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XXVII.—*Studies on Fossil Sponges*.—II. *Lithistidæ*.

By KARL ALFRED ZITTEL.

[Continued from p. 135.]

Attempt at a Classification of the Lithistidæ.

As to the position of the *Lithistidæ* with respect to the other sponges, the opinions of zoologists are somewhat divergent.

O. Schmidt*, in his last great memoir, groups all sponges in four orders: the first contains the *Hexactinellidæ* with sex-radiate spicules; the second includes the sponges with anchor-shaped spicules, or with spicules of the pyramidal type; the third those with uniaxial siliceous spicules and all forms destitute of spicules; and the fourth the *Calcispongiæ*.

In the second order we find the family *Lithistidæ*, together with the *Geodinidæ*, the *Ancorinidæ*, and the fossil *Vermiculatæ*. That this last family (which, however, is only provisionally established) cannot be maintained, as it consists of the most discordant elements, I have already demonstrated elsewhere†. Consequently there remain for the second order only the former *Corticatæ* (*Geodinidæ* and *Ancorinidæ*) and the *Lithistidæ*.

We find the *Lithistidæ* in a similar position in the third edition of Claus's '*Handbuch der Zoologie*.' Claus places the *Calcispongiæ*, as an equivalent group, opposite to all the other marine sponges (*Fibrospongia*). The *Fibrospongia* are divided into twelve families, closed by the *Ancorinidæ*, *Geodinidæ*, *Lithistidæ*, and *Hexactinellidæ* in the sequence stated. Here, therefore, we also find the *Lithistidæ* in the immediate neighbourhood of the *Geodinidæ* and *Ancorinidæ* on the one hand, and of the *Hexactinellidæ* on the other.

A different and somewhat more complicated arrangement of the sponges has been proposed by H. Carter‡. Of Carter's eight orders, *Carnosa*, *Ceratina*, *Psammonemata*, *Rhaphidonemata*, *Echinonemata*, *Holorhaphidota*, *Hexactinellida*, and *Calcarea*, the first five and a great part of the sixth correspond to Oscar Schmidt's third group. Each of the first five orders is subdivided into from two to four families, and these again into a great number of groups.

The order *Holorhaphidota* is the most comprehensive of all, and is formed of constituents which ought hardly to be placed

* Grundzüge einer Spongienfauna des Atl. Geb. p. 83.

† Studien über fossile Spongien, i. p. 6; see Ann. & Mag. Nat. Hist. ser. 4, vol. xx. p. 260.

‡ Ann. & Mag. Nat. Hist. ser. 4, vol. xvi. (1875) pp. 1, 126, 177.

in very close connexion. Thus, among the five groups belonging to it we find, on the one hand, the Renierida, Suberitida, and Potamospongida (*Spongilla*), with uniaxial spicules; and on the other, the Pachytragida and Pachastrellida, with tri- or quadriradiate siliceous elements. Under the Pachastrellida the family Lithistina occurs as a section of the third rank.

I confine myself to the mention of these three most recent classifications of the sponges, as I have already endeavoured to show how little warrant there is for the older opinion of Bowerbank, Gray, and Wyville Thomson, that the Lithistidæ and Hexactinellidæ should be brought close together.

In one point Oscar Schmidt, Claus, and Carter agree: they all place the Lithistidæ close to the Geodinidæ and Ancorinidæ (Pachytragidæ, Carter). But whilst Claus assigns to them the rank of a distinct order, they appear only as a family of an order in Oscar Schmidt's arrangement, and by Carter they are even degraded into a subsection (family) of the Pachastrellidæ.

