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Clypeina lagustensis n. sp., a new calcareous alga from the Lower Tithonian of Lastovo Island (Croatia)

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ABSTRACT

Clypeina lagustensis n. sp. has been found in the Lower Tithonian deposits of Lastovo Island (Dalmatia, Croatia). It is visually similar, obviously related and in some sections appears almost identical, to *Clypeina jurassica* FAVRE, from which it differs by visible swellings and thinning of the central cavity, more pronounced distance between the neighbouring whorls of fertile laterals, and in the shape and structure of the interverticillate thallus parts, characterized by having well developed, hairy, sterile laterals. These, after emerging from the exit pore, divide into several bundles which form a common tuft with a calcareous envelope in the proximal part.

Keywords: Calcareous algae (Dasycladales), taxonomy, stratigraphy, Jurassic (Tithonian), Lastovo Island, Croatia

1. INTRODUCTION

In the preparation for the new lithostratigaphic map of Croatia, the Croatian Geological Survey investigated several regions within the Dinarides, including the insular belt, in order to establish lithostratigraphic units suitable for correlation within the broader Dinaridic area. On Lastovo Island, these investigations were carried out by Husinec and others and included a detailed study of several characteristic cross-sections with systematic sampling. The collected samples were analysed from different aspects, including micropalaeontological analysis. Particular attention was paid to sample LSL-43, due to the abundant fragments and sections reminiscent of the well-known species *Clypeina jurassica* FAVRE. Among numerous transverse and slightly oblique sections of fertile whorls, several longitudinal, longitudinal-oblique, and tangential sections were noticed, which exhibited characteristic features that differed from what so far seemed to be indicative of *C. jurassica*. These included the morphology and structure of the thallus, as well as the values of some biometric parameters, which, in some earlier descriptions, seemed to be taken in variously oriented sections and, consequently, were ill-suited for comparisons. The reason for this seems to be the fact, that *C. jurassica* was both established (FAVRE & RICHARD, 1927) and subsequently determined by numerous authors, mostly involving transverse and oblique sections cutting one or at most a few (2-3) disks (baskets) of fertile laterals, thus making it impossible to gain a complete insight into the thallus morphology and reliable values for most of the biometric parameters. This was previously noticed by REMANE (1969), who, in his detailed morphological and statistical analysis of some biometric parameters of *C. jurassica*, (based upon type material and supplemented by abundant material from other localities), commented on the validity and usefulness of individual biometric parameters, which are mutually dependent on the type and the position of sectioning. In his analysis, REMANE (1969) restricts himself to the values of outer thallus diameter (D), inner diameter (d), number of laterals per whorl (w), distal diameter (in horizontal and vertical plane of

