyms of which I have seen specimens accord with *L. Lenormandi* in the sense here taken. As mentioned under *L. Strömfeltii* I suppose *M. Lenormandi* Farl. includes the former, but not unlikely f. *sublaevis* and perhaps also f. *typica* of the present species. As to my *L. Lenormandi* in Contrib. 1 cp. under *L. Strömfeltii*:

A specimen from the Black Sea determined by Mr. C. Deckenbach as *L. Lenormandi* seems also to me to be referrible to this species, but the numerous and densely crowded conceptacles are emptied, only a border left, and they are smaller than frequently in *L. Lenormandi*, about 200 μ in diameter, partly a little more partly even less. However, I have not examined the structure, the colour is much faded, apparently having been kept in alcohol, and not unlikely it ought to be considered a denominated form of the species.

Relation to other species. I do not know any other species of the subgenus *Lithophyllum* to which the present plant shows greater affinity than *L. tenue* (Kjellm.), a species that I, however, have not seen. Cp. Beringh. Algfl. p. 22, t. 1, fig. 6—10. With reference to its relation to *L. Strömfeltii* cp. under the latter.

Habitat. Along the northern coast it appears frequently to occur in rock pools or on rocks in the lower part of the litoral region, partly in sheltered places partly on open coast. On the southern coast it sometimes descends a little into the sublitoral region. In East-Finmarken specimens with reproductive organs have been taken in the beginning of July, in Nordland in June, July, August and October, and in the Christiania Fjord in December. Most of the conceptacles were, however, recently emptied in the specimens that I have seen. At Helgoland it bears these organs in March and June, on the British coast in January, February and March, and at Cherbourg in February. Thus it seems as if the plant at least in southern waters develops such organs all the year.

Occurrence. This is a more southern plant than *L. Strömfeltii*. I know but little of its distribution with us, as it has often been confounded with other species. The most northern place from

which I possess quite certain specimens is Berlevaag in East-Finmarken. It is not with certainty known between here and Nordland, where I met with it at Lödingen, local but pretty plentiful, and Kleen l. c. quotes it to be common and abundant. Besides, it has been gathered at Nesodden in the Christiania Fjord (Schreiner). It probably is commonly dispersed especially along the southern part of the coast.¹⁾

Geogr. Distribution. The Bahusian coast of Sweden (Areschoug, and others); the western Baltic Sea (Reinke); Helgoland (Sonder, Kuckuck); Britain (Batters, Holmes); the western coast of France (Lenormand, Crouan, Le Jolis); the Mediterranean Sea (Bornet, Falkenberg, Solms-Laubach); the Adriatic Sea (Hauck); the Black Sea (Deckenbach); the Atlantic coast of North America (Farlow)?

Lithothamnion squamulosum Fosl. mscr.

L. fronde lamelliformi, crustacea, 4—7 mm. crassa, violaceo-grisea, lamellis plus minusve horizontalibus, in tubercula minuta verrucæforma prominentibus. Tab. 19, fig. 24—26.

Description of the species. The plant forms rather extended crusts 4—7 mm. in thickness, loosely covering rocks or other crustaceous Lithothamnia, as *L. polymorphum*. The crust is more

¹⁾ After this was ready for the press I met with the typical form of *L. Lenormandi* in considerable abundance on rocks in the lower part of the litoral and upper part of the sublitoral region, descending to about 1 fathom, at Ytteröen in the Trondhjem Fjord. Especially when growing on shady perpendicular rocks, or else in the first named region quite covered with *Fucaceæ* or other algæ it in a living and younger, though fertile, stage frequently assumes a dark violet or now and then purplish violet colour, older, however, getting lighter, lilac, with a more or less yellowish shade or occasionally even greyish. On the other hand, if growing uncovered it always becomes more or less light, frequently a rather feeble lilac, and if exposed to the sun in the lower part of the litoral region it often gets very light, older even quite white or yellowish white. Besides, in an older stage the plant is not so closely adherent to the substratum as in a younger.

At the same place I also found a specimen on a stone just below low-water mark which stands nearest to f. *sublævis*, with the surface nearly smooth, and the conceptacles of sporangia are nearly as flattened as in the above mentioned specimens of this form but more crowded.

or less porous, composed of numerous, minute and more or less horizontal lamels. The lamels of the surface form small wart-like or irregular and densely crowded processes, which partly are formed by a single, convex-concave partly and most frequently composed of more lamels, which, however, never are vertical. The lamels are smooth or feebly zonated. The colour is a sallowish violet-grey, but a rather dark violet in the lower part of a peripheral portion occasionally not clinging to the substratum.

I have not seen certain organs of propagation, but I found a few emptied conceptacles, that probably are those of sporangia. They seem to have been hemispherical, the peripheral portion of the roof not falling away, as in *L. Lenormandi*, and when emptied rather resembling those in f. *typica* of the last named species but smaller, or about 200 μ in diameter.

Relation to other species. It seems to be nearly connected with certain forms of *L. cristatum* (Menegh.) and it, perhaps, may prove to be only a form of the latter, a species that I have not seen. However, it differs by its apparently smaller and more horizontal lamels, which are never vertically raised as frequently in that species, or if raised the upper portion always bends over a subjacent lamel or bends downwards, and the surface of the latter is smoother. Besides, the conceptacles of sporangia appear to be different.

Habitat. According to the kind communication of Cand. real. P. Boye, the finder of the species, it grows in the lower part of the litoral region, and, as it seems, in quiet bays. Specimens taken in July bear newly emptied conceptacles (of sporangia?).

Occurrence. The inner Stensund at Sulen in Sogn, on the western coast (Boye).

Fossil Lithothamnia.

(Pl. 23).

Several species of fossil Lithothamnia have been described, but they appear most frequently to be nearly impossible to identify with certainty, as the recognizable characters are lost. Of the more delicate or little anastomosing forms only fragmentary pieces are to be had, and of the larger anastomosing forms only the more solid central portions appear to be left, so that on the whole only the latter apparently are subject to an approximate determination of species. Besides, often only the organs of propagation afford a certain characteristic. Therefore, it is in most cases very difficult to know whether a form belongs to a living or is an extinct species.¹⁾

An interesting note on Lithothamnia from deep cuttings of the bottom at the mouth of the River Liffey is given by Prof. O'Reilly in Proc. Irish Acad. p. 223. He found several shells coated with Lithothamnia from a depth of about 22 feet 6 inches below the low water mark of the river, and gives a sketch of the different strata above the bed of shells and Lithothamnia. A few years ago he sent me some of these specimens for identification. I then considered them to belong partly to *L. fasciculatum* (Harv.) partly to *L. polymorphum*. Later he kindly sent me a photography of the specimens, and I am still of opinion that those determined as *L. fasciculatum* (Harv.) belong to the same plant to which the

¹⁾ Cp. Unger, Leithakalk; Gumbel, Die sogen. Nullip.; Waters, Notes foss. Lithoth.; and Zittel, Palaeont. II, p. 38.

latter is referred in this paper, viz. *L. crassum* Phil., or perhaps partly belong to *L. fruticosum*. But on the other hand those referred to *L. polymorphum* do not belong to this species in the sense here taken. They not unlikely are identic partly with the same species as the above mentioned partly *L. incrustans* f. *Harveyi*. They, however, ought to be compared with living specimens, as the same species are considered „still to be found living in the Bay of Dublin, but apparently not any longer in the mouth of the River Liffey“.

The Lithothamnion banks in the sea are extensive not only in horizontal but also in vertical direction, in larger banks the lower layers consist of dead specimens, by and by increasing upwards, and in this respect they correspond with the coral-reefs of the tropics. With us I have seen various such banks, which, especially in sounds and branches of fjords, have increased so much in vertical direction, that the top of the bank has been but very little below the present level of low-water and by lowest neap tides even partly laid dry. In places with rapid tides these banks also give rise to a greater accumulation of mud. I got numerous specimens from Vardö obtained by the harbours stirring up mud. Some few of these have been living, and belong to *L. fruticosum* f. *glomerata*. The other and very greatest part of the collection consists of dead individuals and belong to a species which on the one side reminds one of certain forms of *L. fruticosum*; but on the other side by the rather regular subdichotomous, straight and fastigate, not or in the central portions very little anastomosing branches somewhat resemble certain forms of *L. tophiforme*, although they are thinner than frequently in this species, and it not unlikely constitutes a separate and undescribed species. I am told that the bottom was chiefly composed of Lithothamnion, but I have not got full informations with reference to the conditions under which they were taken, and the extent of the layers. I, therefore, here do not more nearly record the last named form.

At some places along the Norwegian coast have been found Lithothamnion above the present level of the sea, although not, so far as I know, petrified forms. I have seen such at Tromsö, but

here only fragmentary pieces which are quite impossible to determine, though perhaps identic with *L. fruticosum* f. *flexuosa*, *L. tophiforme* or *L. coralloides*, or species which are most nearly related to these. At least in some places the so-called „skjælsand“, e. g. sand mixed with fragments of shells, also comprehends fragments of Lithothamnia.

In banks of shells below the bog posteriorly the town Bodö in Nordland occur numerous Lithothamnia some feet above the level of the sea. At least some of these must be referred to *L. fruticosum* f. *typica* (and perhaps also f. *fastigiata*), much resembling specimens of the latter which often are found washed ashore and rubbed by the waves. Cp. pl. 23, fig. 1—9.

In sinking a well at Herö in Helgeland Stud. med. Kristian Schreiner had the opportunity to see Lithothamnia from deeper layers. He kindly informed me, that the specimens apparently belonged to the same series of forms as the last named.

At Garten, a small island at the mouth of the Trondhjem Fjord, I met with similar plants under the green turf just above high-water mark. Pl. 23, fig. 10—15. Also these appear to belong to *L. fruticosum*, sometimes encompassing small stones (fig. 12, 15) sometimes not. At the same place I saw numerous dead specimens at or below low-water mark, but I had not occasion to ascertain whether they had been cast up from deeper water (it seemed to be rather steep below), or perhaps washed out from the bank.

Thus it appears, that the Lithothamnia also with us and especially along the northern part of the coast have been and still are of essential importance in forming new strata of the earth-crust, but the extent of these strata is not yet well known.

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Explanation of the Plates.

The figures are reduced to about one half the diameter, pl. 15—20, however, a little less, and the others partly a little more, especially pl. 2, partly a little less, especially pl. 8, except on pl. 22, where the figures 8 and 11 are magnified about five times and the other ones of natural size.

Pl. 1.

L. glaciale f. *torosa*.

Fig. 1—3. Habit-figure of two smaller specimens from Kvalsund and a larger from Kistrand in West-Finmarken.

Pl. 2.

L. breviaxe et *L. glaciale*.

Fig. 1. Habit-figure of an older specimen of *L. breviaxe*.
 „ 2. A specimen of the same species anastomosed with a form of *L. glaciale*, the latter most nearly connected with the typical form.

Pl. 3.

L. fruticosum f. *typica*.

Fig. 1—6. Older and younger specimens of the plant from Tromsø and Beian. In fig. 6 some of the branches are denudated and afterwards partly grown out into disc-like expansions, or new branches in development.

Pl. 4.

L. fruticosum f. *typica*.

Fig. 1—2. Old specimens with most of the upper branches denudated, the rest afterwards partly anastomosing,

forming crust-like expansions, partly here and there new branches in development.

L. fruticosum f. *glomerata*.

Fig. 3. Habit-figure of an older and typical specimen of the form.

Pl. 5.

L. fruticosum f. *fastigiata*.

- Fig. 1. Habit-figure of a specimen nearly encompassing a stone.
 „ 2, 5, 6. Specimens freely developed on the bottom.
 „ 3. Two specimens freely developed on the bottom but anastomosed.
 „ 4. A specimen apparently in the act of loosening itself from the stone, to which it appears to have been more closely fastened.
 „ 7. A specimen somewhat approaching f. *typica*.

P. 6.

L. fruticosum f. *corymbiformis*.

- Fig. 1. Habit-figure of an older specimen of the plant partly being hollow.
 „ 2. A specimen with most of the upper branches denudated.
 „ 3. An old specimen forming transition to f. *typica*, however, most closely related to the present form. The branches are much denudated, the plant rather hollowed especially by boring-muscles, and the cavity later occupied by other animals, as *Mytilus* and *Pecten*, the shells of which are partly projecting.

Pl. 7.

L. fruticosum f. *flexuosa*.

- Fig. 1. A smaller but fully developed specimen, larger but otherwise closely coinciding with two specimens from Hauck's herbarium of his *L. fasciculatum*.

- " 2. A larger and older specimen of the plant.
 " 3. An older specimen forming transition to f. *typica*, with the upper branches partly denudated.

Pl. 8.

L. fruticosum f. *flexuosa*.

- Fig. 1. An old specimen most nearly related to this form, with an apparently coarse hypothallus, which, however, in fact being caused thereby, that it is much infested with *L. flavescens*.
 " 2. A specimen nearly related and probably referrible to f. *flexuosa*, but on the other hand showing close affinity to certain forms of *L. tophiforme*, or, perhaps, being a hybrid between these two species.

Pl. 9.

L. fornicatum f. *robusta*.

- Fig. 1. An older specimen, hollow, but not yet opened itself in the lower part.
 " 2. A younger specimen apparently freely developed on the bottom, and seems to have been branched from the centre, but here already a small cavity formed.
 " 3. A younger specimen nearly covering the one half of a muscle (*Mytilus modiolus*). The other and lower half of the shell not visible in the figure is partly covered with *L. delapsum*, and both species grow over an earlier founded individual of *L. Strömfeltii*.
 " 4. A specimen with the apex of the branches truncate in the part turning upwards, or here and there nearly disc-shaped.

Pl. 10.

L. dimorphum.

- Fig. 1. The upwards turned part of a specimen with the ends

of the branches truncate or disc-shaped, occasionally somewhat rubbed. In the lower part the branches are obtuse or truncate.

- Fig. 2. The downwards turned part of a similar specimen, but the ends of the branches most commonly obtuse.
- „ 3. The downwards turned part of a specimen that has been much attacked by animals, with the branches rather anastomosed and the ends obtuse, occasionally rounded, and towards the sides truncate. The part that has turned upwards is quite hollowed by boring-muscles, leaving a peripheral portion about 1—2 cm. in thickness, and rather rubbed by the influence of rapid tides.
- „ 4. The corresponding part of a specimen with the tip of the branches everywhere obtuse or truncate.
- „ 5. The upper part of a specimen with the apex of most of the branches forming disc-shaped and somewhat rubbed expansions. The lower part is hollowed, much rubbed, and the branches of the peripheral portion rather denudated, often only the half or less of a branch left in a longitudinal direction of the axis, but here and there new local formations in development.
- „ 6. The lower part of a specimen, with wart-like processes developed from the truncate or somewhat denudated apex of some of the branches.

Pl. 11.

L. dehiscens f. *typica*.

Habit-figure of an older and larger but fragmentary specimen, the longest diameter about 32 cm., nearly cup-shaped and rubbed in the lower part.

Pl. 12.

L. dehiscens f. *typica*.

Fig. 1. Habit-figure of a nearly spherical, younger and somewhat hollowed specimen, showing the part that has turned

towards the bottom, with most of the branches in this part slightly attenuating and the ends rounded or obtuse, however, towards the sides partly with obtuse and partly even truncate ends. In the part that has turned upwards, and not visible in the figure, the branches are coarser, denser and fully according with those of the specimen represented on pl. 11.

- Fig. 2. A nearly whorl-shaped specimen about 23 cm. in diameter, showing the part that has turned upwards, with the apex of the branches frequently obtuse, here and there bearing wart-like processes.

Pl. 13.

L. dehiscens f. *grandifrons*.

- Fig. 1. The upwards turned part of a fragmentary specimen: In the downwards turned part it is partly rubbed partly with new branches in development, and the edges of the frond are bent a little inwards.
- " 2. Fragment of another specimen.
- " 3. A specimen showing the part that has turned towards the bottom, with the small bundles of branches often rather depressed, or confluent, forming small expansions, from which small and wart-like processes are developed. It is rather rubbed and denudated in the part that has turned upwards, with somewhat coarser branches.

Pl. 14.

L. delapsum f. *abbreviata*.

- Fig. 1. Habit-figure of the upwards turned part of a cup-shaped specimen; in the lower part with the edges of the frond bent inwards and together with new developed branches somewhat replenished the concavity.
- " 2. A younger specimen nearly encompassing a stone.
- " 3. A specimen in the act of loosening itself from the enclosed object, a stone. A part of the peripheral portion of the frond is removed.

L. delapsum f. *conglutinata*.

Fig. 4. Habit-figure of an older specimen of the form.

Pl. 15.

L. apiculatum f. *typica*.

Fig. 1—4. Habit-figures of 4 specimens of the plant.

L. apiculatum f. *parvicocca*.

Fig. 5—8. Habit-figures of 4 specimens of the plant.

L. apiculatum f. *connata*.

Fig. 9—13. Habit-figures of 5 specimens of the plant, two of which freely developed on the bottom, the others fastened to stones.

L. apiculatum f. *patula*.

Fig. 14—19. Habit-figures of 6 specimens of the plant.

L. gracilescens.

Fig. 20—27. Habit-figures of 8 specimens of the plant.

Pl. 16.

L. coralloides f. *norvegica*.

Fig. 1—11. Habit-figures of 11 specimens of the plant from different places in the Trondhjem Fjord.

L. coralloides f. *saxatilis*.

Fig. 12—23. Habit-figures of 12 specimens from Skorpen and the Trondhjem Fjord.

L. coralloides f. *australis*.

Fig. 24—31. Habit-figures of 8 specimens of the plant; fig. 24—25 from Haugesund; fig. 26 from Storfosen; fig. 27

—30 from Britain (Cumbrae); and fig. 31 from France (Morlaix).

L. coralloides f. *flabelligera*.

Fig. 32—37. Habit-figures of 6 specimens from France, gathered at Morlaix.

L. coralloides f. *subsimplex*.

Fig. 38—42. Habit-figures of 5 specimens from Britain (Cumbrae).

L. divergens.

Fig. 43—50. Habit-figures of 8 specimens of the plant.

Pl. 17.

L. flabellatum f. *Granii*.

Fig. 1—3. Habit-figures of younger specimens of the plant.

„ 4—5. Older individuals in the act of loosening themselves from the substratum

„ 6—7. Older individuals loosened from the substratum.

L. colliculosum f. *densa*.

Fig. 8—10. Habit-figures of 3 specimens from Skorpen near Tromsø.

L. colliculosum f. *laxa*.

Fig. 11. An American specimen of the form (Collins' coll. D.).

L. colliculosum f. *rosea*.

Fig. 12—13. Norwegian specimens of the plant.

„ 14. An American specimen (Collins' coll. F.).

„ 15—16. British specimens, gathered at Berwick.

L. polymorphum f. *tuberculata*.

Fig. 17—19. Habit-figures.

L. polymorphum f. *valida*.

Fig. 20—21. Habit-figures.

L. polymorphum f. *papillata*.

Fig. 22—23. Habit-figures.

Pl. 18.

L. varians f. *verrucosa*.

Fig. 1—5. Habit-figures of the form.

L. varians f. *irregularis*.

Fig. 6—9. Habit-figures.

L. incrustans f. *depressa*.

Fig. 10—11. Habit-figure of a French specimen (fig. 10) and a Norwegian (fig. 11).

L. incrustans f. *Harveyi*.

Fig. 12—15. Habit-figures of British specimens of the plant.

Pl. 19.

L. compactum.

Fig. 1—4. Habit-figures of two Norwegian specimens (1—2), a Spitzbergian (3) and an American specimen (4).

L. testaceum.

Fig. 5—9. Habit-figures of fragments of a crust.

L. ocellatum.

Fig. 10. A fragment of the lower branch-system of *L. fruticosum* f. *flexuosa* or perhaps *L. tophiforme* infested with this species.

L. uncinatum.

Fig. 11. Habit-figure of a fragmentary specimen.

„ 12—14. Fragments of the same specimen.

L. coalescens.

Fig. 15—20. Habit-figures of the plant.

L. levigatum.

Fig. 21—23. Habit-figure of a younger Norwegian specimen (fig. 22) and fragments of two Helgolandian.

L. squamulosum.

Fig. 24—26. Habit-figures of the plant.

Pl. 20.

L. congregatum.

- Fig. 1—3. Habit-figures of the part of the plant that has turned upwards.
- „ 4. A specimen seen from below, with the lower part of the branch-systems denudated.
- „ 5. A similar specimen with new local formations partly covering the rubbing parts of the denudated branches, and new branches here and there in development.
- „ 6. A similar specimen with numerous new-developed branches.

Pl. 21.

L. nodulosum.

Fig. 1—6. Habit-figures of the plant; fig. 4 an old specimen with the ultimate branches somewhat denudated.

L. tophiforme f. *typica.*

Fig. 7, 10. Habit-figures of the form.

L. tophiforme f. *squarrosa.*

Fig. 8—9. Habit-figures.

Pl. 22.

L. flabellatum f. *Granii.*

Fig. 1. Habit-figure of a younger individual.

L. investiens.

- Fig. 2. A young specimen fastened to *L. tophiforme* f. *squarrosa*.
 „ 3. Part of a free peripheral portion of an older specimen seen from above.
 „ 4. The same portion seen from below.
 „ 5. An older specimen fastened to *L. fruticosum*.

L. evanescens.

- Fig. 6—7. Habit-figure of an American specimen (6) and a Norwegian (7).
 „ 8. Conceptacles of sporangia seen from above.

L. scabriusculum.

- Fig. 9. Habit-figure of the plant.

L. orbiculatum.

- Fig. 10. Habit-figures of younger and older, sporangia-bearing specimens fastened to a stone.
 „ 11. A part of the crust with two conceptacles of sporangia.

L. Strömfeltii f. *macrospora.*

- Fig. 12. Habit-figure of a specimen with not fully developed conceptacles of sporangia and a couple of young conceptacles of cystocarps. The nature of the surface is not quite correctly reproduced by the lithographer.

Pl. 23.

Fossil Lithothamnia.

- Fig. 1—15. Specimens from Bodö (1—9) and from Garten at the mouth of the Trondhjem Fjord (10—15), probably at least partly referrible to *L. fruticosum*.
-

Register.

The synonyms as well as species considered not referrible to *Lithothamnion* are printed in italics, and the species and genera incidentally mentioned are close-printed.