The agreement of the Lithistidæ with the above-mentioned sponges consists in that the anchor-shaped surface-spicules of many Lithistid genera are deceptively like certain skeleton-spicules of the Ancorinidæ and Geodinidæ. With this, however, we have exhausted all that can be said in favour of the affinity of these latter sponges to the Lithistidæ. But if we consider that in the Lithistidæ neither typical quadriradiates (as in *Stelletta*), nor octoradiates, nor siliceous stellules, or radiating siliceous spherules and siliceous disks are observed, it is clear that even in the free siliceous structures there is a considerable difference. This, however, becomes positively fundamental so soon as we take into consideration the true skeletal elements. No other order of sponges at present known possesses similar composite and multifariously branched siliceous corpuscles. Although a quadriradiate axial cross lies at the foundation of the Tetractadina, there nevertheless exists a profound difference between the quadriradiate stars of the Pachytragidæ, in which the individual arms are straight and pointed, and the Lithistid corpuscles, which are more or less ramified at the ends. Moreover, as regards the peculiar union of the latter to form a generally intimately interlocking tissue, and the stony constitution of the whole sponge-body, we may perhaps find a certain analogy with this in the Hexactinellidæ, but certainly not in the other siliceous sponges. Finally, if we take into account the complicated canal-system and the external appearance of the Lithistidæ, it is again only the Hexactinellidæ among the siliceous sponges, and an ex-

inct group of Calcispongiæ which has still to be accurately characterized, that can be compared with them.

In conclusion, the geological distribution of the Lithistidæ and the extraordinary constancy with which they have inherited their skeletal characters from the earliest periods of the earth's history, testifies to the high antiquity of the group, and against their origin from, or even near relationship to, the Pachytragidæ, which I would regard rather as an aberrant ateral branch of the Lithistidæ, if, indeed, any genetic connexion is to be assumed between them.

All these circumstances induce me to regard the Lithistidæ as a distinct order equivalent to the Hexactinellidæ, and taking its place in the system between the Pachytragidæ, Geodinidæ, and Ancorinidæ on the one hand, and the Hexactinellidæ on the other.

A detailed classification of Lithistidæ has not hitherto been attempted, as the few living genera did not show the necessity for any further subdivision, and with regard to the fossil forms as good as nothing has been known. Carter, in his classification which has already been repeatedly mentioned, certainly gives valuable hints towards a grouping of the living Lithistidæ, and also indicates that the genus *Corallistes* of Schmidt is composed of heterogeneous elements; but a systematic arrangement, or even a clearer characterization of the individual genera, was evidently not in the intention of the distinguished English spongologist.

If we bring together the living and the far more numerous fossil forms, we soon see the undeniable necessity of a systematic arrangement of the very considerable material. As in the case of the Hexactinellidæ, so here, I take into consideration, for the characterization of the larger groups, in the first place the characters of the true skeletal corpuscles, in the second the surface-spicules, and in the third the external form. In accordance with these principles the Lithistidæ may be divided into four families (Rhizomorina, Megamorina, Anomocladina, and Tetracladina), and these again in part into several sections.

Revision and Key to the Determination of the Fossil and Living Genera of Lithistidæ.

Class SPONGIÆ.

Order LITHISTIDÆ, O. Schmidt, 1870.

Massive, stony, thick-walled, generally attached siliceous sponges of very various external form. Monozoic or polyzoic.

With central stomachal cavity or scattered oscula. Stomachal cavity sometimes replaced by vertical tubes. Sponge-body composed of more or less distinctly quadriaxial or irregularly ramified skeletal elements, furnished at the ends of the branches or throughout their whole length with nodular or root-like processes, intimately interlocked, but not soldered together; and sometimes of these and of surface-spicules of quadriaxial or uniaxial type. The surface-spicules either forked anchors with a long shaft directed inwards, or short-stemmed anchors with curved and sometimes nodular or branched flukes, or, lastly, uniaxial spicules of variable form and size. Besides these, in the sarcode, minute flesh-spicules of uniaxial type.

Family 1. *Rhizomorina*.

Skeletal corpuscles irregularly branched, beset with shorter or longer, simple or composite root-like processes or nodular excrescences, with a simple or branched central canal. Skeletal elements grouped together into confused fibres, or loosely interlocked with each other. Surface-structures frequently like those of the rest of the skeleton, but uniaxial spicules and forked anchors are also present.

A. Skeletal corpuscles moderately ramified, with a short, simple canal in the main stem; loosely interlocked with each other (see Pl. VIII. fig. 6).

a. Sponge-body thick-walled, top-shaped, nodular, or basin-shaped, with vertical radial fissures, which are frequently furcate towards the outside, and into which run fine radial canals standing serially one above the other.