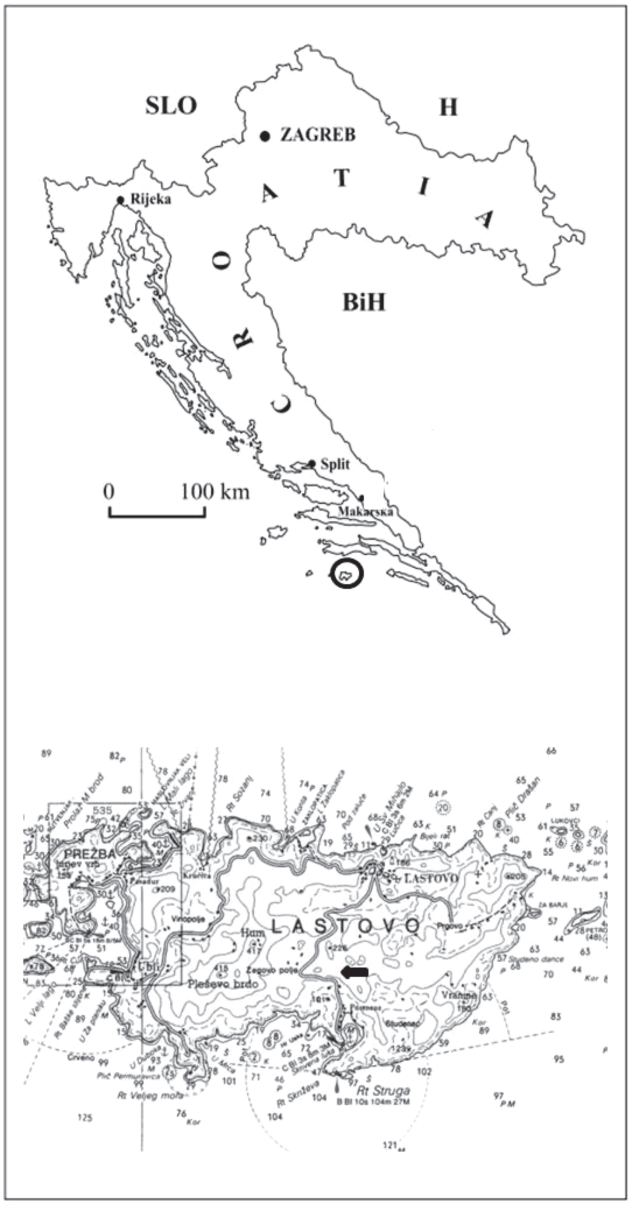

Figure 1: Geographic position of the type locality of *Clypeina lagustensis* n. sp. (Lastovo Island, Croatia).

section) of single laterals (p), and (very few) distance between consecutive whorls (h). He then analysed the observed difference in particular parameters from several aspects: position (inclinations) of the plane of section with regard to the whorl position, larger or smaller steepness of laterals, thallus curvature, possible *post mortem* compression, ecological conditioning, etc. He mentioned, in passing, the existence of slight, irregular bulges between the fertile whorls, visible in his drawings (Fig. 11 b, c; Fig. 29 c, d, e, f), as a possible consequence of post mortem compression, therefore denying any significance to that feature and thus omitting it completely from the concluding diagnosis. Based on his analysis, he also rejects *C. inopinata* FAVRE (1932) and *C. minor* KERČMAR (1962) as independent species, because their biometric parameters fall within the variation range stated for *C. jurassica*.In discussing *C. jurassica*, ELLIOTT (1968) interpreted the variability and differences between sections from different localities as being due to local ecological circumstances, and, besides, mentioned some biometric parameters. He thought that *C. inopinata*, not copiously represented in his Middle East material, may be a successor to *C. jurassica*. At the same time, RADOIČIĆ (1969) presented illustrations of *C. inopinata* as belonging to sections with smaller biometric parameters (D, d, w), but still falling within the range of *C. jurassica*, and some slight differences in the shape of the disks (baskets) of fertile laterals and their distal endings. These differences, being due to the varying inclination of laterals and the position (inclination) of the sections, are neither sufficient nor adequately convincing for distinguishing *C. inopinata* from *C. jurassica*. GRANIER (1986), referring to the analytical study of REMANE (1969), was of the opinion that *C. inopinata* shows a clear synonymy with *C. jurassica*. The same opinion is put forward by BASSOULLET et al. (1978) and GRANIER & DELLOFFRE (1992), whereas RADOIČIĆ (1969) presented new data on the structure of *C. jurassica* and *C. inopinata*, regarding the sterile laterals in the interverticillate portions of the thallus, being preserved (and visible) only in their proximal parts as little shallow cups. These laterals, too, are arranged into rows (whorls) between fertile whorls, and are ascribed to both species: *C. jurassica* having 3-4 rows, *C. inopinata* 5-6 rows. This feature, however, is not clearly visible in RADOIČIĆ'S (1969) sections for *C. jurassica* (fig. 6 a, b) and *C. inopinata* (fig. 6 c-d; figs. 7, 8; fig. 9 a, b, c?, d) and thus they should be, according to this interpretation, considered synonymous, the validity of C. *inopinata* remaining, so far, questionable. Thus, in this case, the newly observed characteristics regarding the thallus structure have been simultaneously ascribed to a questionable species (*C. inopinata*) and to *C. jurassica*, in which, however, the existence of such type of sterile laterals has not yet been undoubtedly proven. This opens the possibility for a third, as yet, unidentified, species. GRANIER (1986, fig. 10) supplemented the graphic interpretation of REMANE (1969, fig. 23) with his vision of the shape and position of sterile laterals, and thus, however hypothetically, gave the example of a possibly different interpretation. In conclusion, according to the present state of availability of published material and presented opinions regarding the validity of *C. inopinata*, we agree with REMANE'S (1969) opinion, accepting also comments and the opinions of SCHLAGINTWEIT, DIENI & RADOIČIĆ (2009) regarding the conservation of the already well-established species-specific name *Clypeina jurassica* FAVRE.