<i>Apora polymorpha</i> Gunn	40, 46, 90
<i>Corallium pumilum</i> Esper	147
Eulithothamnion Fosl.	40
Evanidæ Fosl.	142
Innatæ Fosl.	40
Lithophyllum (Phil.) Fosl.	178
<i>incrustans</i> Phil.	122
<i>lave</i> Fosl.	174
<i>lave</i> Strömf.	174
<i>Lenormandi</i> Fosl.	173, 179
f. <i>lave</i> Fosl.	173
<i>Lenormandi</i> Gobi	173
<i>Lenormandi</i> Rosan	178
<i>zonatum</i> Fosl.	157
Lithothamnion Phil.	40
<i>albicorne</i> Kjellm.	147
apiculatum Fosl.	82
f. <i>connata</i> Fosl.	82
f. <i>parvicocca</i> Fosl.	82
f. <i>patula</i> Fosl.	82
f. <i>typica</i> Fosl.	82
<i>arcticum</i> (Kjellm.) Fosl.	158
<i>Battersii</i> Fosl.	151
<i>boreale</i> Fosl.	40
<i>breviaxe</i> Fosl.	44
<i>byssoides</i> (Lam.) Phil.	146
f. <i>major</i> Fosl.	147
<i>byssoides</i> Unger	87
<i>calcareum</i> Aresch.	148
var. <i>norvegicum</i> Aresch.	90
<i>calcareum</i> Kjellm.	41
<i>calcareum</i> Kleen	41

Lithothamnion circumscriptum Strömf.	16C
<i>α areolatum</i> Rosenv.	160
<i>β validum</i> Rosenv.	131
<i>coalescens</i> Fosl.	162
<i>colliculosum</i> Fosl.	103
<i>f. densa</i> Fosl.	103
<i>f. laxa</i> Fosl.	103
<i>f. rosea</i> (Batt.) Fosl.	103
<i>compactum</i> Kjellm.	131
<i>congregatum</i> Fosl.	142
<i>coralloides</i> Crn.	90
<i>f. australis</i> Fosl.	90
<i>f. flabelligera</i> Fosl.	90
<i>f. norvegica</i> (Aresch.) Fosl.	90
<i>f. saxatilis</i> Fosl.	90
<i>f. subsimplex</i> Batt.	90
<i>crassum</i> (Lloyd).	179
<i>crassum</i> Phil.	59
<i>f. capitellata</i> Fosl.	59
<i>f. typica</i> Fosl.	59
<i>crassum</i> Unger	123
<i>crispatum</i> Hauck	35, 128
<i>cristatum</i> (Menegh.) Fosl.	35, 184
<i>crustaceum</i> Batt.	167
<i>decussatum</i> (Solms-Laub.) Fosl.	35
<i>dehiscens</i> Fosl.	72
<i>f. grandifrons</i> Fosl.	73
<i>f. typica</i> Fosl.	72
<i>delapsum</i> Fosl.	78
<i>f. abbreviata</i> Fosl.	78
<i>f. conglutinata</i> Fosl.	78
<i>dentatum</i> (Kütz.) Aresch.	35
<i>depressum</i> Crn.	122
<i>dimorphum</i> Fosl.	68
<i>divergens</i> Fosl.	96
<i>durum</i> Kjellm.	166
<i>expansum</i> (Phil.) Fosl.	35, 128, 159
<i>evanescens</i> Fosl.	165
<i>fasciculatum</i> Aresch.	41, 60, 83, 148
<i>fasciculatum</i> Crn.	60
<i>fasciculatum</i> Farl.	47, 103
<i>fasciculatum</i> Gobi.	41, 148
<i>fasciculatum</i> Hauck	46
<i>β fruticosum</i> Hauck	46
<i>fasciculatum</i> Kjellm.	41, 62, 71
<i>fasciculatum</i> Kleen	148
<i>fasciculatum</i> Solms-Laub	148

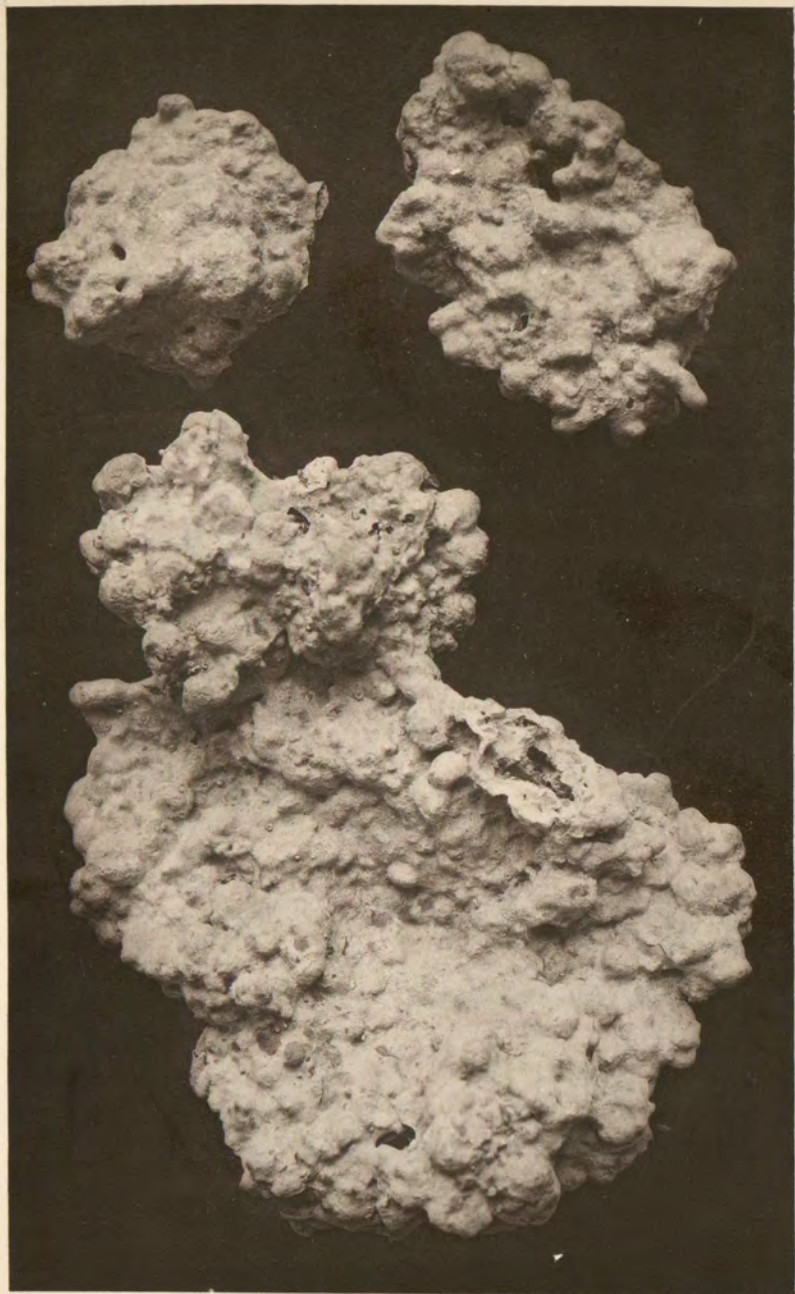
Lithothamnion flabellatum Rosenv.	98
f. Granii Fosl.	98
f. Rosenvingii Fosl.	98
flavescens Kjellm.	138
focundum Kjellm.	137
fornicatum Fosl.	64
f. robusta Fosl.	64
f. typica Fosl.	64
var. Fosl.	78
fruticulosum (Kütz.) Fosl.	46
f. corymbiformis Fosl.	46
f. curvirostra Fosl.	46
f. fastigiata Fosl.	46
f. flexuosa Fosl.	46
f. glomerata Fosl.	46
f. intermedia (Kjellm.) Fosl.	46
f. nana Fosl.	46
f. typica Fosl.	46
glaciale Kjellm.	41
f. torosa Fosl.	41
f. typica Fosl.	41
<i>gracile</i> Phil.	90
gracilescens Fosl.	87
Hauckii Fosl.	58
incrustans (Phil.) Fosl.	122
f. depressa (Crn.) Fosl.	122
f. Harveyi Fosl.	122
<i>intermedium</i> Kjellm.	46
investiens Fosl.	157
lævigatum Fosl.	167
Lenormandi (Aresch.) Fosl.	178
f. sublaevis Fosl.	179
f. typica Fosl.	179
lichenoides (Ell. et Sol.) Fosl.	35, 158, 159
loculosum Kjellm.	116
<i>mamillosum</i> Hauck	58
nodulosum Fosl.	144
<i>norvegicum</i> (Aresch.) Kjellm.	91
f. <i>distans</i> Fosl.	96
f. <i>globulata</i> Fosl.	82
ocellatum Fosl.	140
orbiculatum Fosl.	171
papillosum Zanard	120
<i>polymorphum</i> Aresch.	114, 171
polymorphum (L.) Aresch.	114
f. papillata Fosl.	115
f. tuberculata Fosl.	114

Lithothamnion polymorphum (L.) Aresch. f. valida Fosl.	114
<i>polymorphum</i> Crn.	123
<i>polymorphum</i> Farl.	131
<i>polymorphum</i> Fosl.	110, 115
<i>polymorphum</i> Hauck.	115, 123
<i>polymorphum</i> Le Jo.I.	123
<i>polymorphum</i> Kjellm.	110, 115
<i>polymorphum</i> Kleen.	110, 115
<i>polymorphum</i> Rosan.	123
<i>purpureum</i> Crn.	115
<i>racemus</i> auct.	60
<i>ramulosum</i> auct.	47
<i>roseum</i> Batt.	103
<i>rubrum</i> Phil.	91
<i>scabriusculum</i> Fosl.	170
Sonderi Hauck.	155
<i>soriferum</i> Kjellm.	147
f. <i>alcicornis</i> (Kjellm.) Fosl.	147
f. <i>divaricata</i> Fosl.	147
f. <i>globosa</i> Fosl.	147
<i>soriferum</i> Rosenv.	98, 148
Strömfeltii Fosl.	173
f. <i>macrospora</i> Fosl.	173
f. <i>tenuissima</i> Fosl.	173
squamulosum Fosl.	183
<i>tenue</i> (Kjellm.) Fosl.	174, 177, 182
<i>tenue</i> Rosenv.	173
<i>testaceum</i> Fosl.	135
<i>tophiforme</i> Unger	147
f. <i>alcicornis</i> (Kjellm.) Fosl.	147
f. <i>globosa</i> Fosl.	147
f. <i>squarrosa</i> Fosl.	147
f. <i>typica</i> Fosl.	147
<i>undulosum</i> (Bory) Fosl.	179
<i>uncinatum</i> Fosl.	154
<i>Ungeri</i> Kjellm.	47
<i>varians</i> Fosl.	109
f. <i>irregularis</i> Fosl.	110
f. <i>verrucosa</i> Fosl.	109
Mastophora Desne	33
Melobesia Lamour.	35
<i>calcareo</i> Harv.	148
<i>compressa</i> M'Calla	148
<i>fasciculata</i> Harv.	46, 60
<i>Lenormandi</i> Aresch.	178
<i>Lenormandi</i> Farl.	173, 179
<i>polymorpha</i> Harv.	122

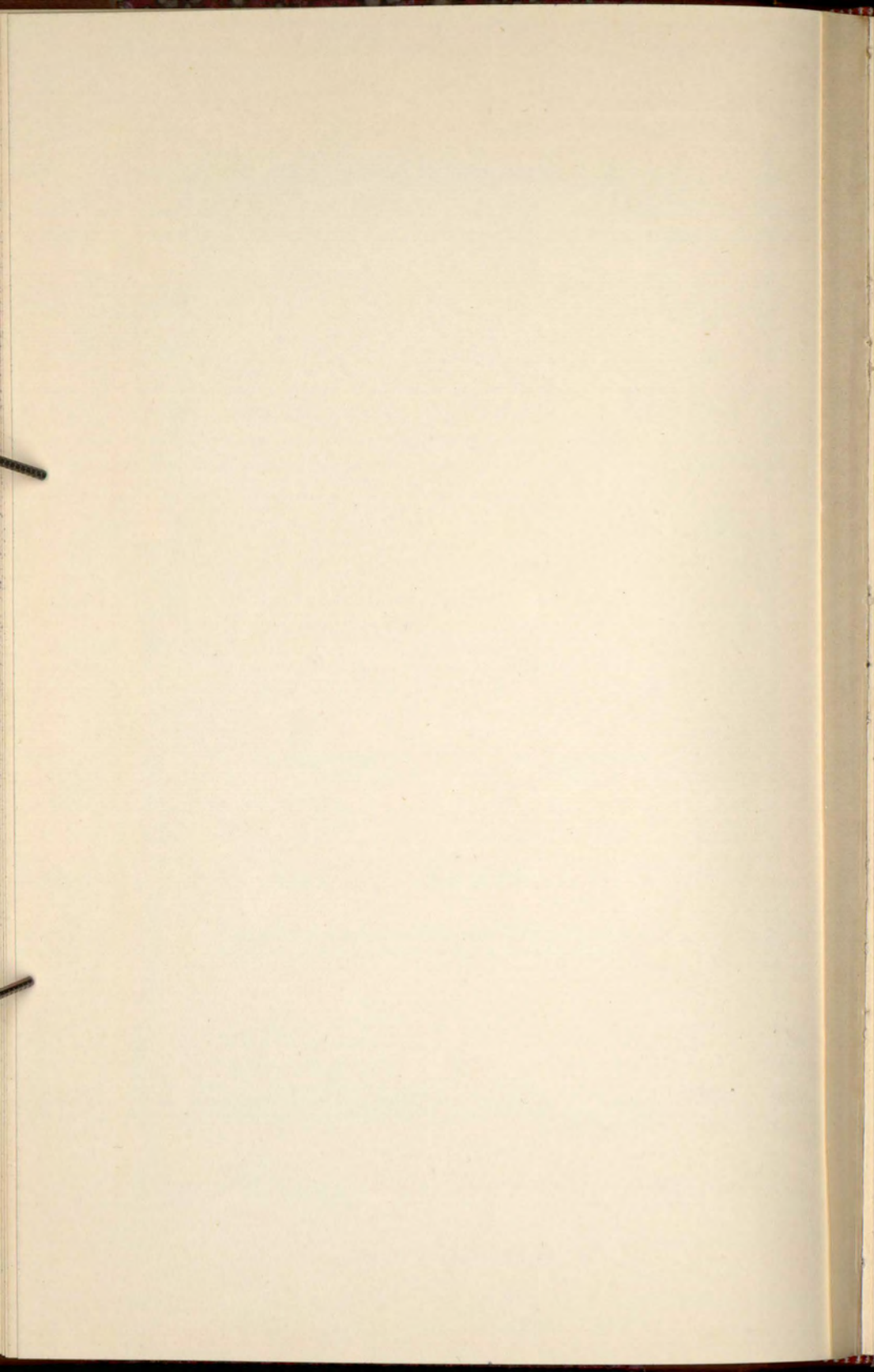
<i>Millepora byssoides</i> Lam.	146
<i>calcareo</i> Ell. et Sol.	148
<i>calcareo</i> Lam.	148
<i>fasciculata</i> Lam.	60
<i>informis</i> Lam.	151
<i>polymorpha</i> Ell. et Sol.	148
<i>polymorpha</i> var. <i>dicaricata</i> Esper	154
<i>polymorpha</i> var. <i>globosa</i> Esper	148
<i>polymorpha</i> var. <i>tophiiformis</i> Esper	148
<i>polymorpha</i> L.	114
<i>polymorpha</i> Mohr	115, 147
<i>Nullipora calcarea</i> Johnst.	90, 148
<i>fasciculata</i> Johnst.	60
<i>polymorpha</i> Johnst.	46, 60, 122
<i>Trochanter</i> Bory	179
<i>Spongites</i> Kütz.	33
<i>byssoides</i> Kütz.	146
<i>confluens</i> Kütz.	122
<i>coralloides</i> Crn.	90
<i>crassa</i> Kütz.	60
<i>crustacea</i> Kütz.	115
<i>fasciculata</i> Kütz.	60
<i>fruticulosa</i> Kütz.	46
<i>incrustans</i> Kütz.	123
<i>polymorpha</i> Kütz.	148
<i>racenosa</i> Kütz.	123
<i>ramulosa</i> Kütz.	46
<i>Tenarea</i> Bory	178
<i>undulosa</i> Bory	179

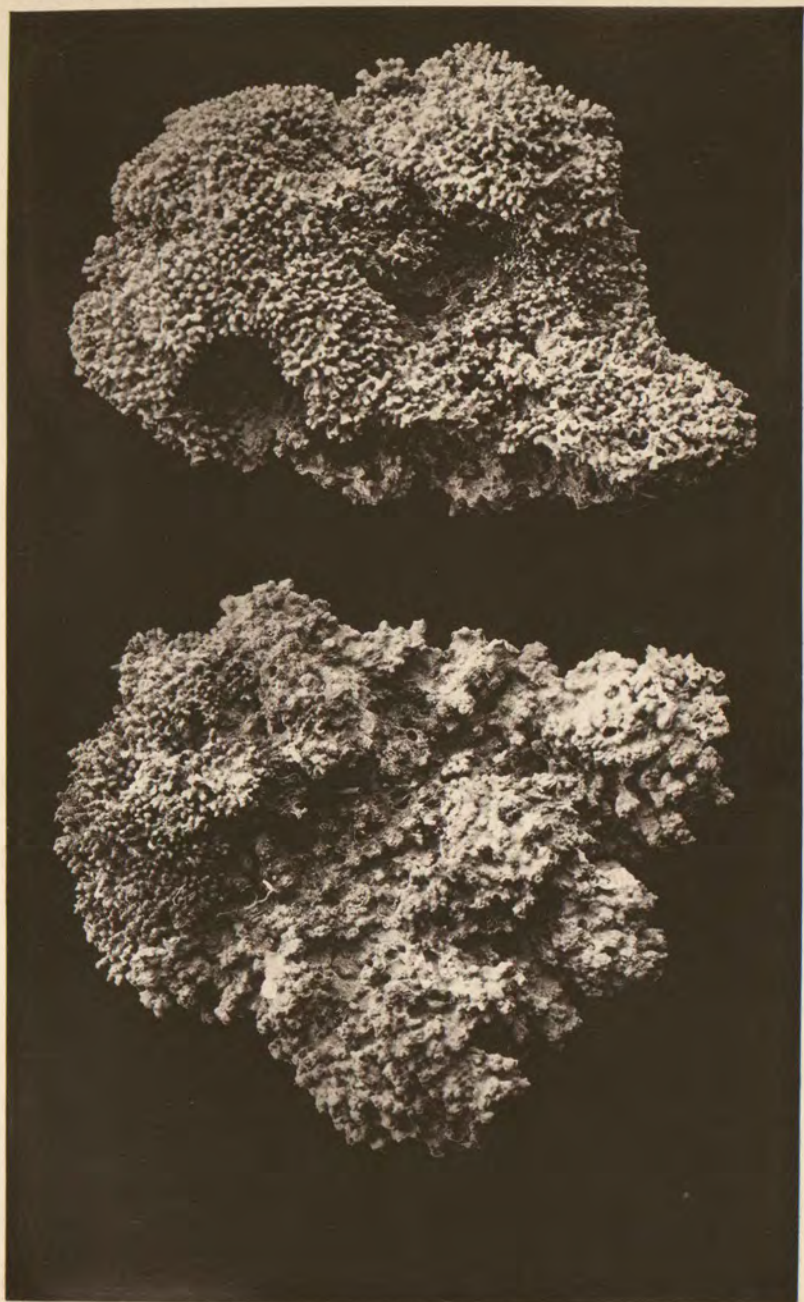
Errata.

Page 35, 13th line from the top, for dendatum read dentatum.
" 39, 9th " " " " " Vittrock read Wittrock.
" 43, 10th " " " " " bottom, for torulosa read torosa.
" 43, 11th " " " " " " " orulosa " torosa.
" 100, 10th " " " " " top, for of parts read or parts.



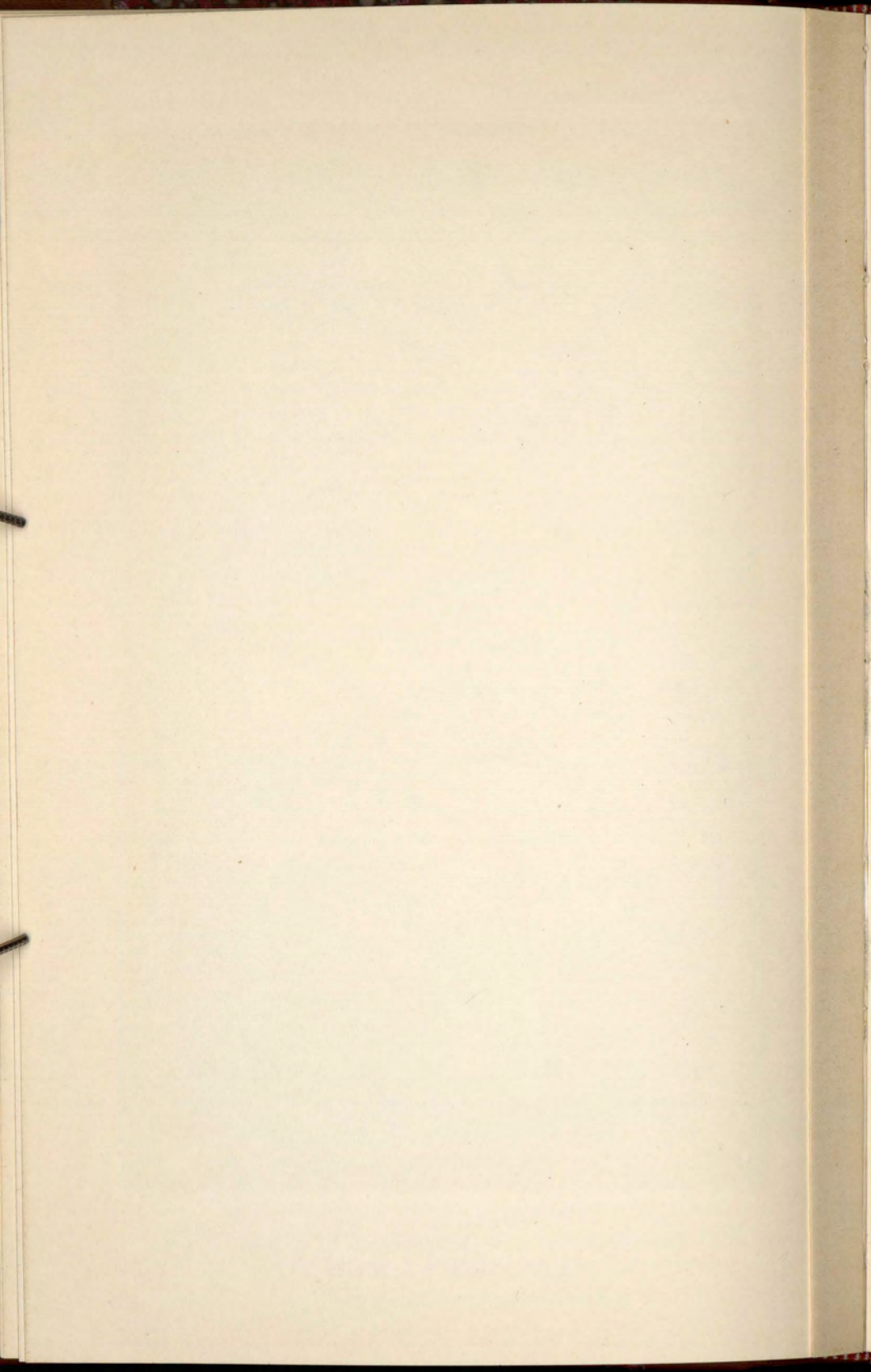
L. glaciale f. torosa.