Cnemidiastrum, Zitt. (Jura). Top-shaped, nodular or basin-shaped, with small round canal-ostia on the radial fissures.

Corallidium, Zitt. (Jura). Top-shaped; surface coated with epidermis up to the upper margin.

b. Sponge-body basin-shaped, top-shaped, or laminiform. Radial canal-system very fine, indistinctly developed; in the centre sometimes vertical canals.

Hyalotragos, Zitt. (Jura). Basin-shaped or top-shaped; oscula on the inner surface; vertical canals present.

Pyrgochonia, Zitt. (Jura). Basin-shaped; elevated oscula on both sides; vertical canals in the centre.

Discostroma, Zitt. (Jura). Disciform; upper surface convex, frizzled, with a central cavity; lower surface with smooth epidermis.

Epistomella, Zitt. (Jura). Laminiform; upper surface with elevated oscula; lower surface porous.

Leiodorella, Zitt. (Jura). Laminiform, cylindrical, nodular; both surfaces with margined oscula; between them smooth epidermis.

Platyechonia, Zitt. (Jura). Laminiform; both surfaces with fine pores.

B. Skeletal corpuscles strongly branched, with a rather wide ramified canal, often interlocked to form fibre-like trains.

a. Sponge-body nodular or branched, without a distinct canal-system. Surface with scattered oscula, which are sometimes pit-like, sometimes radiate, or sometimes only with fine pores.

Bolidium, Zitt. (Cretaceous). Nodular or branched, without oscula.

Astroboia, Zitt. (Cretaceous). Nodular, with scattered, radiate or large pit-like oscula.

b. Sponge-body basin-shaped, cup-shaped, ear-shaped, or laminiform. Wall with oscula or pores on one or both surfaces; from these simple or slightly ramified and generally curved canals penetrate perpendicularly into the wall, but do not traverse it. Surface-spicules, when present, like the skeletal elements, or forked anchors, sometimes also anchors with recurved prongs. Uniaxial spicules are also generally present in abundance.

Chonella, Zitt. (Cretaceous). Cup- or basin-shaped; both surfaces furnished with pores.

Seliscotho, Zitt. (Cretaceous). Basin-, cup-, or plate-shaped; wall consisting of vertical laminæ; on the radial canals of the inner surface there are small oscula.

Chenendopora, Lamx. (Cretaceous). Cup-shaped, stalked, with a branched root; inner surface with scattered impressed oscula; stem with vertical tubes; skeletal corpuscles rather large, knobby.

Arabescula, Cart. (Recent). Thin, incrusting; surface with pores and fine furrows.

Corallistes, Schm. (Recent). Cup- or basin-shaped, or curved discoid; oscula on the inner surface; surface covered with a coat of forked anchors.

Heterophymia, Pom. (Recent). Fan-shaped, undulately folded; upper surface with oscula; under surface porous. Surface-spicules of the under surface curved anchors with short incrassate prongs; of the upper surface smooth, irregularly branched corpuscles of small size.

Macandrewia, Gray (Recent). Vase-shaped or clavate. Inner surface with warty oscula. Surface-spicules consisting of a short shaft and three branched, finely divided, and curved arms. Flesh-spicules uniaxial, pointed at both ends.

Azorica, Cart. (Recent). Vase-shaped, stalked. Warty oscula on the inner surface. Skeletal corpuscles small. Main branches smooth, strongly branched at the ends. Surface-structures resembling the skeletal elements.

Leiodermatium, Schm. (Recent). Like *Azorica*, but the prominent oscula on the outside.

Verruculina, Zitt. (Cretaceous). Basin-, cup-, or ear-shaped or laminiform. Inner (upper) surface with prominent warty oscula. Surface-elements like those of the skeleton.

Amphithelion, Zitt. (Jura, Cretaceous). Like *Verruculina*, but with warty oscula on both surfaces.

c. Sponge-body massive, cylindrical; vertex convex, truncate, or depressed. In the interior vertical tubes, either scattered or grouped in bundles. Radial canals simple, radiating from the centre towards the periphery.