This short, partly reduced, review, of the earlier studies, opinions, supplements, and (taxonomically often confused) interpretations, including their deficiencies, was deemed necessary as a preliminary introduction to our further considerations, better understanding, and legitimacy for establishing an independent taxon for a new form, in spite of its visual similarity with *C. jurassica*, but nevertheless displaying newly observed characteristics. These include: thallus morphology and its structure in the interverticillate portions, large range of *h* value, and visibly well developed sterile lat-

Table 1: Comparison of biometric parameter values by different authors for *Clypeina jurassica* FAVRE, *C. inopinata* FAVRE, and *C. lagustensis* n. sp. Symbols: L = maximum observed length; D = outer diameter at the level of whorls; d= inner diameter, approximately at the level of whorls; D' = outer stem diameter between fertile whorls; d' = inner stem diameter between whorls; h = distance between neighbouring fertile whorls; pp = diameter of fertile lateral stalk; pd = distal diameter in vertical section; l = length of fertile lateral; w = number of fertile laterals per whorl; α = dip of laterals from horizontal plane; f. = fertile lateral; st. = sterile lateral; hor. = horizontal section; vert. = vertical section.

	L	D	d	d/D	D'	d'	d'/D'	h	pp	pd	l	w	α
FAVRE 1927 *C. jurassica*		1.45-2.25	0.33-0.51							vert. 0.37		11-13	
FAVRE 1932 *C. inopinata*		up to 1.7	0.18-0.40									12-19	
RODA 1965 *C. jurassica*		1.37-2.05	0.34-0.53					0.27-0.28		hor. 0.28-0.46		11-15	
ELLIOT 1968 *C. jurassica*		2.5	up to 0.5						0.05	0.30-0.39		up to 24	
RADOIČIĆ 1969 *C. jurassica*		0.80-2.28	0.19-0.80									8-22	
RADOIČIĆ 1969 *C. inopinata*		0.60-1.6	0.15-0.40									8-17	
REMANE 1969										hor.			
C. jurassica type locality		0.52-3.44	0.08-0.59					0.17-0.51		0.15-0.48		5-20	
other localities		0.36-2.53	0.07-0.68					0.22-0.47		0.18-0.47		5-21	
GRANIER 1986 *C. jurassica*		0.54-2.10	0.19-0.63					f. 0.30-0.40 st. 0.05		0.23-0.35	0.17-0.90	8-16	
this paper *C. jurassica*		1.20-3.10	0.30-0.82					0.45-0.68	0.08-0.20	0.28-0.72	0.40-1.32	8-21	up to 30°
Clypeina lagusteasis n. sp.	8.87	0.62-2.08	0.16-0.40	0.125-0.277	0.40-1.24	0.20-0.58	0.313-0.825	0.30-2.14	0.03-0.10	0.20-0.58	0.30-0.96	6-16	0-35°

Remark: The value of the parameter D depends directly on the state (degree) of preservation of the calcite film enveloping the tufts of sterile laterals. The comparison of individual biometric parameters mentioned by different authors is not reliable, because the quoted values, designated by the same symbol, have been measured in differently positioned sections.

erals of specific shape. In contrast, it's incontestable affinity with *C. jurassica*, as shown in almost visual identity in some, similarly oriented, sections of fertile whorl laterals, intracellular calcification, open distal ends of fertile laterals, and identical values for some biometric parameters in their overlapping intervals within their overall ranges leads to the bewildering fact that this form cannot be, always and in all sections, clearly and reliably distinguished from *C. jurassica*. Therefore we hesitated as to which taxonomic category this form should be assigned; should it be considered as a case of heteromorphism, variation, subspecies, or be separated as a new taxon? Taking all its specific features together, as a set of differences with regard to *C. jurassica*, and accepting the possibility that by gradual acquisition of new, more or less pronounced, features, species become the origin for another species, we decided to put this form in the species rank as *Clypeina lagustensis* n. sp.