1. *L. breviace.*

2. *L. breviace* et *L. glaciale* f.



1



2



3



4



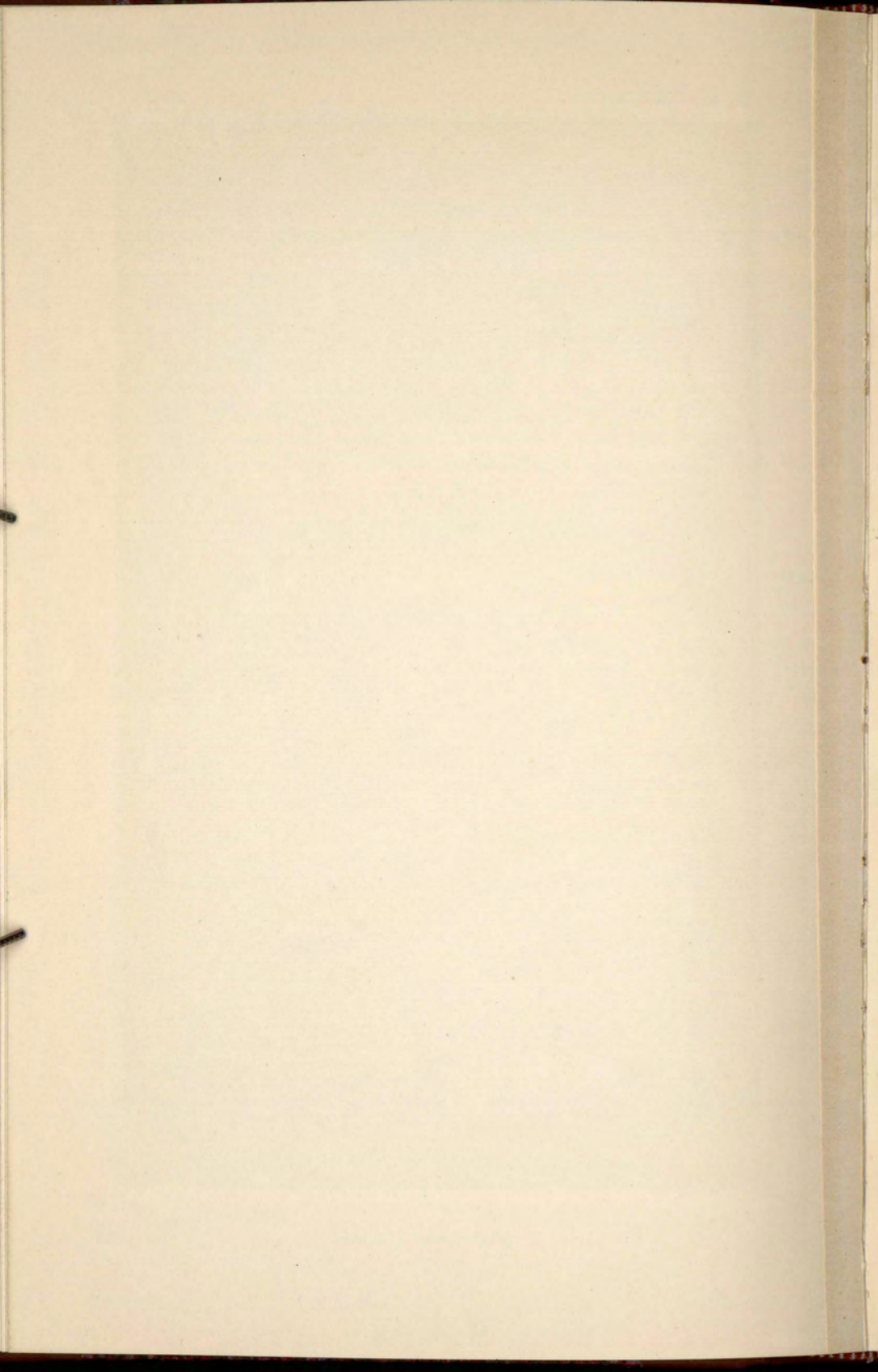
5

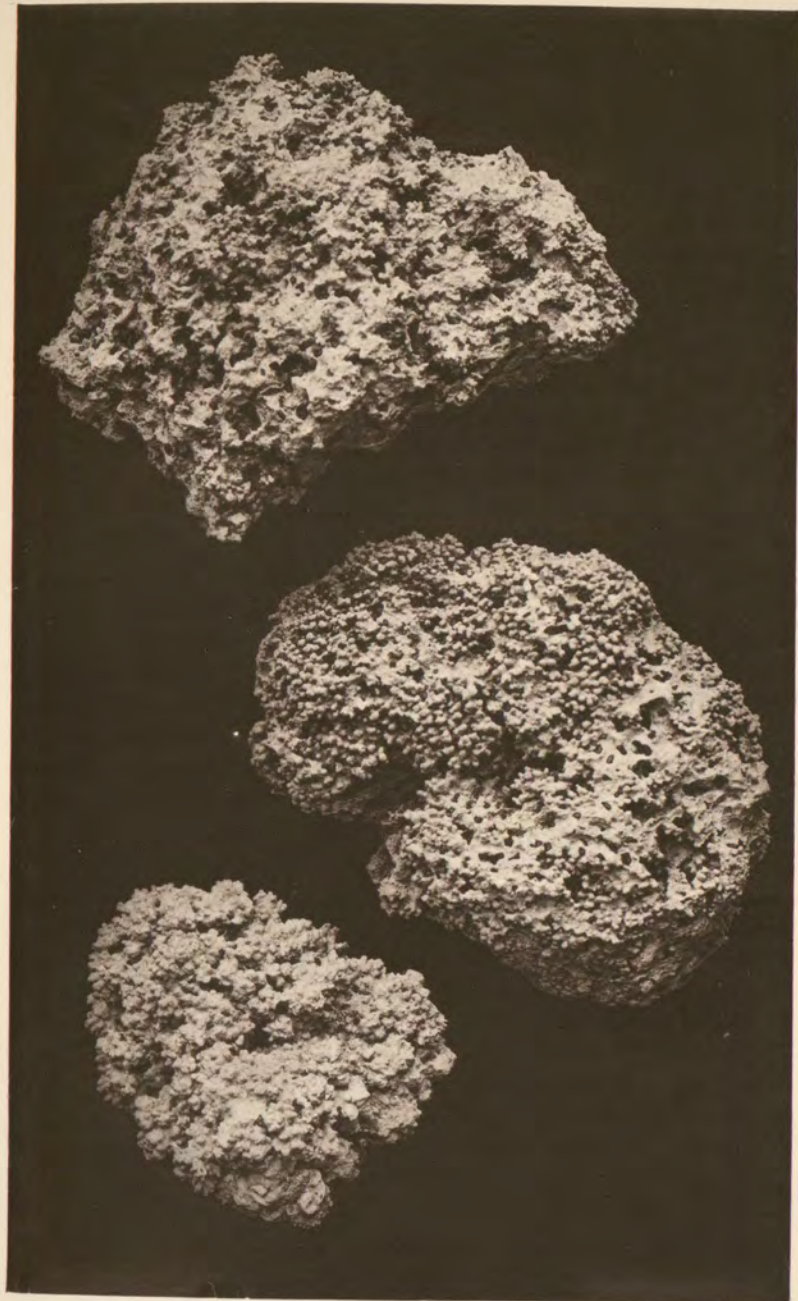


6

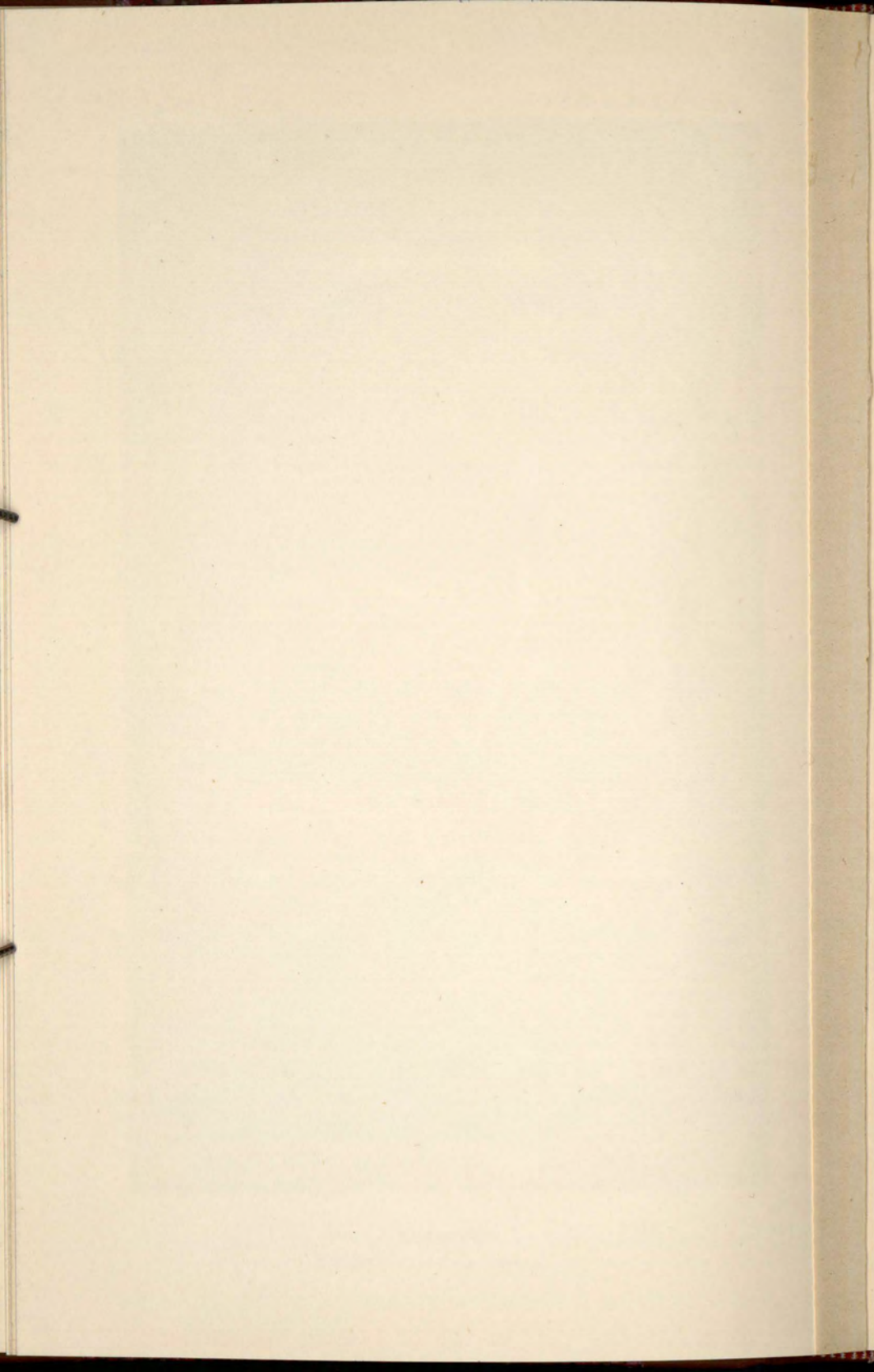


L. fruticosum f. typica.





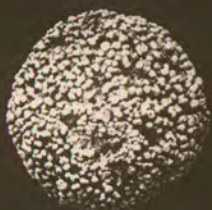
1-2. *L. fruticosum* f. *typica*.
3. *L. fruticosum* f. *glomerata*.



1



2



3



4



5



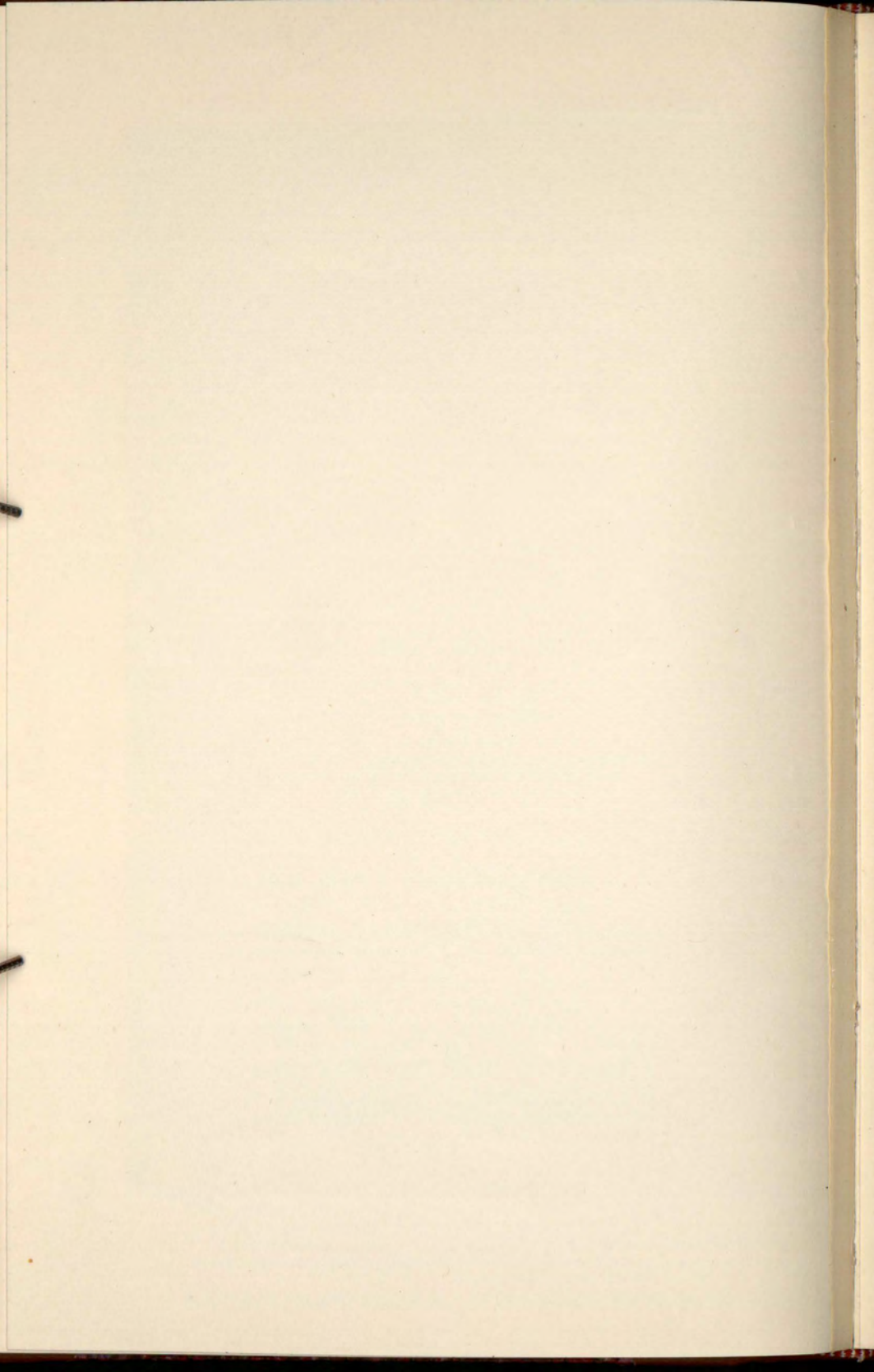
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7

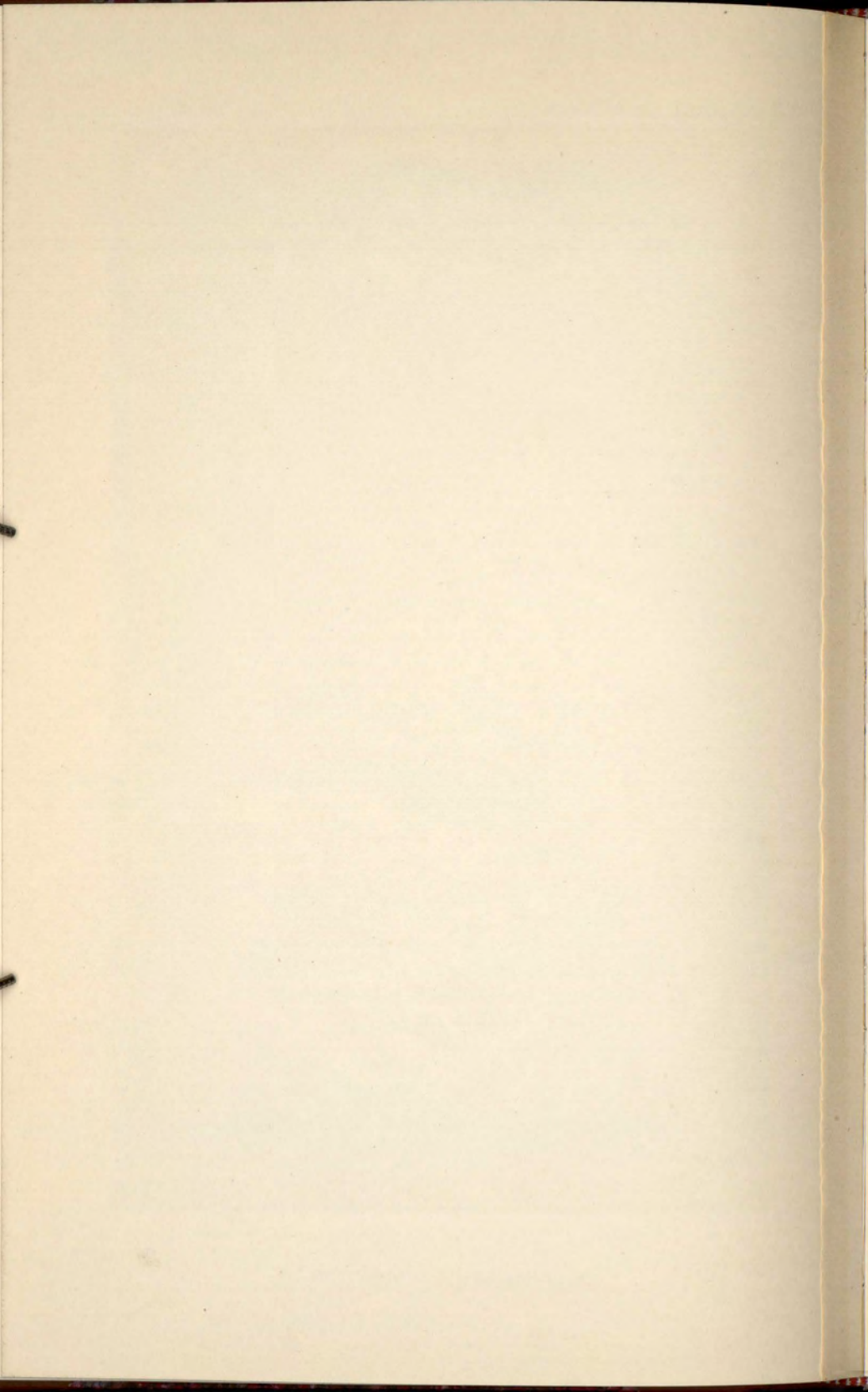


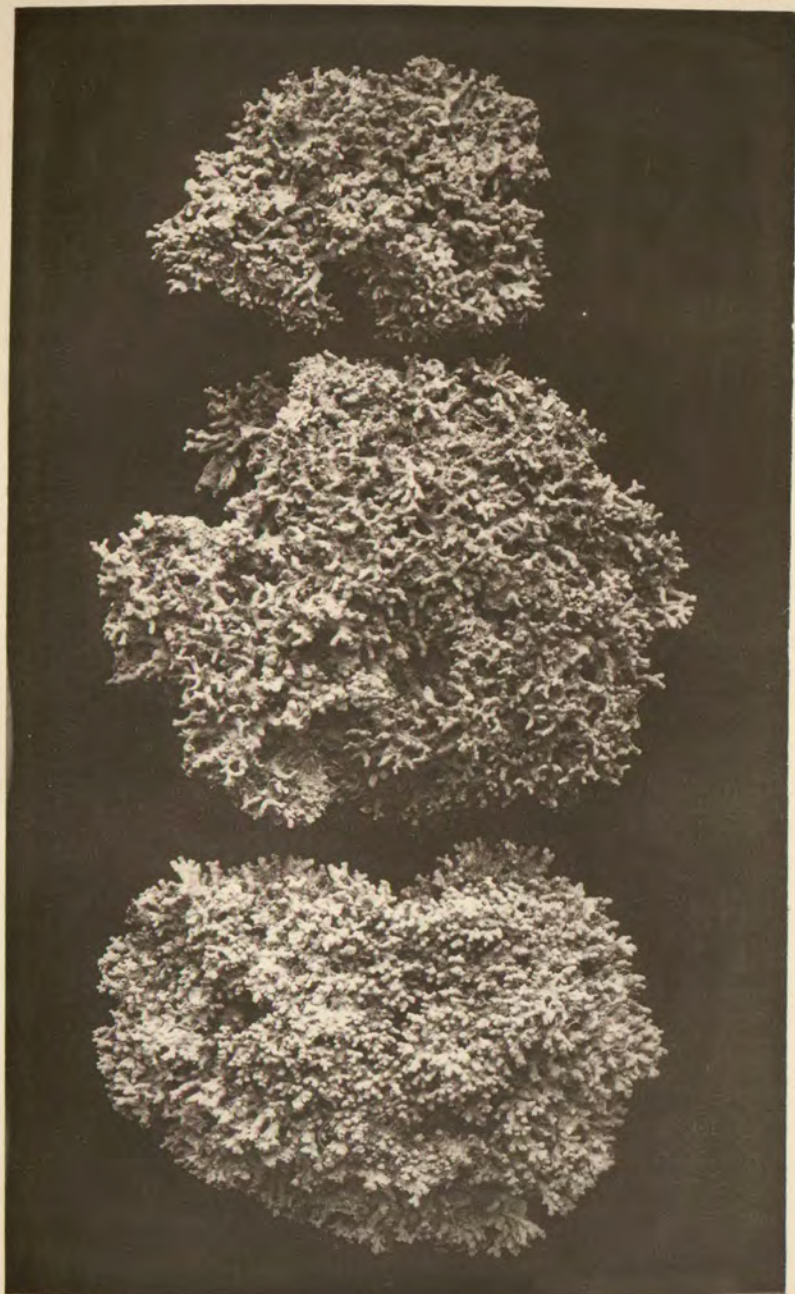
L. fruticosum f. fastigiata.