Stichophyma, Pom. (Cretaceous). Vertex convex, with scattered warty oscula, connected with vertical tubes.

Jereica, Zitt. (Cretaceous). Vertex truncate or depressed, with a bundle of vertical tubes in the middle.

Pomeia, Zitt. (Miocene, Recent). Clavate; vertex convex, with numerous fine vertical tubes opening into a small depression; at the sides also isolated pits furnished with tubes. Surface finely porous.

d. Sponge-body cylindrical, trochiform, or globular, thick-walled, with a simple central cavity. Oblique, capillary, perforating, and sometimes also coarser radial canals opening into the stomachal cavity.

Cœlocorypha, Zitt. (Cretaceous). Globular or trochiform. Stomachal cavity shallow; only fine radial canals.

Scytalia, Zitt. (Cretaceous). Cylindrical. Stomachal cavity reaching to the base; besides the fine radial canals there are coarser ones opening into the stomachal cavity.

Pachinion, Zitt. (Cretaceous). Cylindrical. Stomachal cavity wide, deep; skeletal elements knobby, very large; surface-corpuscles small, fine, branched.

Stachyspongia, Zitt. (Cretaceous). Cylindrical. Stomachal cavity simple, tubular; surface with conical tubercles.

Family 2. **Megamorina.**

Skeletal elements large, elongated, smooth, curved, irregularly branched, or only forked at the ends, with a simple axial canal, loosely interlocked with each other (Pl. VIII. figs. 3 & 4). Among them sometimes smaller skeletal corpuscles of Rhizomarine type. Surface-spicules uniaxial or forked anchors.

Megalithista, Zitt. (Jura). Cylindrical or basin-shaped, with simple central cavity. In the surface-layer numerous bacillar spicules and a few forked anchors.

Doryderma, Zitt. (Cretaceous). Cylindrical or branched, with a bundle of vertical tubes in the centre. Surface meshed; in the meshes there are tufts of short-toothed forked anchors with very long shafts turned inwards.

Lyidum, Schm. (Recent). Basin-shaped; on both surfaces with ostia of coarse simple canals. Skeletal elements branched, smooth, with thickened ends. Surface-spicules uniaxial.

Carterella, Zitt. (Cretaceous). Cylindrical, much elongated, with traversing vertical tubes. Skeletal elements very long, very sparsely branched.

Isorhaphinia, Zitt. (Cretaceous). Cylindrical, with a wide central cavity. Skeletal elements spiculiform, only slightly forked or thickened at the ends.

Heterostinia, Zitt. (Cretaceous). Vase-like, stalked, with branched roots. Wall on both surfaces with ostia and radial canals. Skeleton consisting partly of large branched megamorphine, and partly of smaller knobby rhizomorphine elements.

Family 3. *Anomocladina*.

Skeletal elements consisting of four or more smooth arms meeting in a thickened centre; arms forked at the end (Pl. VIII. fig. 5). Bacillar spicules are also present in great abundance.

Melonella, Zitt. (Jura). Globular or pyriform, with wide central cavity, into which arched canals open. Oblique radial canals running upwards and outwards from the centre are also present. Base with siliceous epidermis.

Cylindrophyma, Zitt. (Jura). Cylindrical, with wide central cavity. Radial canals horizontal.

Lecanella, Zitt. (Jura). Basin-shaped, thin-walled. Canal-system absent.

Mastosis, Zitt. (Jura). Nodular, with warty elevations; surface with fine pores.

Family 4. *Tetracladina*.

Skeletal elements quadriradiate, the four arms branched or thickened at the ends, with four axial canals meeting at angles of 120° (Pl. VIII. fig. 1). Surface-spicules generally present in abundance (forked anchors, lobate or entire siliceous disks, and bacillar spicules).

a. Sponge-body hemispherical to trochiform, not adherent. Base coated with a wrinkled siliceous membrane. Skeletal elements indistinctly quadriradiate, the smooth arms strongly branched at the ends. Stomachal cavity simple, with ostia of curved canals; besides these, radial canals obliquely directed outwards.