2. GEOLOGICAL SETTING

The Lastovo Archipelago is composed of the homonymous island and 45 smaller islands and islets located in the southern Croatian part of the Adriatic Sea. The backbone of the archipelago consists of Upper Jurassic to mid Cretaceous shallow-water limestone, dolomite, and intraformational breccia. It's geological makeup has been described by JAGAČIĆ (1970), KOROLIJA & BOROVIĆ (1975), and KOROLIJA & al. (1977). Recently, HUSINEC & READ (2006, 2007) described in detail the microfacies, sequence stratigraphic framework and chemostratigraphy of the Late Jurassic Tithonian sequence.

The oldest strata outcropping on the island are Late Jurassic, Oxfordian in age, and composed of predominantly thick-bedded to massive subtidal mudstone and wackestone with benthic foraminifera and fragments of gastropods and echinoids. These formed in quiet lagoon settings below the zone of frequent wave reworking. Local bioherms indicate the presence of patch reefs that were colonized by corals and algae, while rare ooid grainstones suggest that shoals were of very limited extent (JAGAČIĆ, 1970; KOROLIJA & BOROVIĆ, 1975; KOROLIJA & al., 1977). The overlying Kimmeridgian-Lower Tithonian sequence is composed of the following facies (from deepest to shallowest): dasyclad-oncoid mudstone-wackestone-floatstone (deeper lagoon), skeletal-peloid wackestone-packstone (shallow lagoon), intraclast-peloid packstone and grainstone (shoal-water), and barren lime mudstone (restricted lagoon). These facies typically form 0.7-to-4.5-m-thick shallowing upward parasequences capped by unfossiliferous lime mudstone (HUSINEC & READ, 2007). The bulk of the Upper Tithonian is oolitic, consisting of thinner, 1-3-m-thick parasequences composed of basal transgressive oolite, overlain by skeletal mudstone-wackestone (rare), intraclast-peloid packstone-grainstone (common), regressive oolite (rare), unfossiliferous mudstone, and most are capped by fenestral grainy and muddy carbonates. The most distinctive features of the Upper Tithonian sequence are dark-grey oolitic units with oversized ooids with primary calcite fabrics that were previously termed „vadoids" by TIŠLJAR (1985). However, based on their striking resemblance to modern low-energy lake and marginal-marine pond ooids, and their common position at the base of parasequences, HUSINEC & READ (2006) reinterpreted these as having formed predominantly during initial inundation of supratidal flats, along the shores of shallow hypersaline ponds and restricted lagoons of the platform interior. The long-term shallowing continued towards the end of the Jurassic, as evident by the predominance of fenestral limestones, and culminated in platform exposure at the Tithonian-Berriasian transition, as evidenced by several subaerial exposure breccia interbeds with lime clasts floating in reddish to greenish clays, desiccation features and erosional truncation surfaces. The overlying Lower Cretaceous Berriasian sequence is composed of pale to almost white skeletal mudstone with calcareous algae and fragments of bivalves and gastropods; it is commonly burrowed and has fenestral fabrics. Less common are peloid-intraclast packstones and grainstones. The youngest carbonate platform deposits on the island are separated from the older succession by a fault that runs along the northern shore of the island; these are predominantly skeletal mudstone and wacke-packstones of probably Upper Hauterivian-Lower Barremian age, as suggested by sparse occurrences of the alga *Clypeina? solkani* CONRAD & RADOIČIĆ. The younger Mesozoic (Albian-Cenomanian) strata do not outcrop on the island, but make up the smaller islands and islets westwards towards Mljet Island. The youngest deposits on the island are aeolian Quaternary sands that occur as patchy outcrops of very limited extent in the eastern part of the island.

3. SYSTEMATIC PALAEONTOLOGY

***Clypeina lagustensis* n. sp.**
Pls. I-II; Pl. III, figs. 3, 6; Pls. IV-VI

?1966 *Clypeina jurassica* FAVRE – RADOIČIĆ, Pl. CXVIII, fig. 1.

1969 *Clypeina inopinata* FAVRE – RADOIČIĆ, p. 75-81, fig.6 a-d (pars), fig.9 (a-b, c?, d), fig. 10.