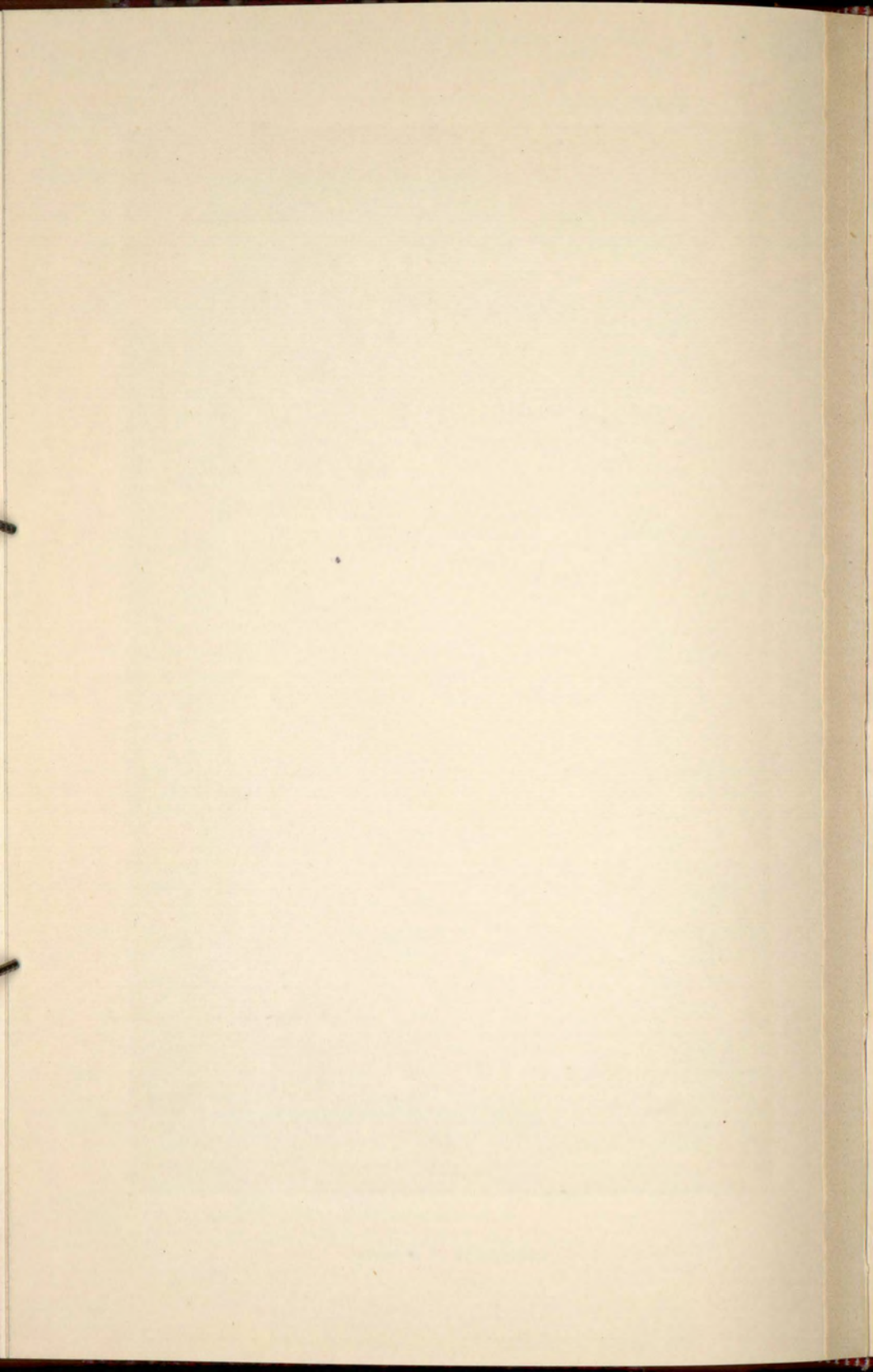


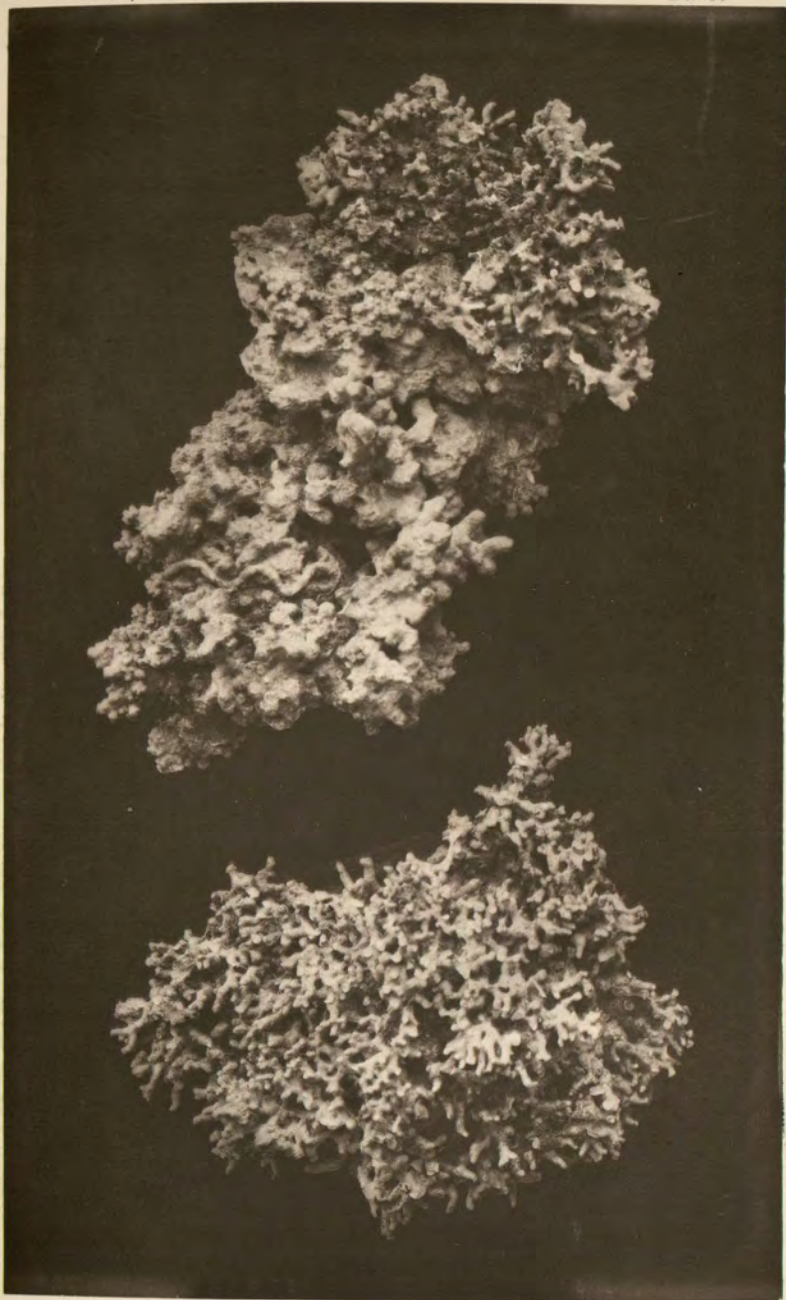
L. fruticosum f. *corymbiformis*.



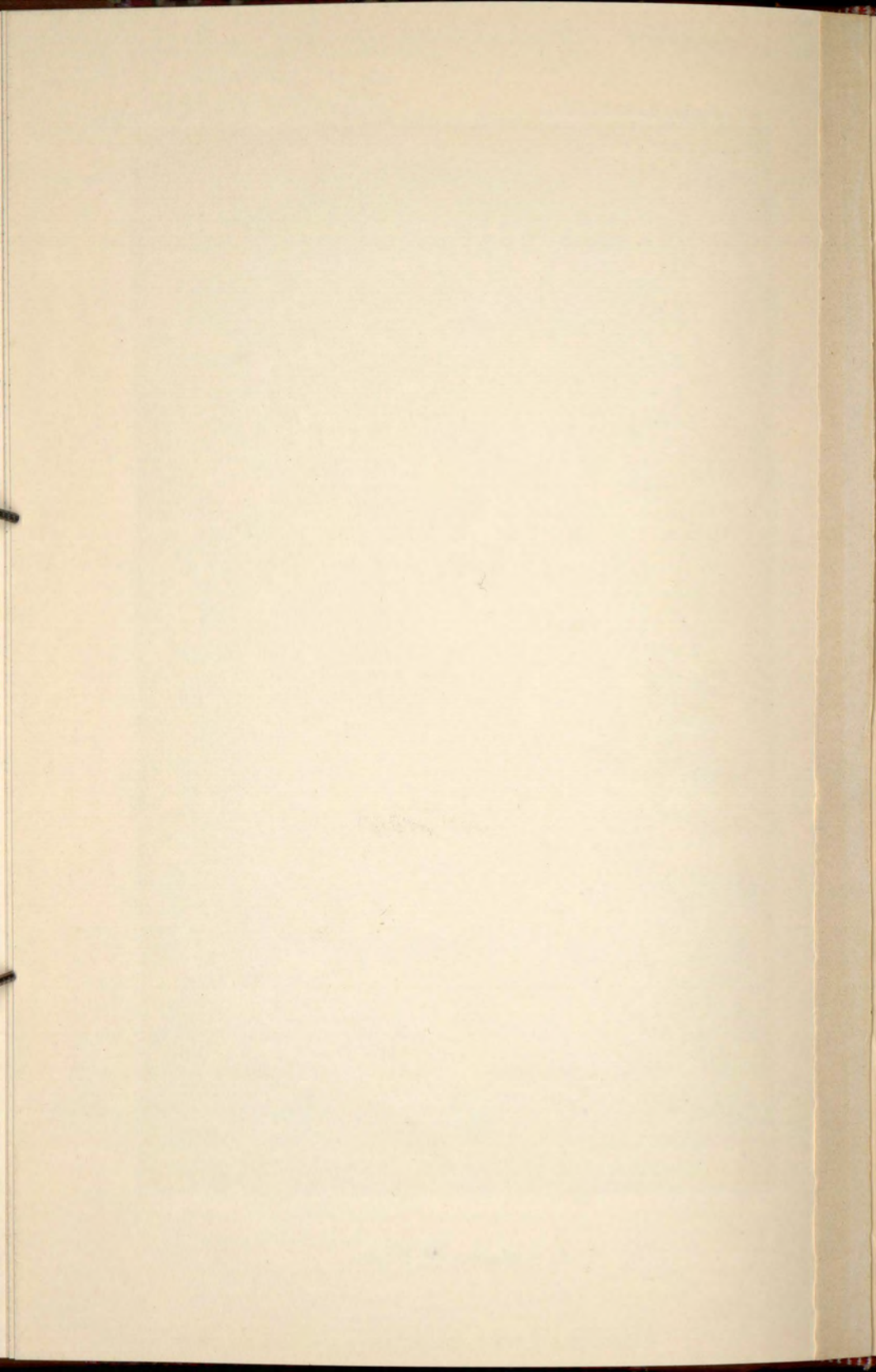


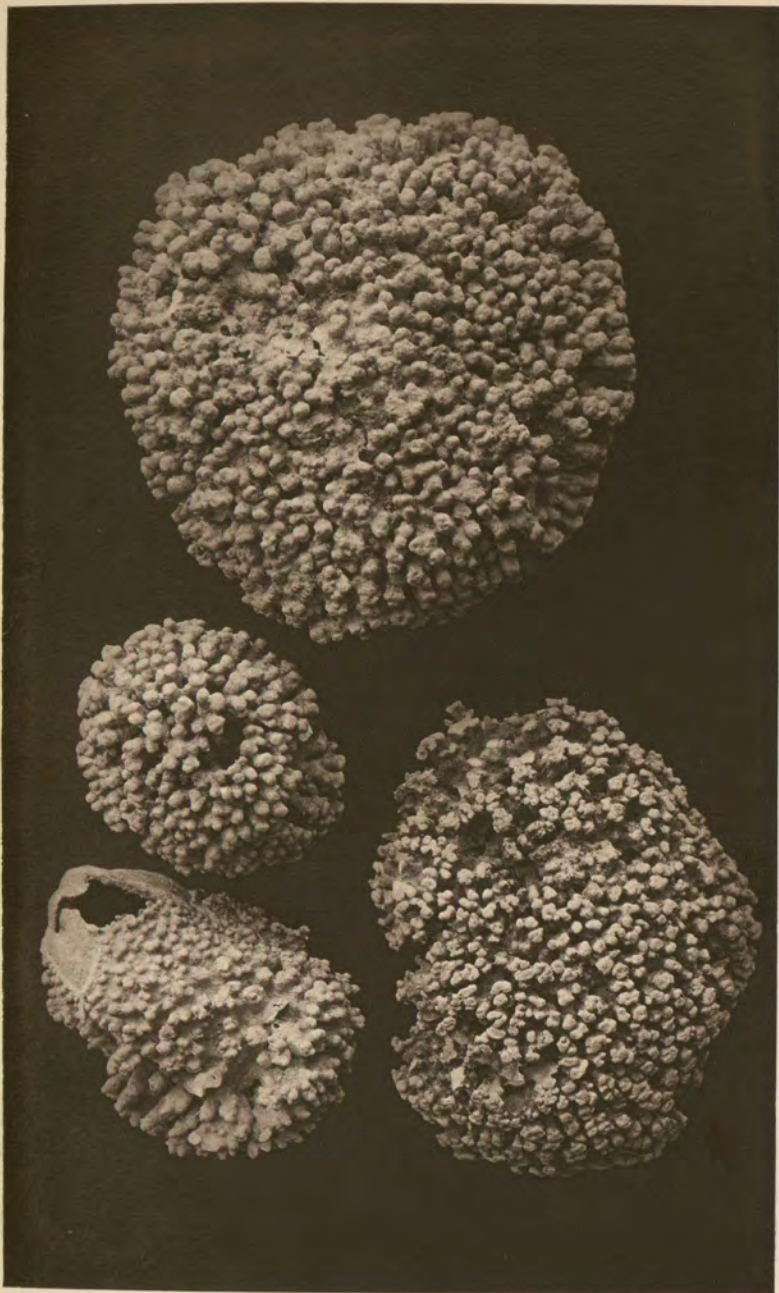
L. fruticosum f. *flexuosa*.



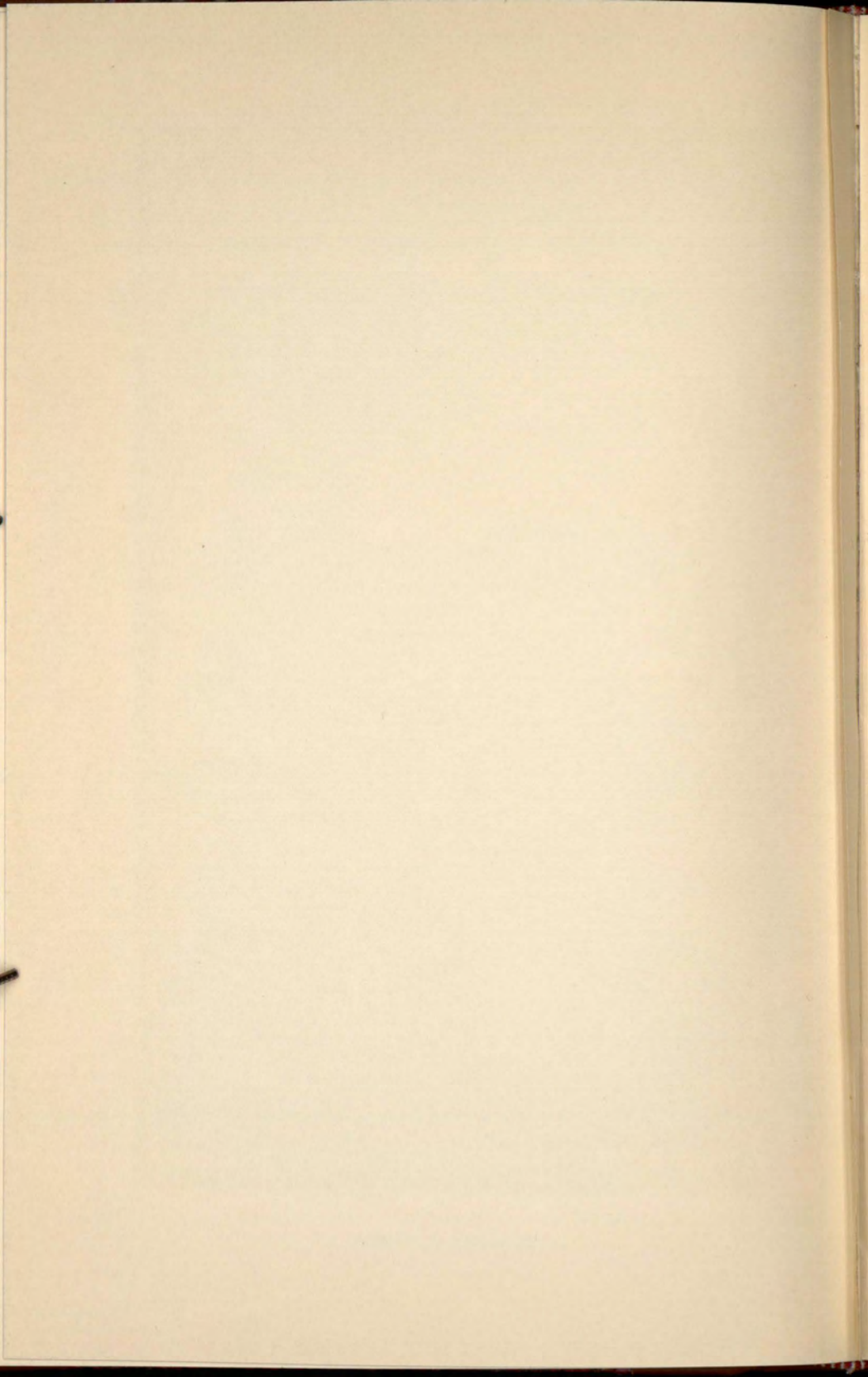


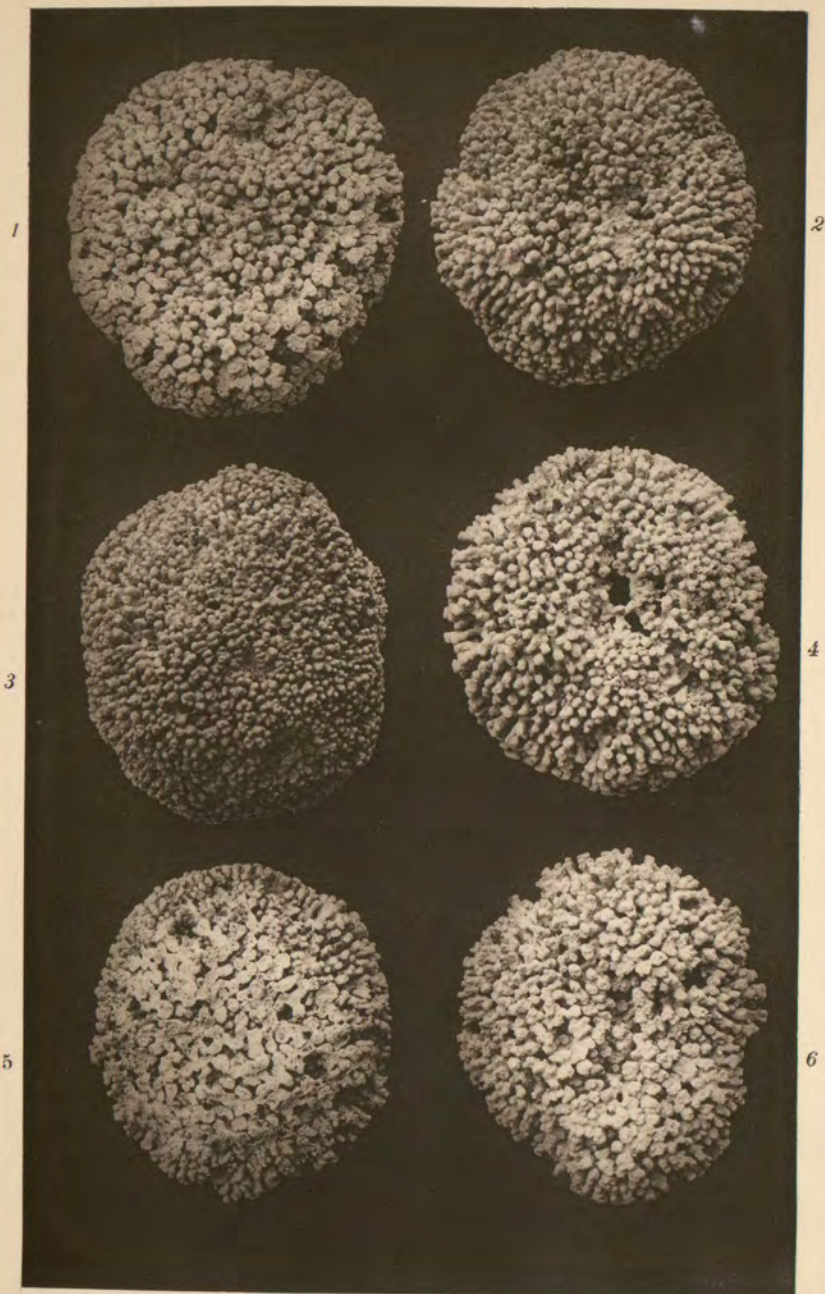
L. fruticosum f. *flexuosa*.