Aulocopium, Oswald (Silurian).

b. Sponge-body cylindrical, pyriform, globular, rarely basin-shaped, simple or branched. Skeletal elements with four equal, smooth, rarely somewhat knobby arms, ramified at the ends. Surface with forked anchors and uniaxial spicules.

Phymatella, Zitt. (Cretaceous). Cylindrical, with nodular excrescences. Central cavity wide. Radial canals horizontal.

Aulaxinia, Zitt. (Cretaceous). Elongate, pyriform, massive. Surface with longitudinal furrows, in which radial canals open. Root with distorted elongated skeletal elements (Pl. VIII. fig. 2).

Callopegma, Zitt. (Cretaceous). Basin-shaped, with wide central cavity. Surface with forked anchors.

Trachysyon, Zitt. (Cretaceous). Fig-shaped, with tubular stomachal cavity. Surface with conical warts. Radial canals horizontal.

- Siphonia*, Park. (Cretaceous). Fig-shaped or pyriform, stalked. Central cavity wide, with ostia of bent radial canals. There are also canals running obliquely from within outwards.
- Jerea*, Lamx. (Cretaceous). Like *Siphonia*, but with a bundle of vertical tubes, the ostia of which open at the vertex.
- Nelumbia*, Pom. (Cretaceous). Clavate. Vertex with the ostia of short vertical tubes. Sides with impressions in which canals open.
- ?*Marginospongia*, D'Orb. (Cretaceous). Cup-shaped, stalked. Wall traversed by vertical tubes.
- Polyjerea*, From. (Cretaceous). Tufted. All individuals traversed by tubular canals. Surface coated with a siliceous skin consisting of small branched lithistid corpuscles.
- Astrocladia*, Zitt. (Cretaceous). Simple or branched, cylindrical, massive. Oscula scattered, in connexion with tubular canals.
- Calymmatina*, Zitt. (Cretaceous). Branched or simple. The individuals trochiform, with simple stomachal cavity. Surface rough, completely coated with a siliceous skin in which forked anchors lie.
- Thecosiphonia*, Zitt. (Cretaceous). Simple or polyzoic. Individuals trochiform. Vertex with an impressed pit, in which are the openings of vertical tubes. Base and a part of the sides coated with siliceous skin.
- Turonia*, Mich. (Cretaceous). Irregular, nodular. Upper surface convex or conical, rough, with longitudinal furrows. In the interior scattered vertical tubes. Base with a siliceous skin, in which are forked anchors.

c. Skeletal elements quadri- or polyradial, strongly branched at the ends. In the surface short-shafted forked anchors with curved prongs, or with lobate or round, short-stalked siliceous disks.

- Theonella*, Gray (Cretaceous and Recent). Cup-shaped. Outer surface porous; inner surface with numerous not prominent oscula. Anchors of the surface with curved forked prongs.
- Discodermia*, Bocage (Cretaceous and Recent). Cup-shaped. Surface with entire-margined rounded siliceous disks.
- Kaliopsis*, Bow. (Recent). Incrusting, thin, without oscula. Surface with toothed, multilobate, short-stalked, siliceous disks.
- Rhacodiscula*, Zitt. (Cretaceous and Recent). Clavate, nodular, cylindrical or cup-shaped. Surface with lobate, short-stalked, siliceous disks.
- Rhagadinia*, Zitt. (Cretaceous). Basin-shaped or laminar. Surface with furrow-canals. Covering layer consisting of lobate, short-stalked, siliceous disks and bacillar spicules.

d. Skeletal elements large, quadri- or polyradial, knobby, with the ends either very slightly branched or merely thickened.

- Plinthosella*, Zitt. (Cretaceous). Globular or nodular. Surface with large, tile-like, entire-margined or lobate siliceous disks.
- Spongodiscus*, Zitt. (Cretaceous). Disciform. Upper surface with radiating ribs. Canal-system wanting.

In this classification, with a few exceptions, only such genera are accepted as I have myself examined microscopically. I have left out of consideration a number of the genera of

Billings, Courtiller, Pomel, &c., because the extant descriptions and figures furnish no information as to the minuter structural characters.