?1997 *Clypeina jurassica* FAVRE – DE CASTRO, Pl. 19 (pars), Pl. 20, figs.2, 5-6.

Origin of the name: after the Latin name (Lagusta) for the Lastovo island.

Type locality: Beds exposed along the road leading northward from the Skrivena luka cove to the Lastovo village, about 450 m off the coast (fig. 1). GPS readings: x = 6409212, y = 4734003; coordinates: 42º44'40.8''N, 16º53'27''E.

Type beds: Lower Tithonian, light brown, thin- to thick-bedded wackestone to packstone, composed of peloids and skeletal fragments of dasyclad algae, benthic foraminifera (small ataxophragmiids), oncoids, and sparse intraclasts. Beds with *C. lagustensis* n. sp. occur within the deposits situated between the transitional Kimmeridgian-Tithonian levels, defined by a rich fossil assemblage including: *Pseudoclypeina distomenesis* BARATTOLO & CARRAS, *Parurgonina caelinensis* CUVILLIER et al., the first occurrence of *Clypeina* sp. and *Salpingoporella annulata* CAROZZI in the base, and the first occurrence of *Campbelliella striata* CAROZZI, frequently accompanied by *C. jurassica* FAVRE, in the immediately overlying beds. Passing upwards, *Humiella sardiniensis* (OTT & FLAVIANI) sporadically occurs; in the top part, there are sparse *Clypeina catinula* CAROZZI and *Oternstella lemmensis* (BERNIER). This defines the stratigraphic position of the algal-bearing beds on the type locality within the range of the Lower Tithonian.

Holotype: Longitudinal section in the thin-section LSL-43/27, figured in Pl. I, fig.2. Isotypes are represented by variously oriented sections, figured in Pls. I-II; III, figs. 3, 6; IV-VI. For the time being, the complete material is stored in the Sokač collection and will be handed over to the archives of the Croatian Museum of Natural History, Zagreb.

Diagnosis: Cylindrical thallus bears pronounced separated whorls of fertile laterals and is characterized by regularly spaced constrictions of the central cavity. Fertile laterals are connected to the central stem by a short stalk, often bent downwards. Going outwards, fertile laterals gradually and evenly widen to about the mid-point of their length, after which they broaden abruptly, slightly bending downwards. Between the disks (or baskets) of fertile whorls, the stem bears sterile laterals, with exit pores that seem to be arranged (at least in deep tangential sections) into more or less regular rows (whorls?). Going out from their exit pores, the hairy sterile laterals divide into several bundles which form tufts with a calcified envelope in their proximal parts, resembling shallow cups.

Description: The calcareous skeleton is generally cylindrical. The swellings and constrictions of the central cavity, alternating at regular intervals, results in an apparent, more or less visible segmentation. The stem broadens between the fertile laterals and becomes narrower at the levels with whorls. Immediately above the fertile whorls, the stem is at its narrowest. Between the less distant whorls, the swelling of the stem assumes a barrel-like shape (Pl. I, fig.4; Pl. II, fig 3; Pl. IV, figs. 3, 5), whereas between the more distantly arranged whorls, the stem becomes cylindrically elongated (Pl. I, fig. 5; Pl. II, fig.2; Pl. III, fig. 6; Pl. IV, fig. 4). Quite frequently, the thallus is outlined by a well-marked, dark, almost black, micritic zone; this is due to a muddy substance being infiltrated into the space of distally non-calcified, densely arranged, and probably mutually intertwining sterile laterals – hairs (Pl. I, figs. 3–4, 6; Pl. II, figs. 1, 4).