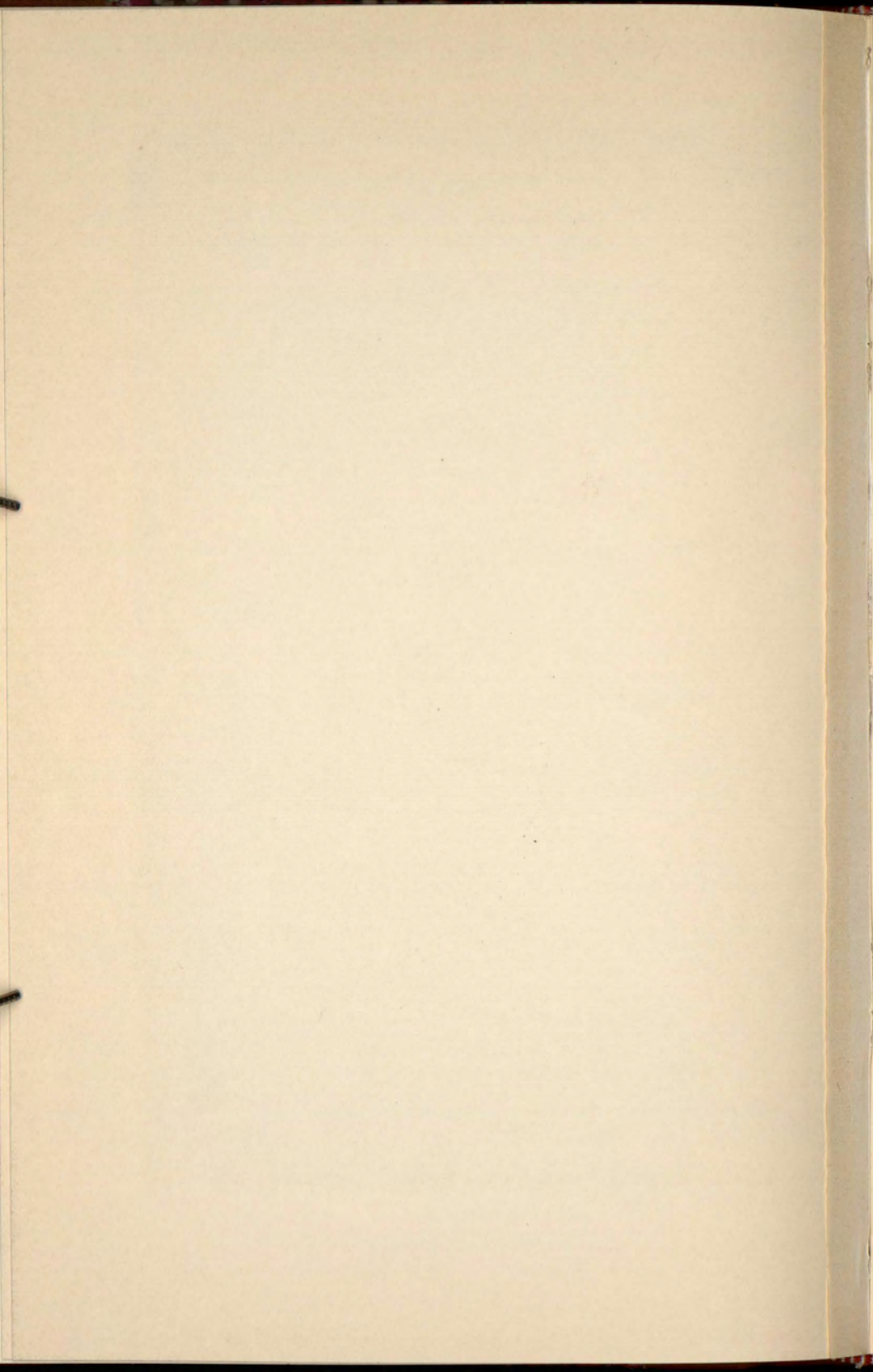


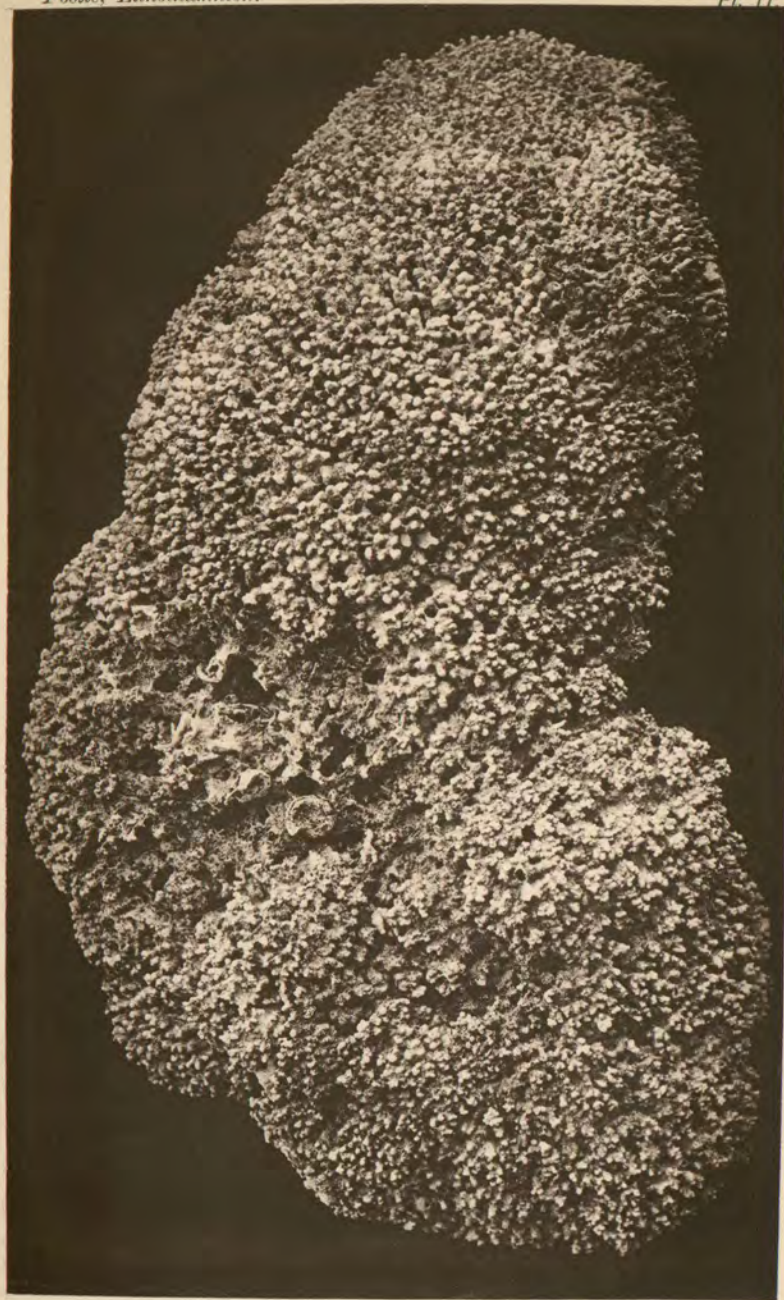
L. fornicatum f. robusta.



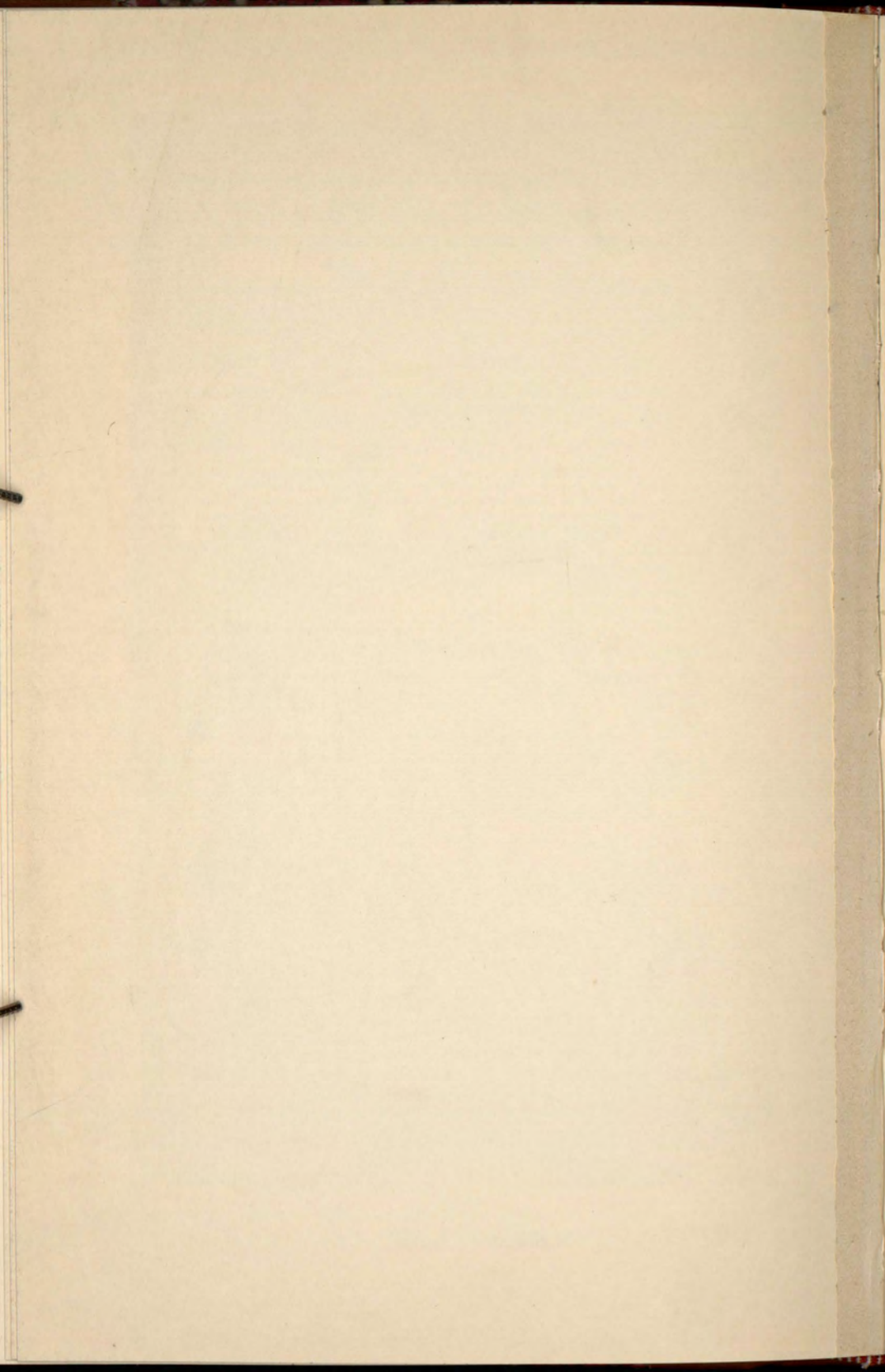


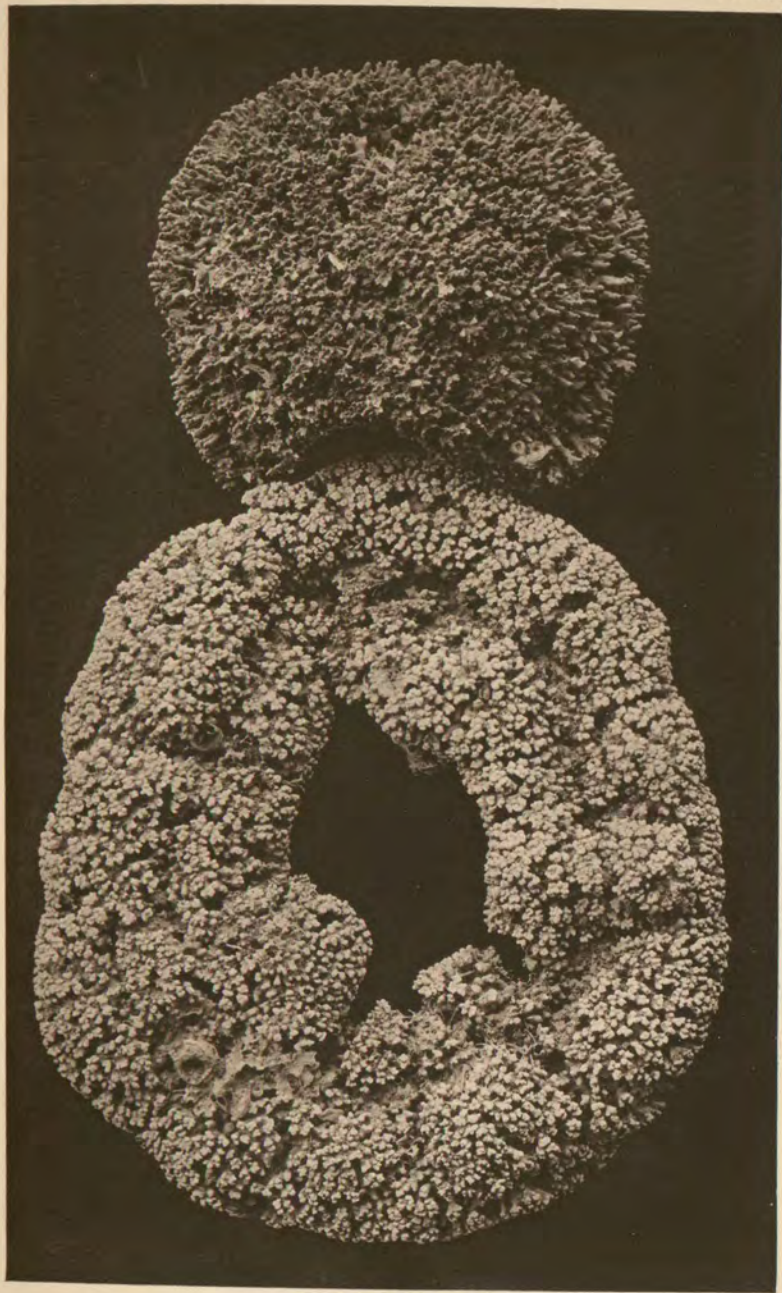
L. dimorphum.



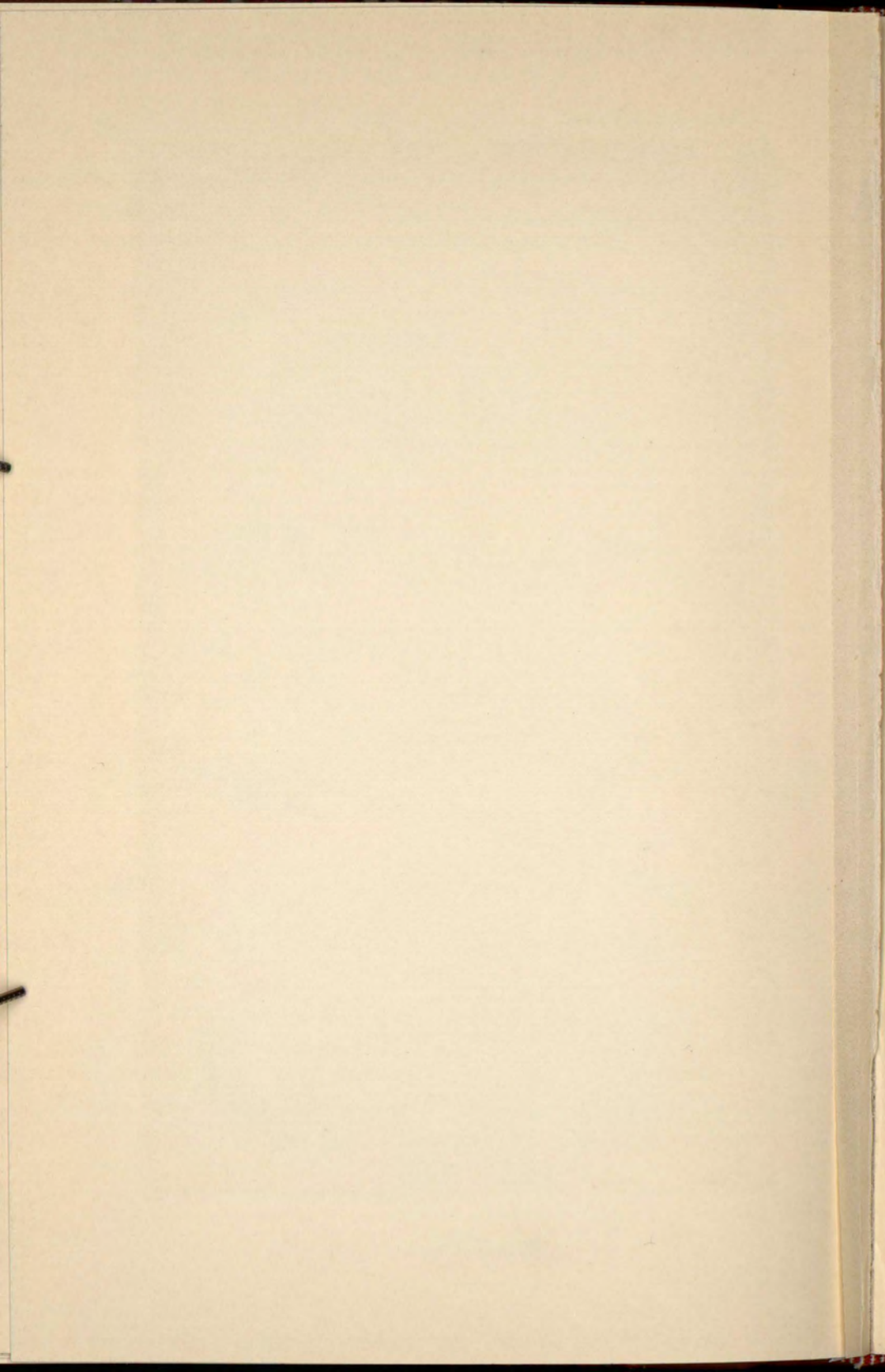


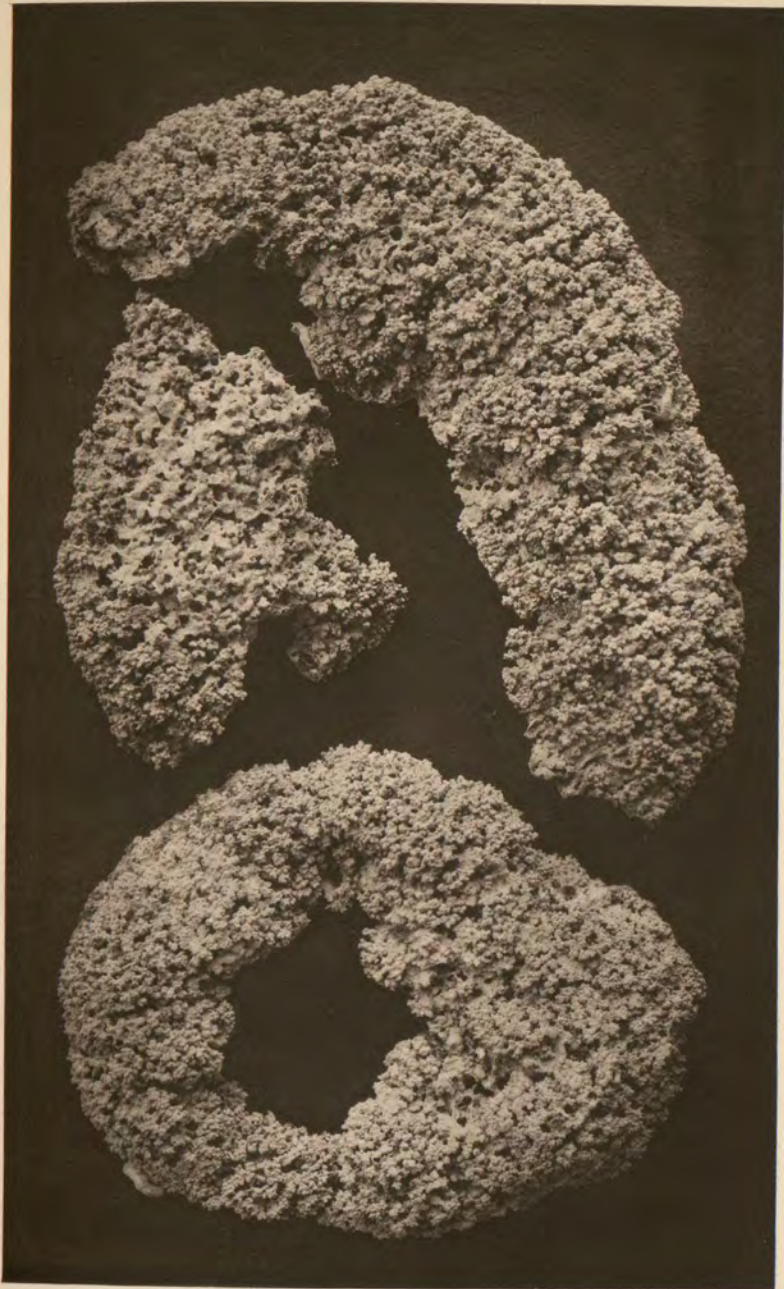
L. dehiscens f. *typica*.