The Silurian genus *Aulocopium* presents some difficulties. Its skeletal elements are of indifferent type: in many respects they resemble those of the Tetracladina; but their irregularity approximates them equally to Anomocladina, and even to certain Rhizomorina. This is a significant hint as to the history of the development of the Lithistid stem. In the Silurian formation the different groups appear not to have yet acquired the differentiation which they show later on; the characters which subsequently divided themselves between the individual families are in part still united in the old collective type.

The Anomocladina also occupy a similar position. They show affinities in all directions; but it is impossible for the present to bring them into genetic connexion with any other group of Lithistidæ.

The other groups, Rhizomorina, Megamorina, and Tetracladina, may be with great certainty distinguished from one another by their microstructure, as a glance at the Tables shows. The Jurassic Rhizomorina, in their short, simple, axial canal, present a remarkable difference from the Cretaceous and recent representatives of this group. All the Jurassic genera of Rhizomorina possess very similar skeletal corpuscles; so that the nature of the skeleton alone does not suffice to characterize the genera. *Mutatis mutandis* this applies also to the Cretaceous Tetracladina and Rhizomorina.

Habitat and Distribution of the Recent Lithistidæ.

The circumstance that the first recent form belonging to the Lithistidæ (*Macandrewia azorica*, Gray) was described in 1859, proves sufficiently that these sponges are not to be reckoned among the easily accessible inhabitants of our sea-coasts. In fact nearly all the species at present known have been brought up from the ocean by the dredge; and the few data as to their bathymetrical distribution, for which we are indebted to O. Schmidt and Carter, would indicate that the Lithistidæ dwell between 75 and 374 fathoms, and frequently occur associated with Hexactinellidæ. The following Table contains the extant information as to their geographical and bathymetrical distribution *.

* The species marked with an * are those which I have had the opportunity of examining in nature.

Species.	Habitat.	Depth in fathoms.	Authority.
A. RHIZOMORINA.			
* <i>Corallistes Bowerbanki</i> , <i>Johnst.</i> , sp. (<i>C. typus</i> , O. Schm.).	Madeira, Cape St. Vincent, West Indies; Florida.	75-374 152-228	Carter. O. Schmidt.
* <i>Corallistes Masoni</i> , <i>Bow.</i> , sp. (<i>Dactylocalyx Masoni</i> , <i>Bow.</i>).	Madeira.	?	
* <i>Corallistes microtuberculatus</i> , <i>Schm.</i>	St. Iago, Cape Verd.	?	
* <i>Corallistes elegantior</i> , <i>Schm.</i>	Portugal.	?	
*— <i>noli-tangere</i> , <i>Schm.</i>	Portugal, St. Iago.	?	
<i>Heterophymia</i> (<i>Dactylocalyx</i>) <i>heteroformis</i> (<i>Val.</i> , sp.), <i>Bow.</i>	Shanghai.	?	
* <i>Macandrewia azorica</i> , <i>Gray</i>	Azores; Færoe Islands; St. Vincent, W. Indies.	75-374	Carter.
*— (<i>Corallistes</i>) <i>clavatella</i> , <i>Schm.</i>	Florida.	152-270	O. Schmidt.
* <i>Pomelia Schmidtii</i> , <i>Zitt.</i>	Florida.	?	
* <i>Azorica Pfeifferæ</i> , <i>Cart.</i>	Madeira, St. Vincent.	75-374	Carter.
— (<i>Corallistes</i>) <i>borealis</i> , <i>Cart.</i> , sp.	Færoe Islands.	?	
* <i>Leioderma</i> <i>lynceum</i> , <i>Schm.</i>	Portugal.	?	
— <i>ramosum</i> , <i>Schm.</i>	Florida.	125	O. Schmidt.
* <i>Arabescula parasitica</i> , <i>Cart.</i>	Eng. Channel, Seychelles.	?	
B. MEGAMORINA.			
* <i>Lyidium torquilla</i> , <i>Schm.</i>	Cuba.	270	O. Schmidt.
C. TETRACLADINA.			
* <i>Theonella Swinhoei</i> , <i>Gray</i>	Formosa.	?	
*— (<i>Dactylocalyx</i>) <i>Pratti</i> , <i>Bow.</i>	East Indies.	?	
*— <i>ferruginea</i> , <i>Häck.</i>	?	?	
<i>Rhacodiscula asteroides</i> , <i>Cart.</i> sp. (<i>Corallistes polydiscus</i> , <i>Schm.</i> non <i>Bow.</i>).	Florida.	152-270	O. Schmidt.
* <i>Rhacodiscula</i> , sp. nov.	Philippines.	?	Carter.
* <i>Kaliopsis cidaris</i> , <i>Bow.</i>	Pacific.	?	
* <i>Discodermia polydiscus</i> , <i>Boc.</i> , sp. (<i>Dactylocalyx polydiscus</i> , <i>Bow.</i>).	Portugal, St. Iago, St. Vincent.	75-374	Carter.