Fertile laterals, within the calcified envelope, of the phloiophorous type, open at their outer ends, laterally pressed against one another, are arranged into variously spaced whorls. The distance between neighbouring whorls (*h*) is one of the main distinguishing characteristics of the new species; the average value varying from 0.70 to 1.35 mm, quite often reaching 1.50 mm, the maximum observed value being 2.14 mm. Laterals are connected to the central stem by a short stalk (Pl. I, fig. 5 arrow; Pl. II, fig. 2, Pl. IV, fig. 5 arrow). The stalks are often inclined downwards, sometimes being bent in a knee-like fashion (Pl. I, fig. 6; Pl. IV, fig. 7). Going outwards, and after escaping from the short stalk, fertile laterals widen quite uniformly up to half their length; then they abruptly broaden distally, assuming the shape of a broad funnel (Pl. III, fig. 5; Pl. IV, figs. 3, 5), which by their outer end bends downwards, thus decreasing the thickness of the calcified wall (Pl. IV, figs. 3, 5; Pl. V, fig. 3). Being open at their outer ends, the pronounced widened laterals of neighbouring whorls touch distally, being separated only by a poorly calcified micritic primary membrane. Due to reduced calcification and their being open at the distal ends, these parts of the laterals are, as a rule, erased (eroded), their square-like shape being observable only in extremely rare random tangential sections, and also showing an insufficiently clear alternating arrangement of laterals in neighbouring whorls (Pl. V, fig. 5). The inclination of fertile laterals varies: from being most frequently sub-horizontal (Pl. I. fig. 5; Pl. III, fig. 3) to being slightly directed upwards (Pl. I, fig. 2; Pl. III, fig. 6), or being proximally obliquely directed upwards and distally bent downwards (Pl. V, fig. 3). Depending on the angle of inclination, fertile laterals of the same whorl, being laterally pressed close to each other, form a concave disk or, to say it more figuratively, a shallow or slightly deeper bowl.

The thallus stem between fertile whorls has a very thin calcified wall (Pl. I, figs. 1, 5; Pl. II, fig. 2; Pl. IV, figs. 2, 4) and is covered by the exit pores of sterile laterals (Pl. I, fig. 3; Pl. IV, fig. 6; Pl. V, fig. 7). In deep tangential section, these pores, indistinctly separated from one another, are visible as dark, dense, more or less regular rows, thus suggesting their arrangement in whorls (Pl. V, fig. 7; Pl. VI, fig. 3). Leaving the pores, a group of hairs is divided into several (2-?5) bundles (Pl. V, figs. 6, 8, 10 arrow; Pl. VI, figs. 1, 5 arrow) which form a common tuft, enveloped, in its proximal part, by a calcite sheath (Pl. V, fig. 8; Pl. VI, figs. 4, 5 arrow). The tuft's envelopes are visible near the thallus stem, in vertical and oblique sections, as small, irregular cups or small, shallow bowls (Pl. II, fig 1; Pl. III, fig. 6; Pl. V, fig. 1; Pl. VI, fig. 4). More distantly of the stem, their sections become oval, elongated, mostly irregular, deformed in appearance, and not clearly separated from one another (Pl. V, figs. 1, 8; Pl. VI, fig. 5). In most sections, sterile laterals are fully micritic, thus appearing in transverse sections in the form of a dark ring with variable diameter (Pl. V, fig. 9; Pl. VI, fig. 7 arrow). In rare cases, sterile laterals are calcified with visible, chaotically arranged, tuft's envelopes (Pl. VI, fig. 2). Variability of the envelopes' shapes and diameters depends on the number of bundles in them and the different cutting planes with regard to their direction of growth. The tufts (i.e., their calcitic envelopes) can be perpendicular to the longitudinal thallus growth axis or obliquely inclined either upwards or downwards, even in the same specimen (Pl. V, fig. 1), thus indicating their mutual growing through each other, resulting in their irregular, chaotic arrangement. Distally, calcification of tufts is lacking. The fine-grained, muddy substance of the surrounding sediment is infiltrated into, and kept within, the dense mass of hairs and thus *post mortem* marks the hairs and their extent towards the terminations of fertile laterals; or even outside, it is marked by visible, dark, almost black zone of micritic sediment (Pl. I, fig. 4; Pl. II, figs. 1, 6).

Similarities and differences: *Clypeina lagustensis* n. sp. is related, similar, and in some sections appearing almost identical, to *C. jurassica* FAVRE. The similarity includes the general thallus shape, the morphology and arrangement of fertile laterals and their whorls, the intracellular calcification of fertile laterals, the existence of sterile laterals in interverticillate stem parts (i.e., between the whorls of fertile laterals), and the values of some of the biometric parameters. These, though falling within the range of *C. jurassica* FAVRE established so far, cluster around smaller values for *Clypeina lagustensis* n. sp.