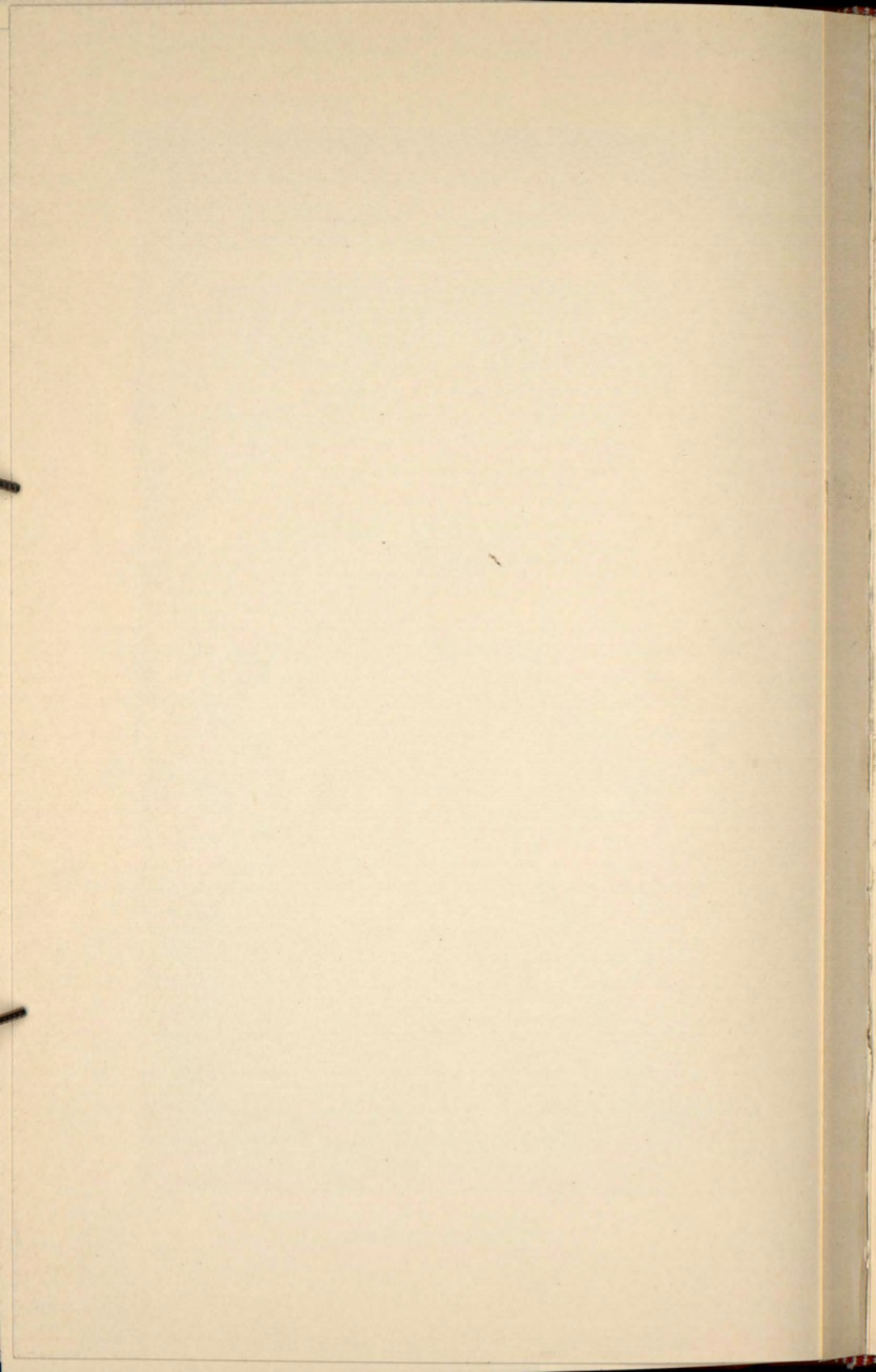


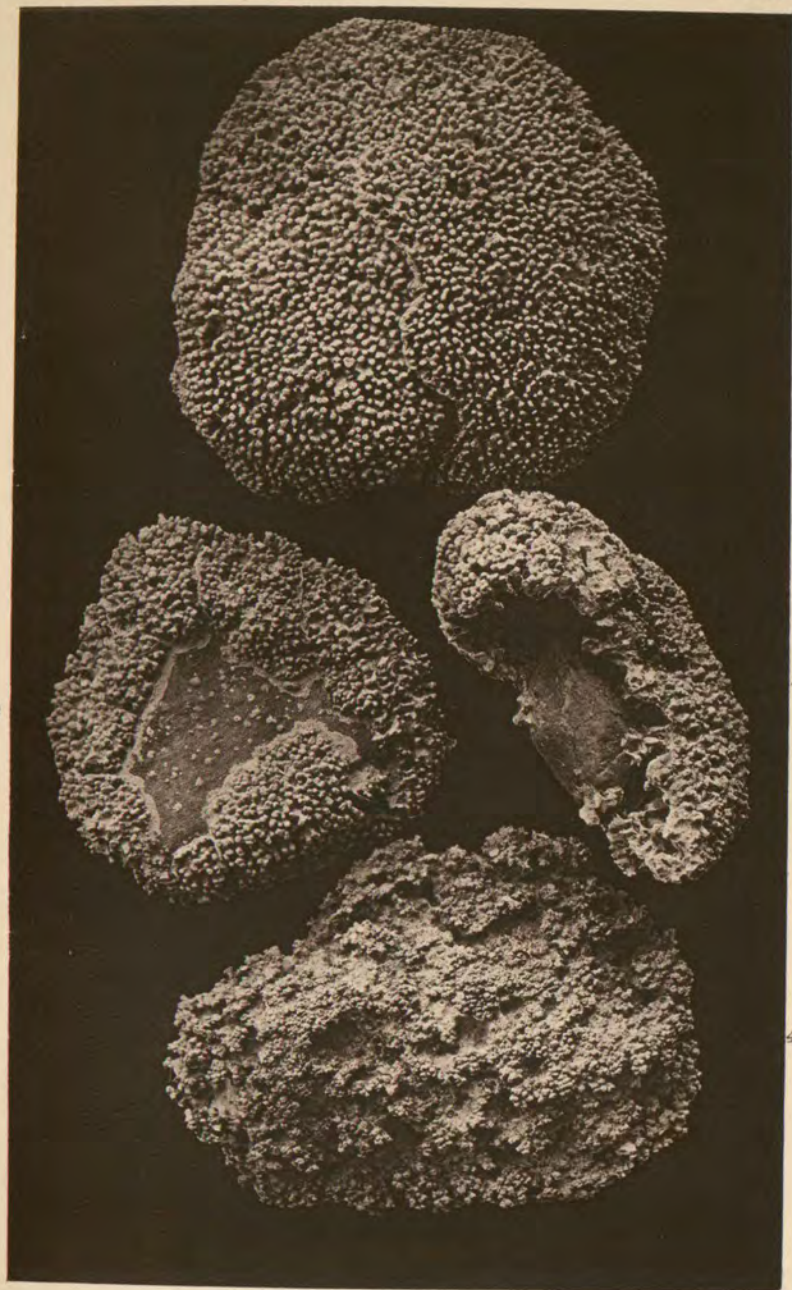
L. dehiscens f. typica.



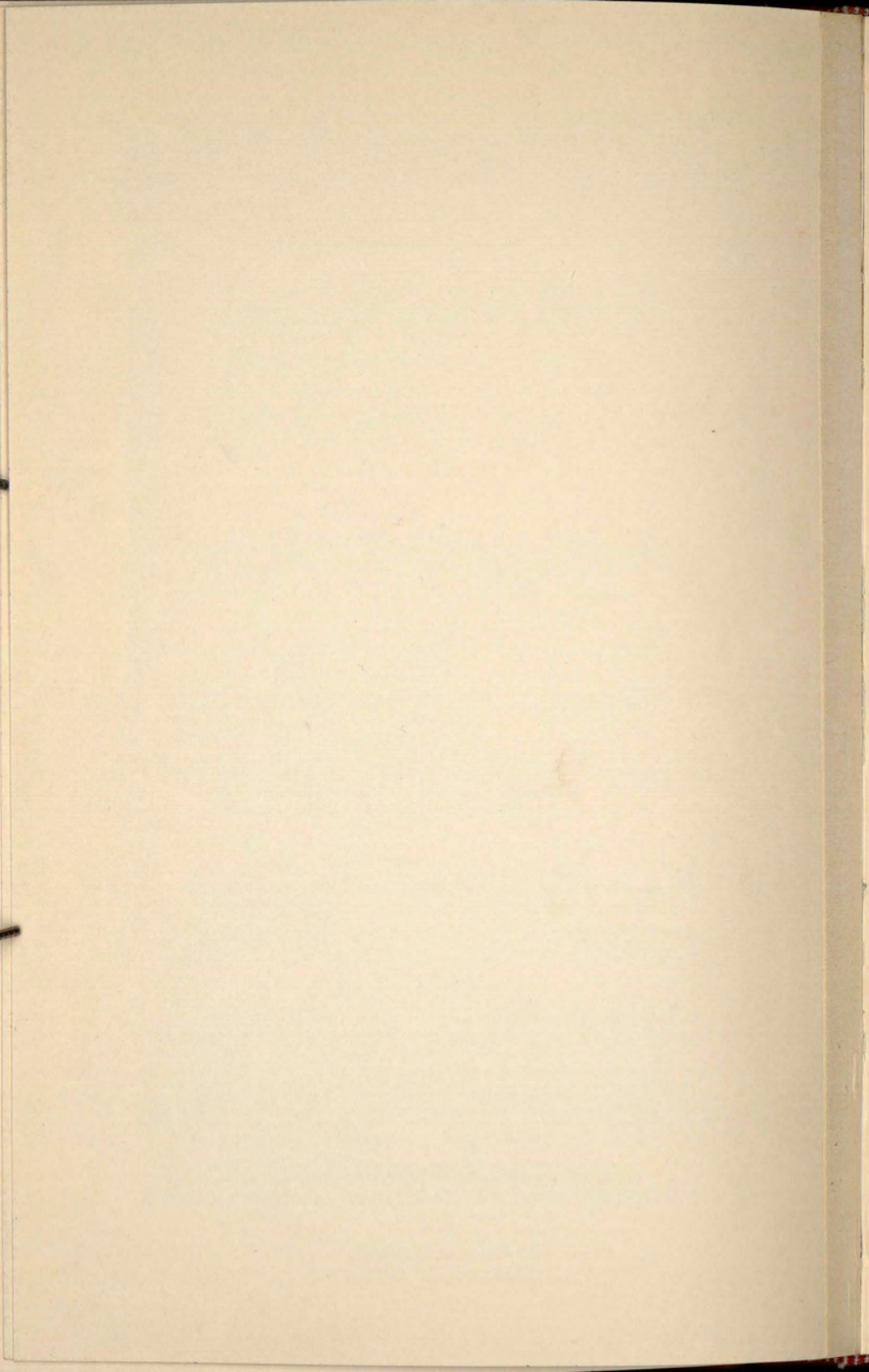


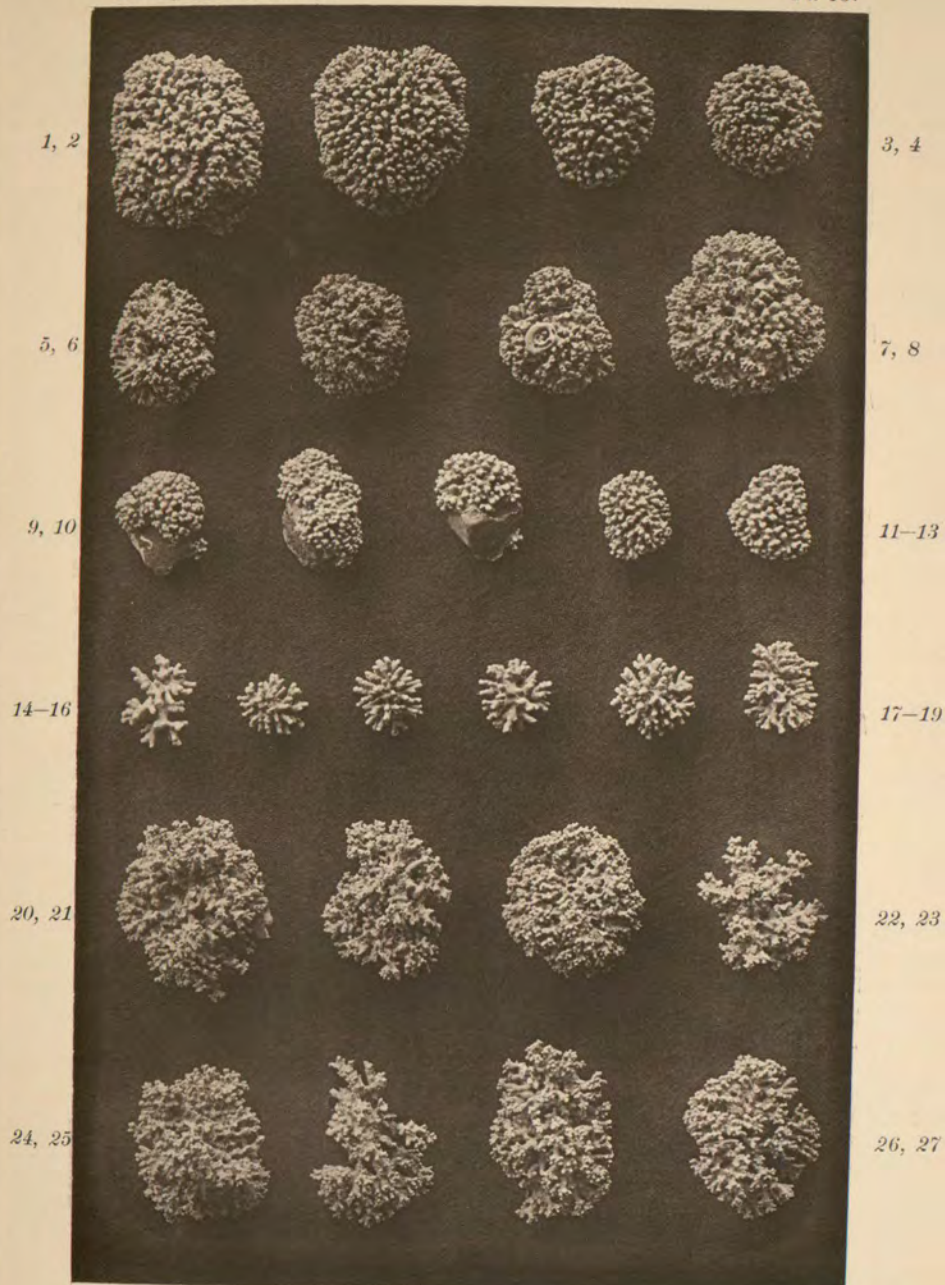
L. dehiscens f. *grandifrons*.



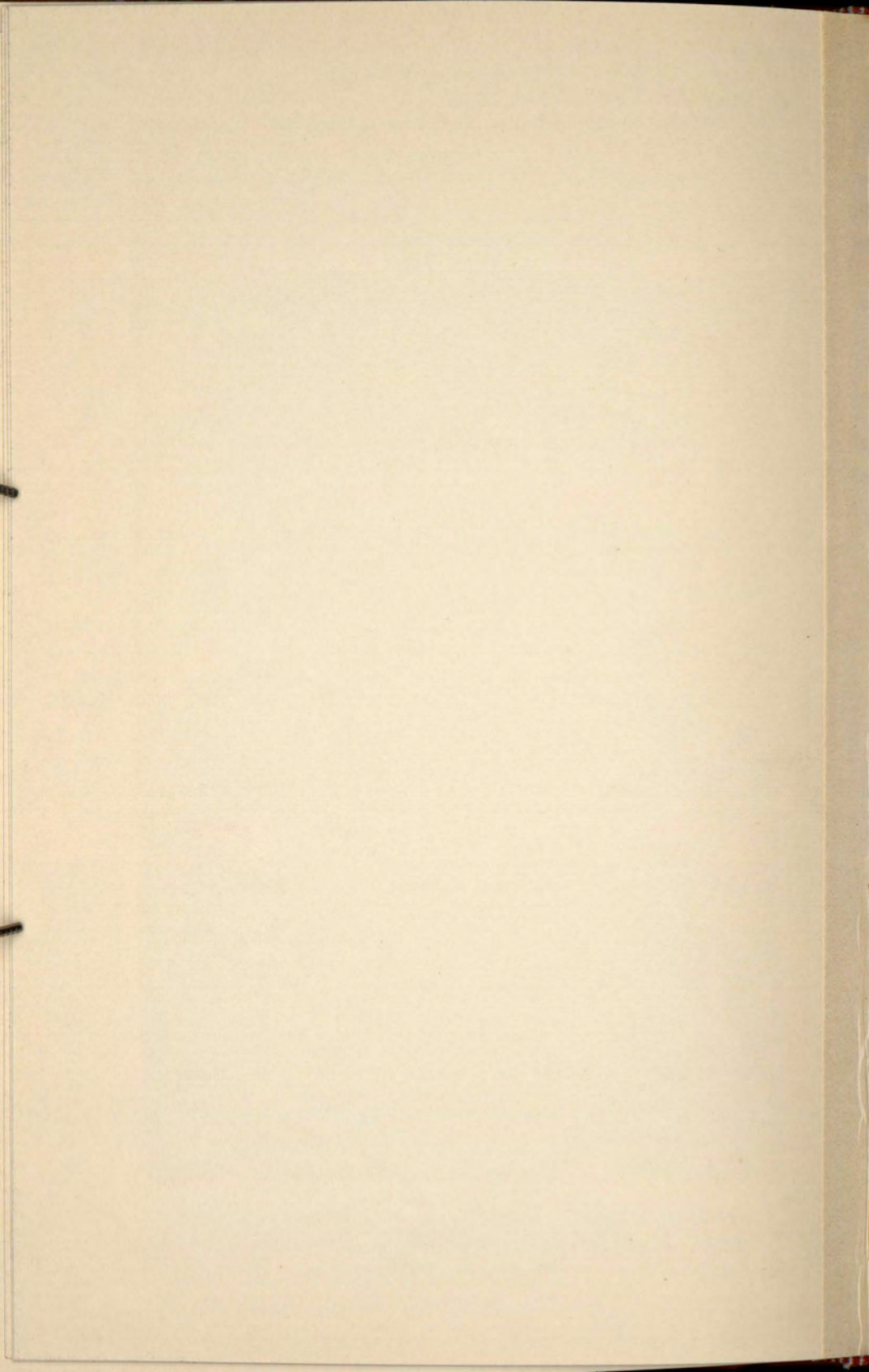


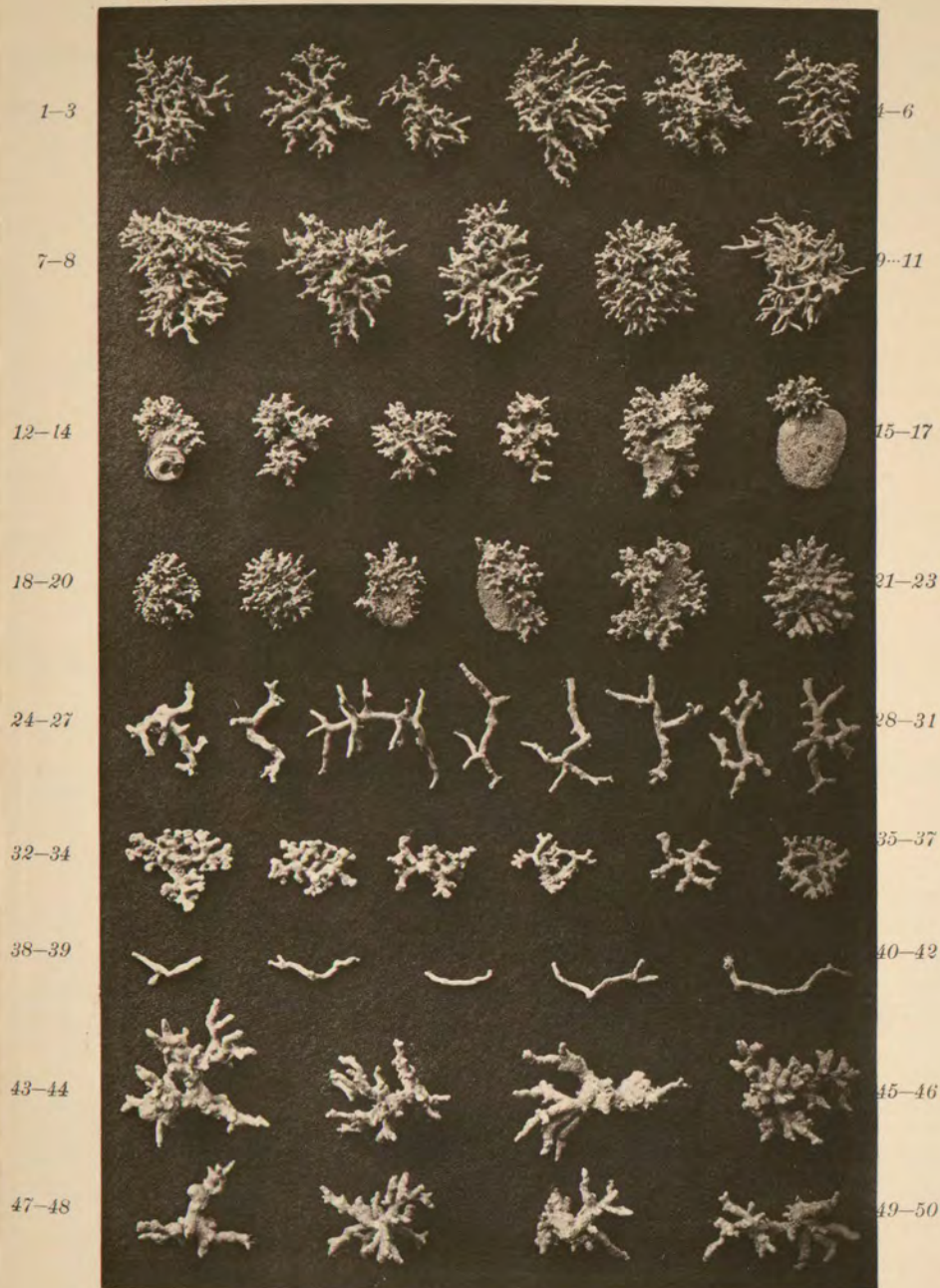
1-3. *L. delapsum* f. *abbreviata*.
4. *L. delapsum* f. *conglutinata*.