Phyletic Development.

From the mode of life of the existing Lithistidæ we may fairly conclude that their fossil ancestors also preferred to dwell in moderately deep water. The fossil Lithistidæ, especially in the Upper Jura, and here and there also in the Upper Cretaceous, are very frequently accompanied by numerous Hexactinellidæ; but there are localities (e. g. the Chalk of Touraine, Normandy, and Yorkshire) where the Lithistidæ

occur in great quantities, and the Hexactinellidæ only very sparingly. This indicates that the conditions of existence of the two sponge-groups were similar but not identical. In general the living Lithistidæ appear never to occur at such great depths as the Hexactinellidæ. Deposits in which the latter predominate must therefore have been formed in deeper water than the formations which abound in Lithistidæ.

In decidedly littoral deposits we know scarcely any Lithistidæ; and this circumstance may chiefly serve to explain the evidently very imperfect materials in our palæontological museums. They are limited to isolated deposits, widely separated both in space and time, and each as a rule containing a different sponge-fauna from those of the earlier- or later-formed strata. We cannot demonstrate any constant and gradual evolution of the fossil Lithistidæ; nay, even the passage of a genus, to say nothing of a species, from one formation into a later one can hardly be proved.

The Palæozoic formations have hitherto furnished only a single well-defined genus* (*Aulocopium*).

I know of no Lithistidæ from the Trias and Lias; but I have found a *Melonella* and a species of *Cnemidiastrum* in the Hohenegger collection from the Brown Jura of the Cracow district.

The Lithistidæ are remarkably numerous, especially in individuals, in the Sponge-limestones of the White Jura. Here the genera *Cnemidiastrum*, *Hyalotragos*, *Platychonia*, and *Cylindrophyma* especially predominate. *Leiodorella*, *Epistomella*, *Pyrgochonia*, *Discostroma*, *Megalithista*, *Lecanella*, *Mastosa*, and *Melonella* occur more isolatedly. In the Lower White Jura they occur in moderate numbers along with the Hexactinellidæ which there predominate; but their chief development only appears in the White Jura δ , in which the Hexactinellidæ are rather more scanty. In the older horizons of the Cretaceous formation the Lithistidæ are not entirely deficient, but they occur only as rarities. On the other hand, the Cenomanian is the home of numerous species of *Siphonia*, *Jerea*, *Stichophyma*, *Chonella*, *Verruculina*, and *Amphithelion*. Celebrated localities are the Greensands of Blackdown and Haldon, the Glauconitic Chalk of Normandy and Touraine, and the Lower Pläner of North Germany, Saxony, Bohemia, and Bavaria.

* Possibly the insufficiently described genera *Aulocopina*, *Calathium*, and *Euspongia* of Billings also belong to the Lithistidæ. The Silurian genera *Archæocyathus* and *Trachium* of Billings require to be microscopically examined in order to ascertain whether they are really to be referred to the Hexactinellidæ.

The climax of their development is attained by the Lithistidæ in the Upper Cretaceous. In Touraine and Normandy, in Yorkshire, and in some districts of North Germany (on the Sutmerberg, near Ahlten, Linden, Boimtsdorf, Ilsenburg, Döhrnten, and Salzgitten) the multiplicity of forms of Lithistidæ is absolutely astonishing. The genera *Chonella*, *Seliscotho*, *Chenendopora*, *Verruculina*, *Amphithelion*, *Bolidium*, *Astrobolia*, *Stichophyma*, *Jereica*, *Cœlocorypha*, *Scytalia*, *Pachinion*, *Doryderma*, *Isorhaphinia*, *Phymatella*, *Callopegma*, *Trachysycon*, *Jerea*, *Polyjerea*, *Astrocladia*, *Turonina*, *Rhagadinia*, *Plinthosella*, *Spongodiscus*, &c. have here either their exclusive or their principal habitat. It is remarkable that the Cretaceous formation has not a single genus in common with the Jura.

On quitting the Cretaceous formation there are in Northern Europe only a few isolated fragments of Lithistidæ (*e.g.* in the Eocene sands of Brussels); but on the other hand, in the province of Oran, in Algeria, Pomel has discovered and described a remarkably rich Miocene Lithistid fauna. Unfortunately I have had no materials from this region at my disposal; and as Pomel's descriptions and figures relate only to the external form and the canal-system, but take little notice of the finer structural characters, I must for the present refrain from giving an opinion upon most of the genera. In general habit, however, the Lithistid fauna from the Miocene of Oran appears to be at least as nearly allied to the existing forms as to those of the Cretaceous formation. Among the numerous species of the genera *Scytophymia*, *Pleurophymia*, and *Cnemaulax* a closer examination may show representatives of *Corallistes*, *Macandrewia*, and *Azorica*; on the other hand, the genera *Jereopsis*, *Jerea*, *Allomera*, *Meta*, &c., which are exceedingly numerous in individuals, seem rather to indicate Cretaceous predecessors. To my regret I have found myself compelled to ignore most of Pomel's genera in the special part of this memoir, as a definitive arrangement of them in the system will be possible only when their structural characters have been carefully investigated.

The following Table gives a summary representation of the historical sequence of the Lithistidæ, and, at the same time, some indications of the mode in which their phyletic evolution may be conceived. For the present, with our imperfect knowledge both of the fossil and living Lithistidæ, the establishment of complete series of forms, or even the construction of a genealogical tree, is no more to be thought of than in the case of the Hexactinellidæ.

		<i>Rhizomorina</i> .	<i>Megamorina</i> .	<i>Tetracaladina</i> .
Recent.	Leiodermatium.			Discodermia.
	Azorica.			Rhacodiscula.
Recent.	Macandrewia.		Pomelia.	Thaenella.
	Heterophymia.			Kaliopsis.
	Corallistes.			
	Arabescula.			
			<i>Lyidium</i> .	
Miocene.	Corallistes.			
	(Seytrophymia, Pleurophymia,	? Marisca.		
	Agophymia).	? Meta.		
	? Chrenaulax.	? Iscladia.		
	? Spongoconia, ? Taseoconia.	? Strebla.		
	? Tretolopia, ? Adelopia.	? Dihojerea.		
	? Histodia.	? Jerea.		
		? Pleuromera.		
		? Allomera.		
		? Jereoopsis.		
Upper and Middle Cretaceous.	Amphithelion.			Callopegma.
	Verruculina.			Phymatella.
	Plococonia.	Stachyspongia.		Anaxina.
	Selscothion.	Pachion.		Turonina.
	Chenendopora.	Colocorypha.		Calymmatina.
	Chonella.	Seytalia.		Thlecosiphonia.
				Astrocladia.
				Marginojerea.
				Polyjerea.
				Neilumbia.
Lower Cretaceous.	Chonella.	Jereica.		Jerea.
				Trachyscon.
White Jura (Main).	Leiodorella.			Siphonia.
	Epistomella.			Discodermia.
	Platyconia.			Rhagadina.
	Discostroma.			Plinthosella.
	Pyrgoconia.			
	Corallidium.			
	Chemidiastrium.			
Dogger.	Chemidiastrium.			
Suturian formation.

Mintern Bros lith.