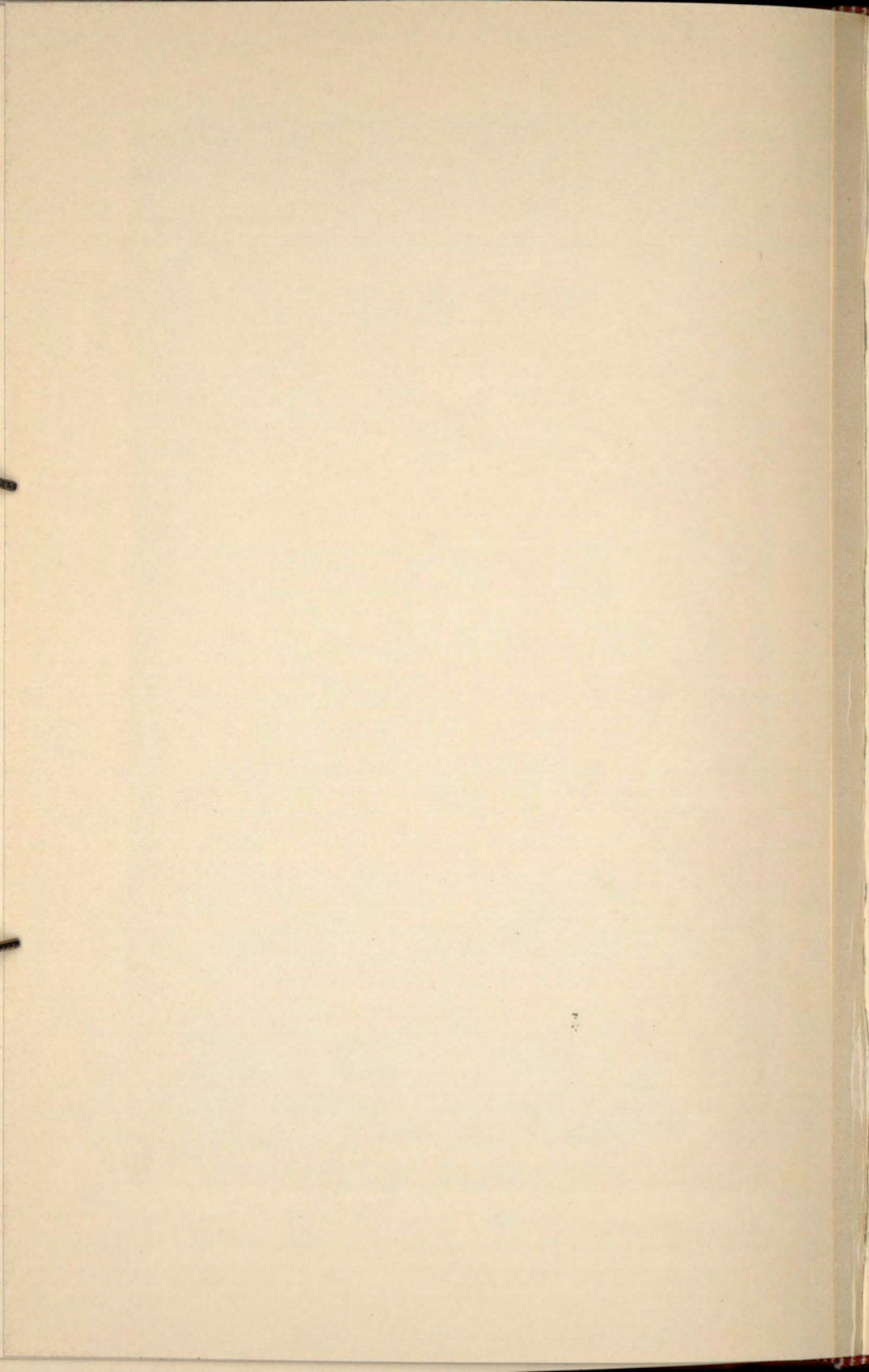


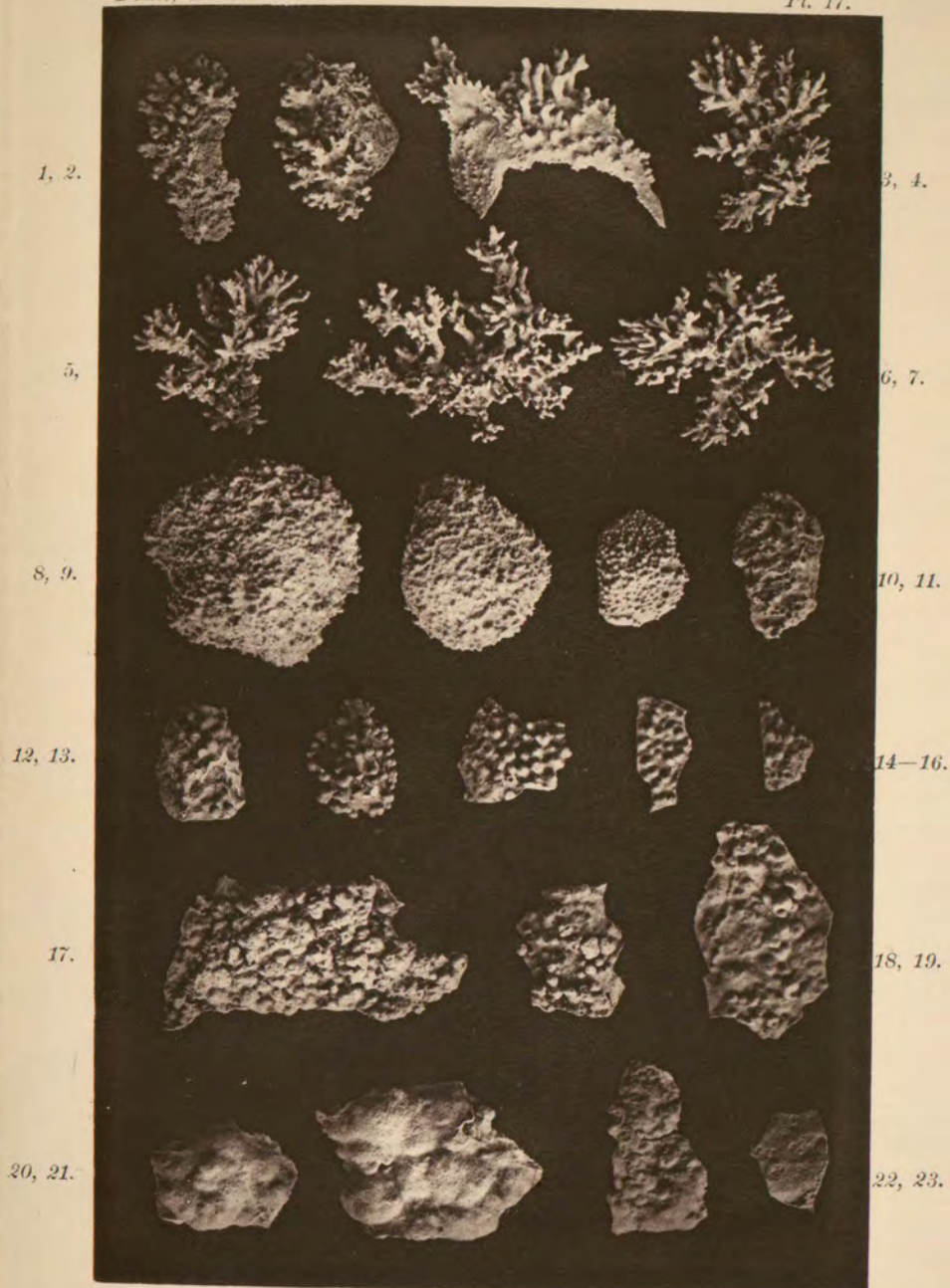
1-4. *L. apiculatum* f. *typica*. 5-8. *L. apiculatum* f. *parvicocca*.
 9-13. *L. apiculatum* f. *connata*. 14-19. *L. apiculatum* f. *patula*.
 20-27. *L. gracilescens*.



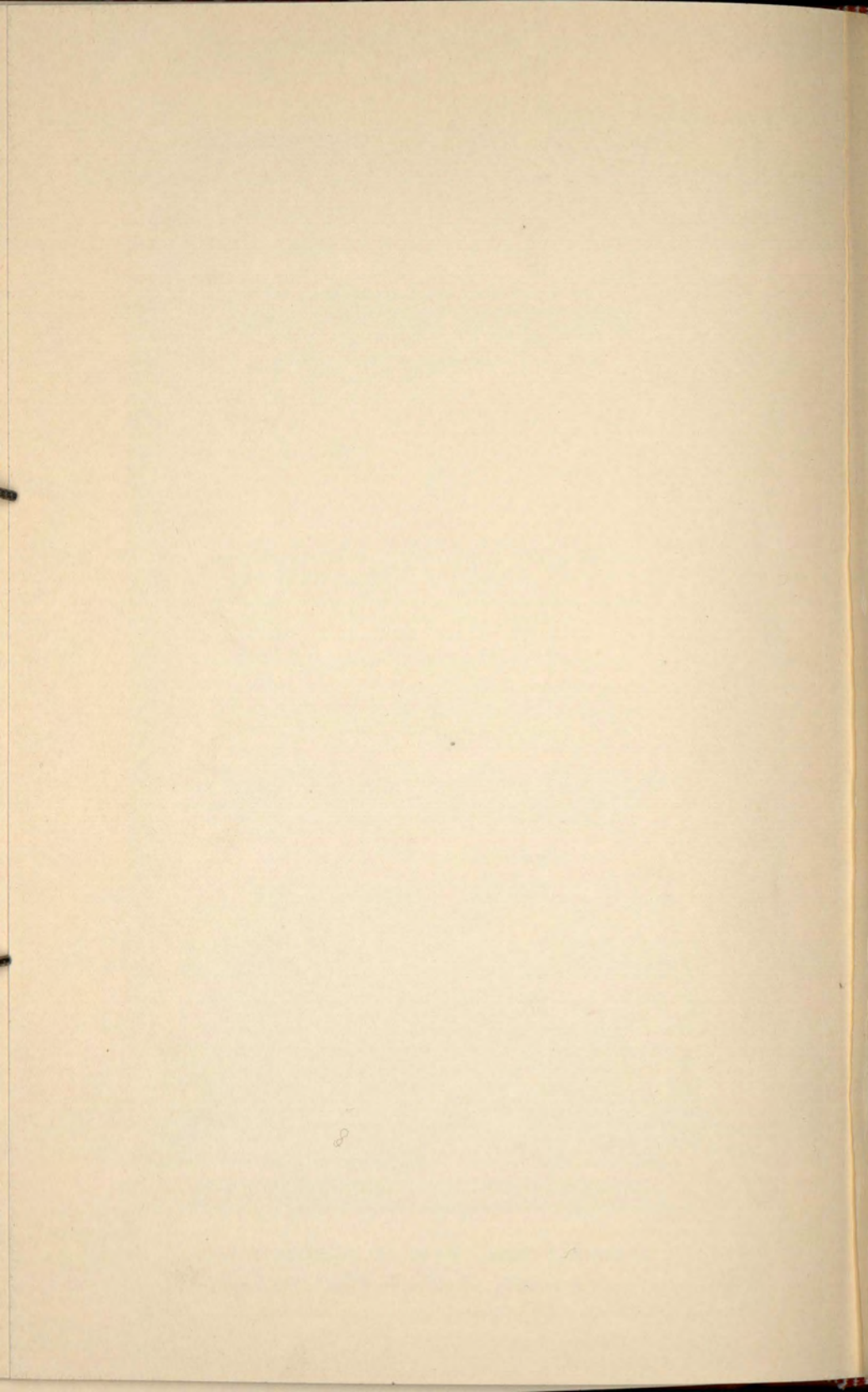


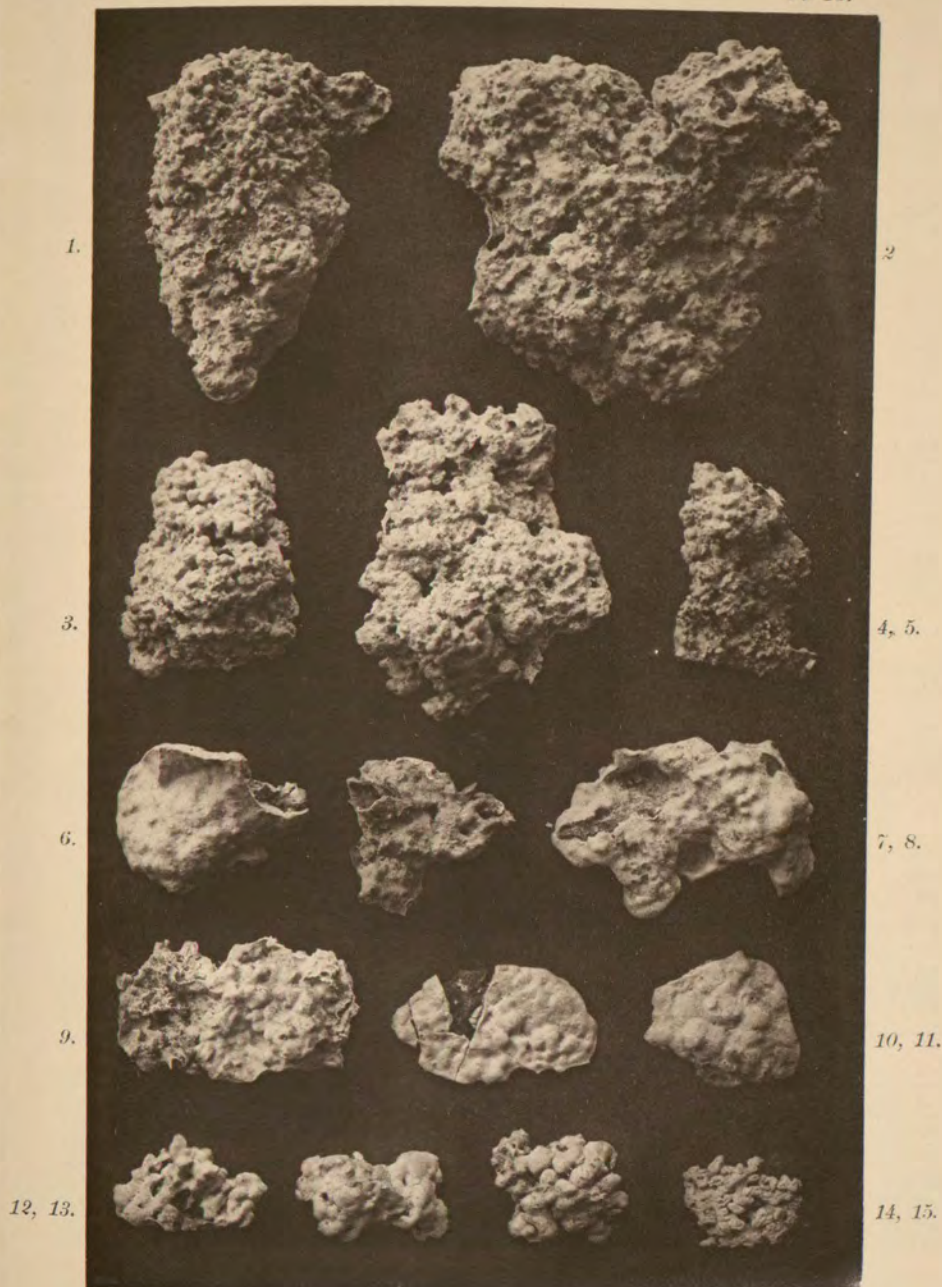
1-11. *L. coralloides* f. *norvegica*. 12-23. *L. coralloides* f. *saxatilis*.
 24-31. *L. coralloides* f. *australis*. 32-37. *L. coralloides* f. *flabelligera*.
 38-42. *L. coralloides* f. *subsimplex*. 43-50. *L. divergens*.



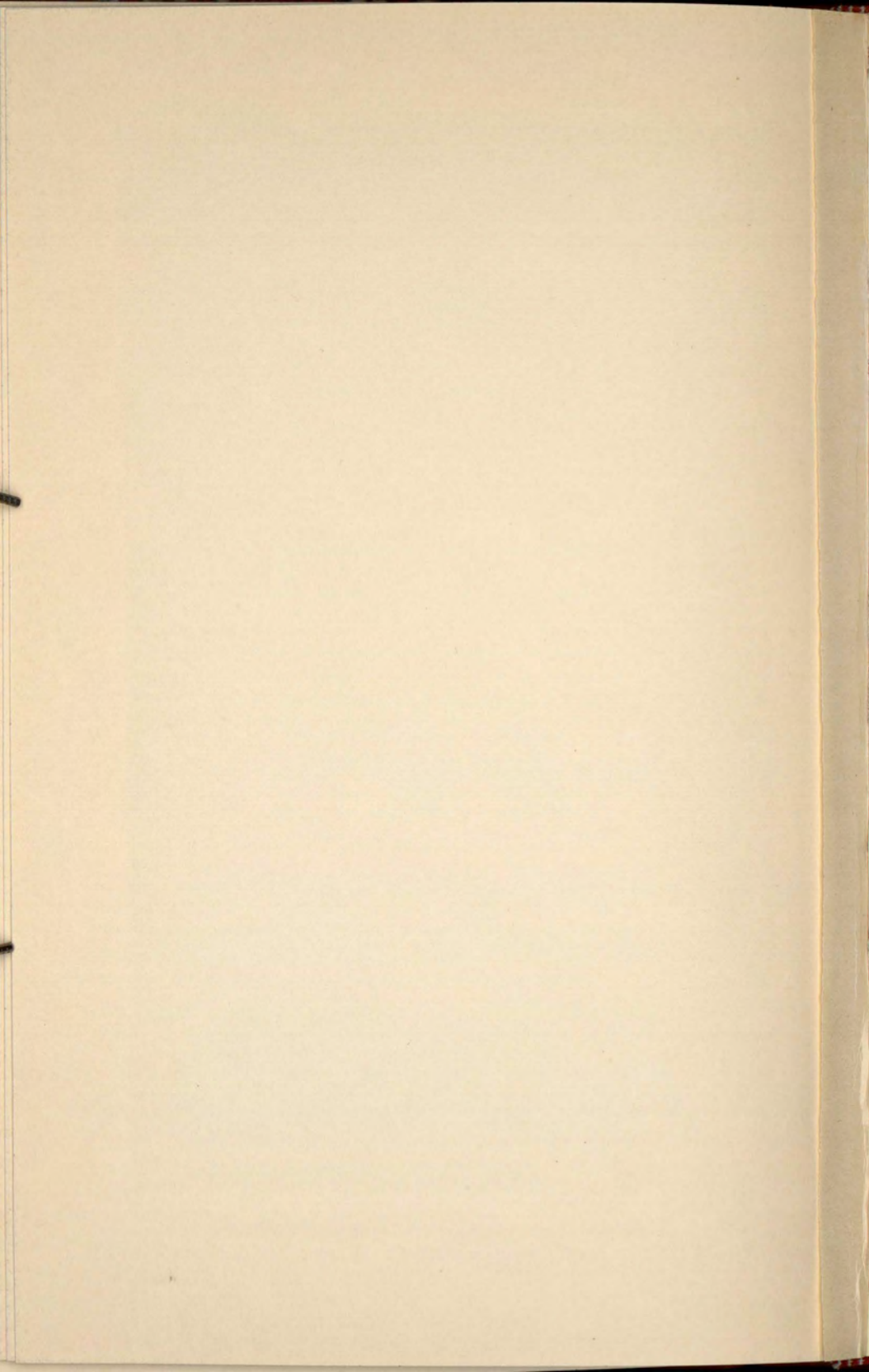


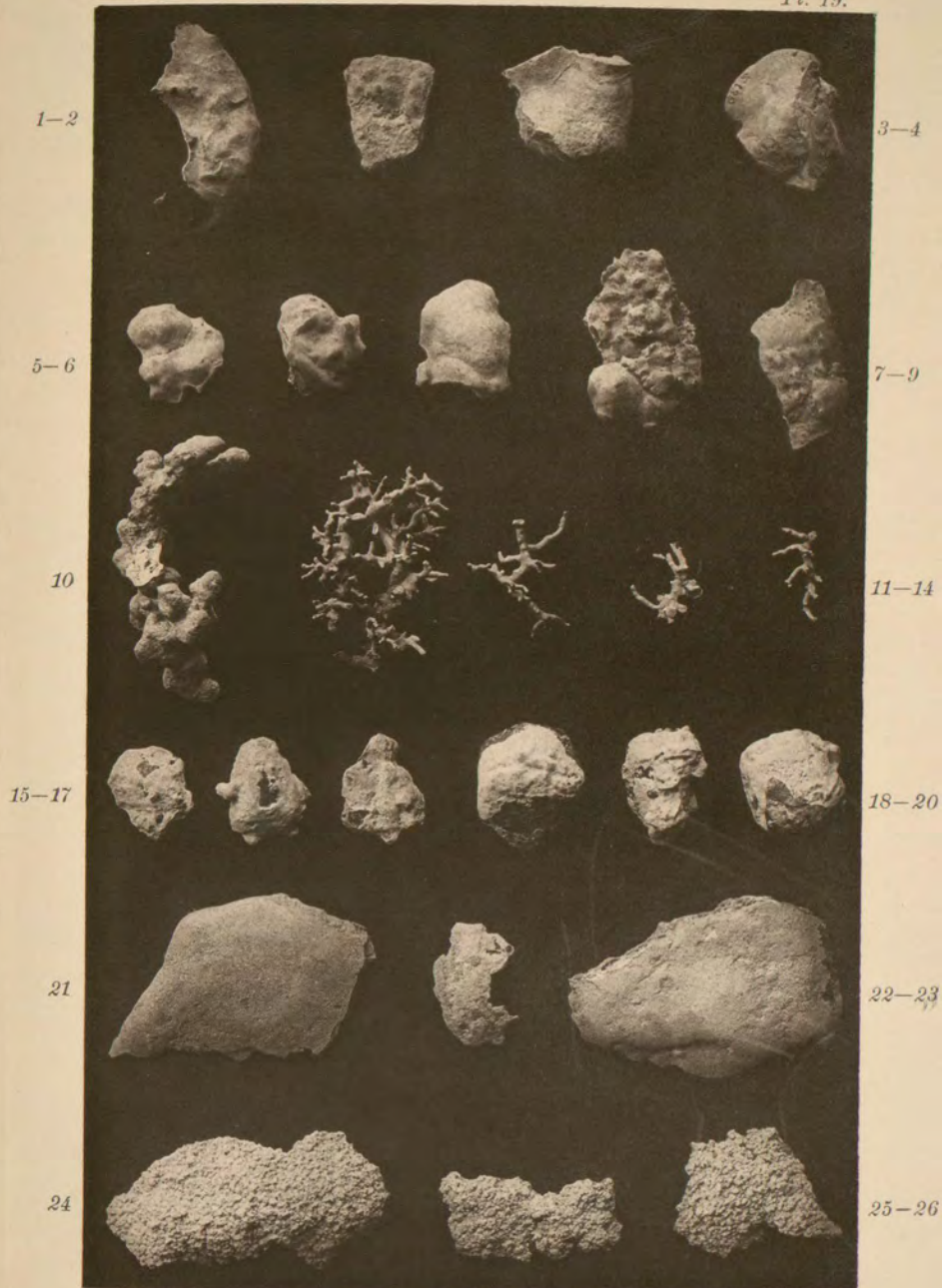
1-7. *L. stabelatum* f. *Granii*. 8-10. *L. colliculosum* f. *densa*.
 11. *L. colliculosum* f. *laxa*. 12-16. *L. colliculosum* f. *rosea*.
 17-19. *L. polymorphum* f. *tuberculata*, 20-21. *L. polymorphum* f. *valida*.
 22-23. *L. polymorphum* f. *papillata*.



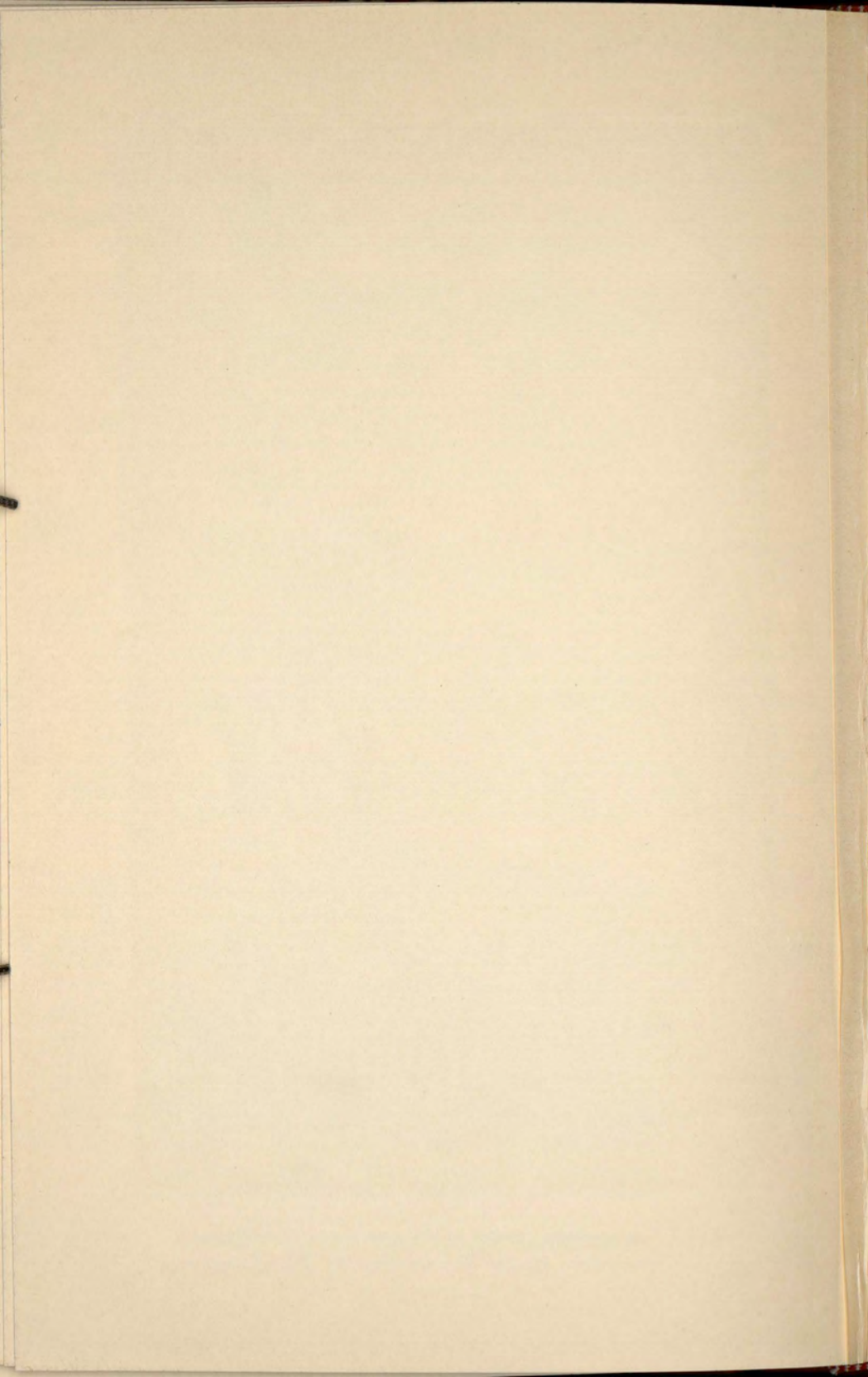


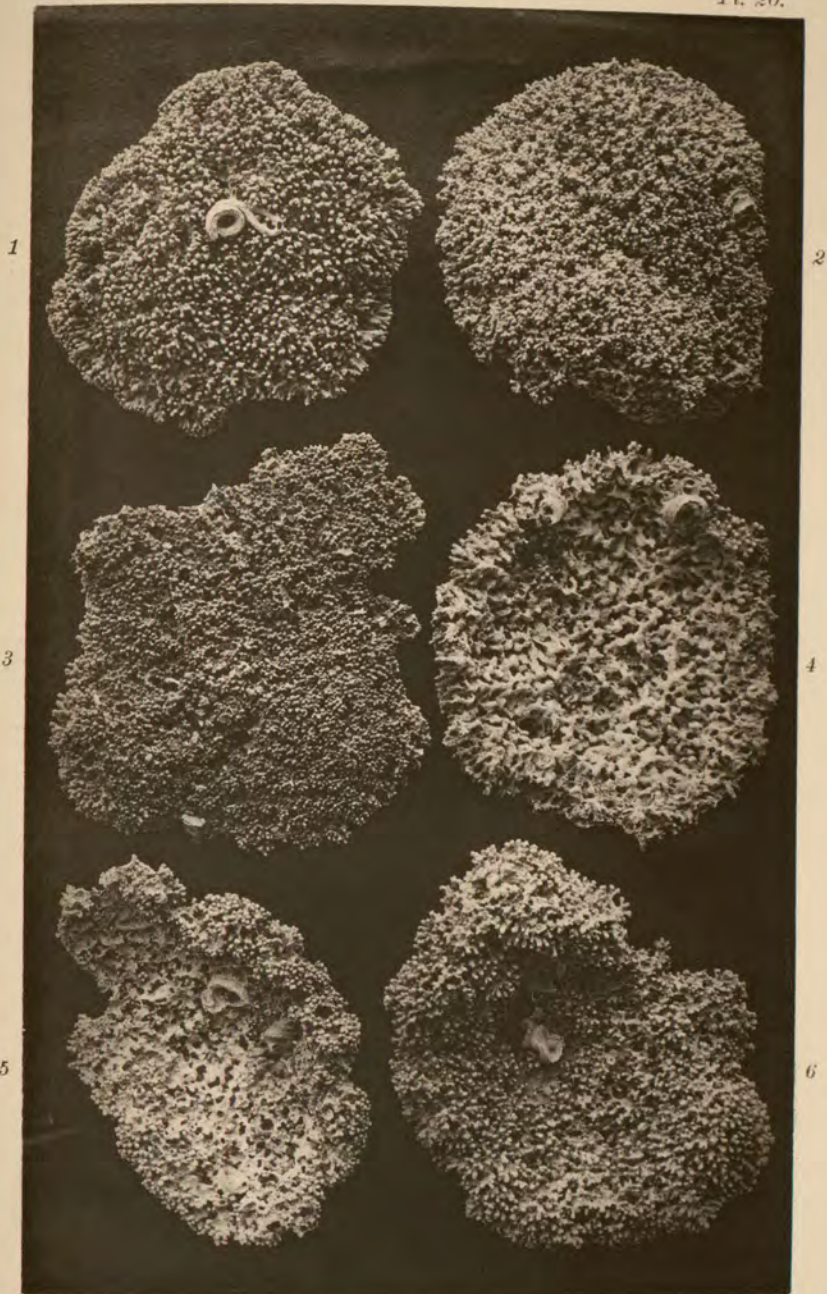
1-5. *L. varians* f. *verrucosa*. 6-9. *L. varians* f. *irregularis*.
10-11. *L. incrustans* f. *depressa*. 12-15. *L. incrustans* f. *Harceyi*.





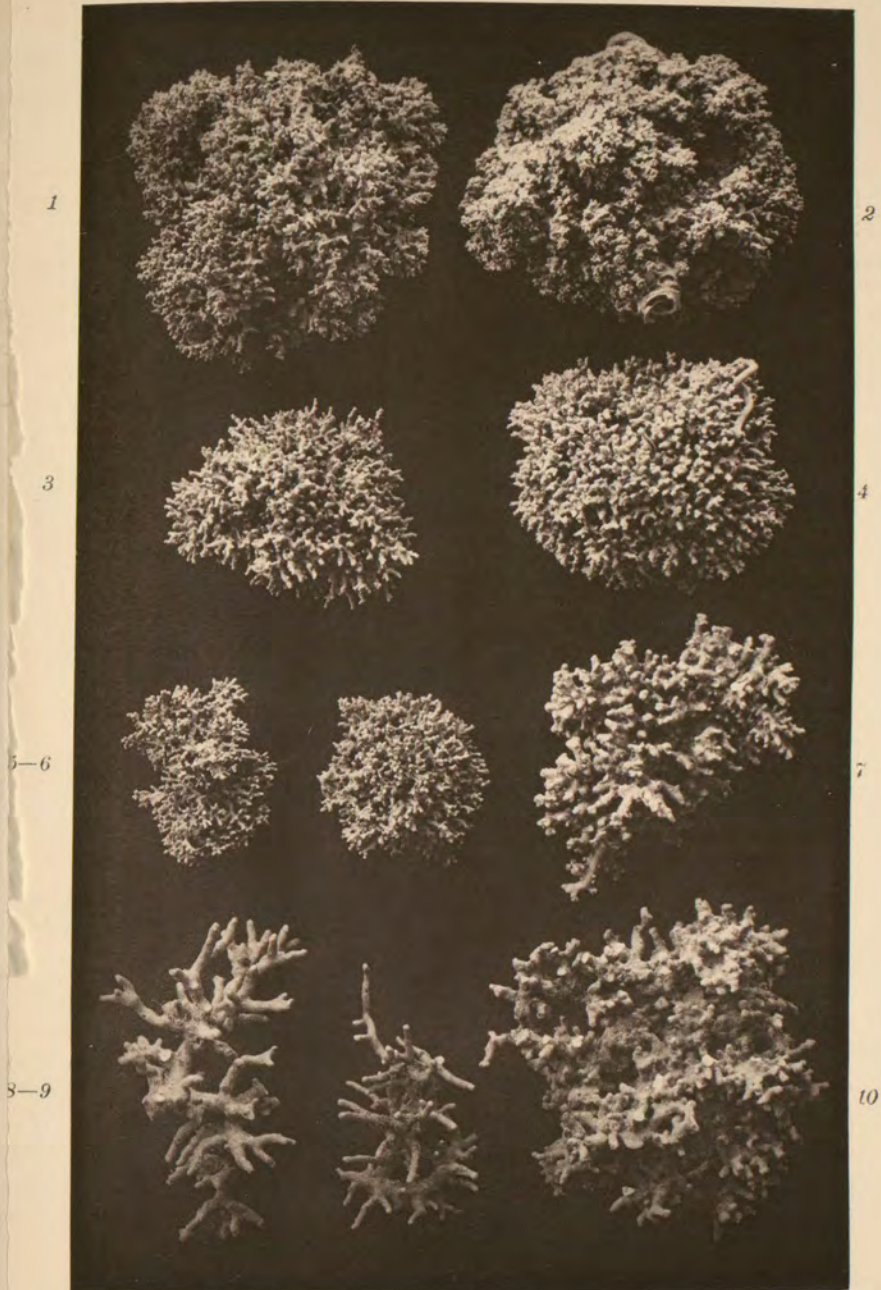
1-4. *L. compactum*. 5-9. *L. testaceum*. 10. *L. ocellatum*.
11-14. *L. uncinatum*. 15-20. *L. coalescens*. 21-23. *L. laevigatum*.
24-26. *L. squamulosum*.





L. congregatum.

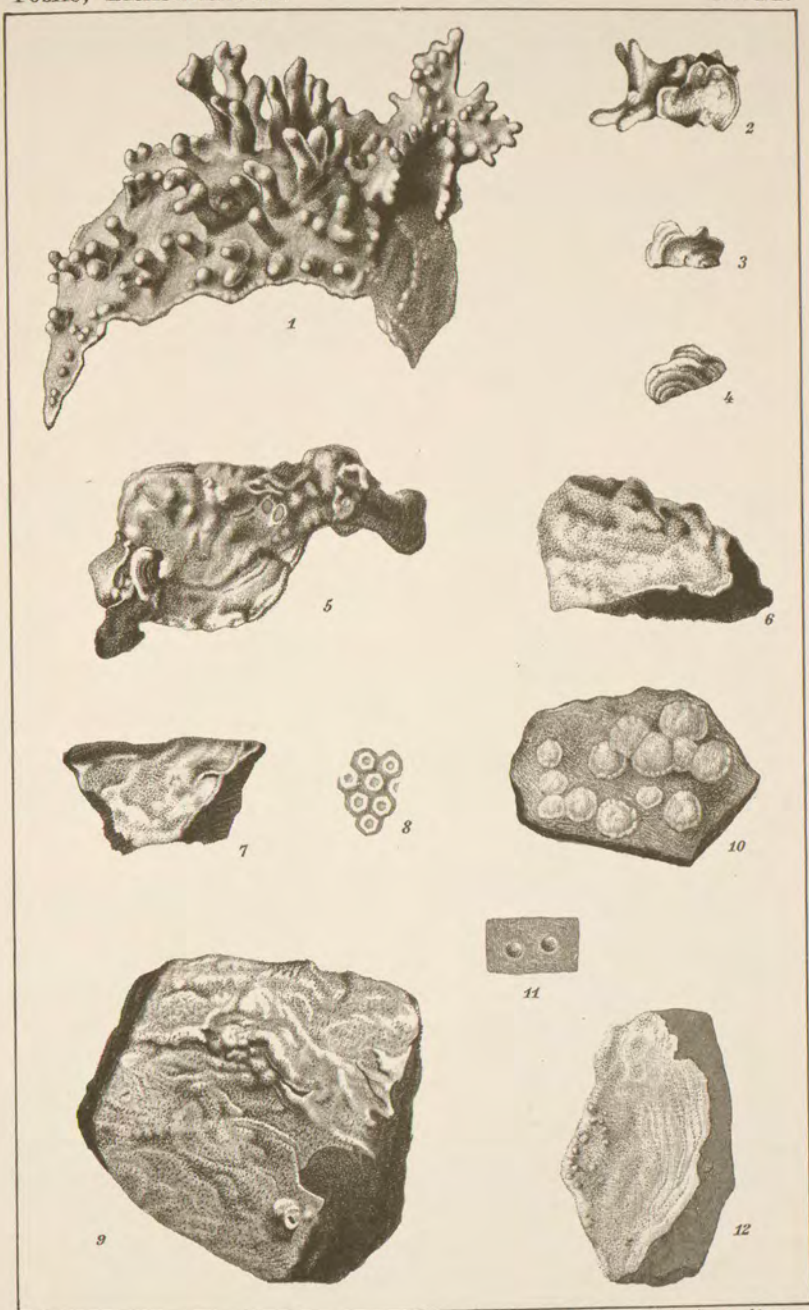




1-6. *L. nodulosum*. 7, 10. *L. tophiforme* f. *typica*.

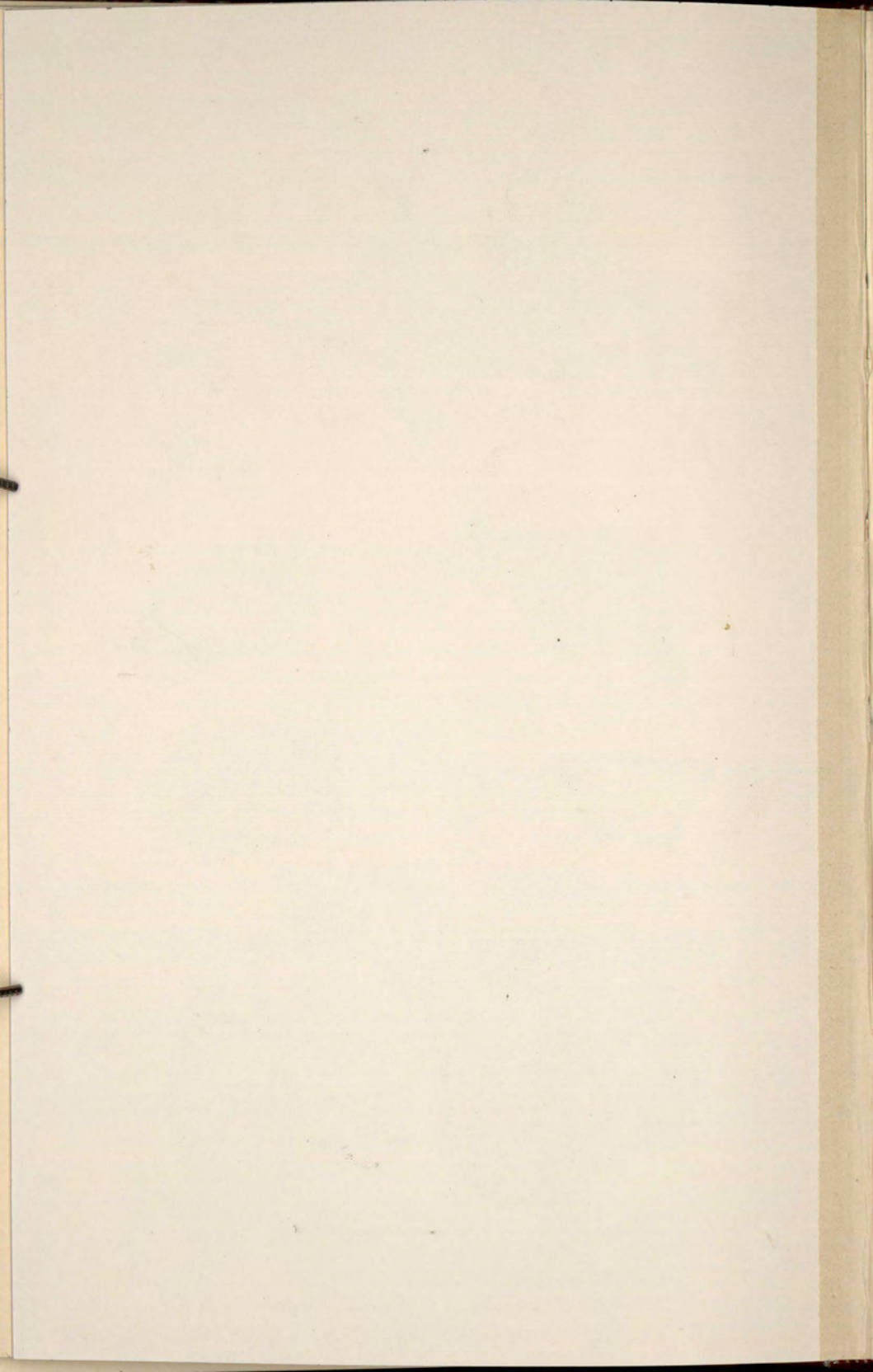
8-9. *L. tophiforme* f. *squarrosa*.

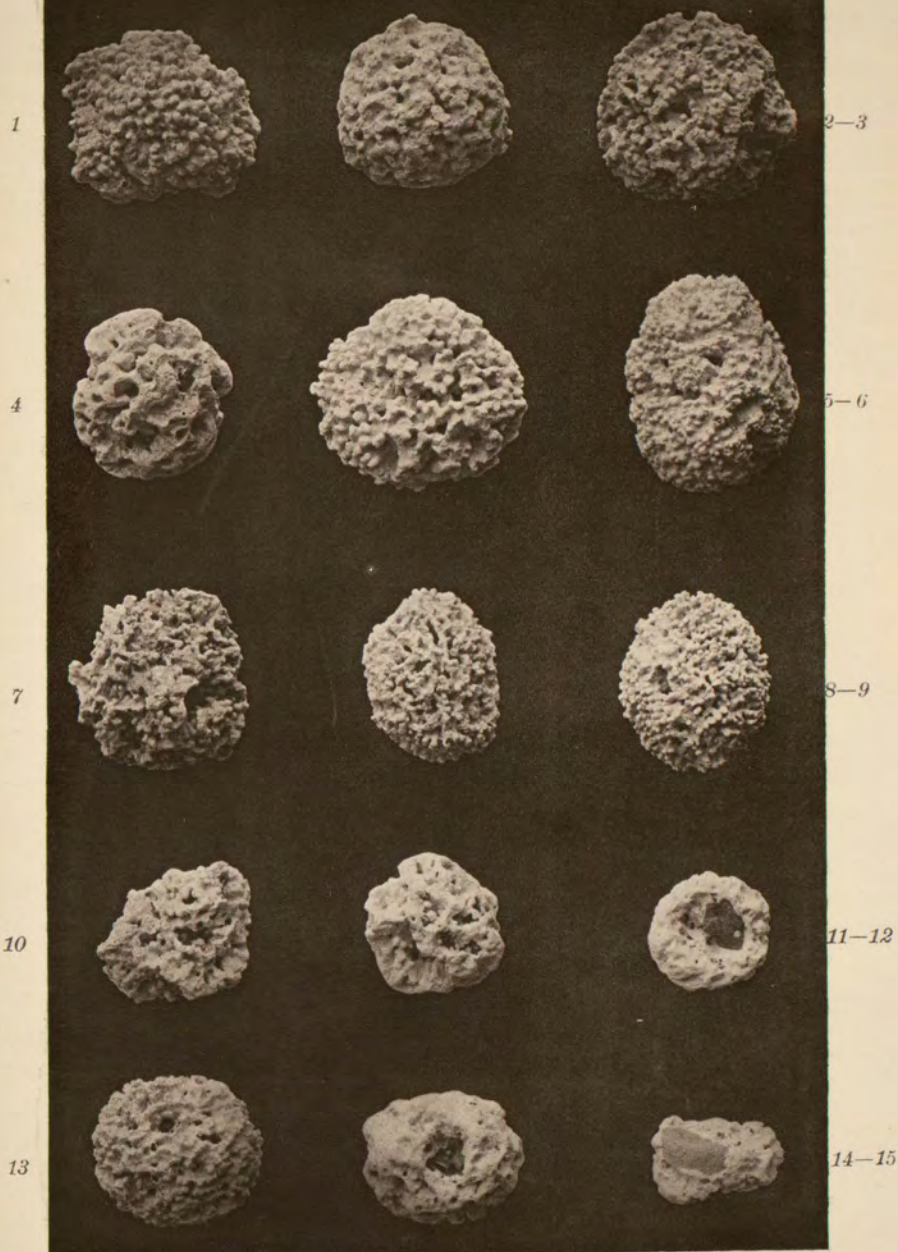




M. Lyng's lith. Anst. Chr.a.

1. *L. flabellatum* f. *Granii*. 2-5. *L. investiens*.
 6-8. *L. evanescens*. 9. *L. scabriusculum*.
 10-11. *L. orbiculatum*. 12. *L. Strömfeltii* f. *macrospora*.





Fossil Lithothamnion. (*L. fruticosum?*)

P:60:1
10:4