These similarities prevent the clear and unambiguous distinction of the two species, in some cases and in all similarly oriented sections. This refers particularly to transverse and oblique sections cutting through the outer parts of the fertile whorls. However, the differences are clearly brought out in longitudinal and oblique-longitudinal sections, in which the regularly alternating, swellings and constrictions of the central cavity in *C. lagustensis*, are clearly visible and always present. In *C. jurassica*, this feature is either completely absent (Pl. III, figs. 1-2, 4-5) or rather indistinctly and irregularly developed (REMANE, 1969, figs. 11 b, c; 29 c, d, e), or merely hinted at (DE CASTRO, 1996, pl.20, fig. 1). Also, a visible difference between the two species concerns the shape of the fertile laterals and how they are attached to the central stem. In *C. jurassica*, fertile laterals, when leaving the central stem, are slightly inflated (swollen), then slightly taken in and again distally widened, thus acquiring a funnel-like shape. They are attached to the central cavity directly by their broadened base (Pl. III, figs. 1-2, 4-6, 7-9). Because of this shape, the laterals in transverse sections, depending on the cutting plane, often appear as oval-shaped pores, seemingly detached from the remaining part of the lateral (Pl. III, pars fig. 7-8). In contrast, this has never been noticed in *C. lagustensis*. DE CASTRO (1997), in the description of his plate 20, fig. 1, mentions a small protuberance in the proximal part of a lateral in *C. jurassica*. According to our sections, we cannot confirm that determination with certainty, though the section figured in Pl. III, fig. 8, allows for such a possibility. However, in contrast to those features in *C. jurassica*, fertile laterals in *C. lagustensis* are attached to the central stem mostly by a short and small stalk, the diameter of the stalk being equal to that of the exit pore. This excludes the possibility of the lateral displaying any sort of an irregular, protuberance-shaped, broadening. In addition to the afore-mentioned differences, there is another essential characteristic feature that easily enables distinction between *C. lagustensis* and *C. jurassica*, and this refers to the distance between the neighbouring fertile whorls (h). Though in about 20% of measured sections in *C. lagustensis* this value varies in the range 1:5, the minimum h values in *C. lagustensis* are approximately equal to the maximum h values in *C. jurassica*; that parameter seems to be only seldom mentioned in *C. jurassica*, being measured, apparently, only in a small number of sections. The average h value (= distance between the consecutive whorls) in *C. lagustensis* is, in about 60-70% specimens, 2-3 times larger, in 10% specimens being even 4 times larger, than in *C. jurassica*. In addition to these three characteristic differences (morphology of the central stem, the way of attachment of fertile laterals to central stalk, and the relation of the *h* values), there is another characteristic. It concerns the development, shape, and position of the sterile laterals in the interverticillate parts of the central stem. Sterile laterals, as described above, have been observed only in the new described species, *C. lagustensis*. Also, we are of the opinion that the majority of sections illustrated by RADOIČIĆ (1969) and labelled *Clypeina inopinata*, should be assigned to the new species. Regarding the above mentioned taxonomic status of *C. inopinata*, and the opinion of numerous authors of it being a possible synonym of *C. jurassica*, the characteristics of sterile laterals in *C. lagustensis* n. sp. (assigned by RADOIČIĆ to *C. inopinata*), cannot be unambiguously transferred to *C. jurassica*. The shape and arrangement of sterile laterals, marked by tiny pores, in some sections of *C. jurassica* (Pl. III, fig. 9), has remained unknown and incomparable up to the present.

With regard to other *Clypeina* species, encountered in the range Tithonian-Neocomian, the enumerating of differences to *C. lagustensis* seems unnecessary, because of its specific thallus morphology, intercellular calcification of fertile laterals, and well developed sterile laterals with characteristic features. These characteristics have not been observed in any other species within a similar stratigraphic range. Some of them, such as *C. isabelae* MASSE et al. (MASSE et al., 1999) and *C. loferensis* SCHLAGINTWEIT et al. (SCHLAGINTWEIT et al., 2009), besides the stated differences, have thalli that are several times smaller than *C. lagustensis* n. sp.

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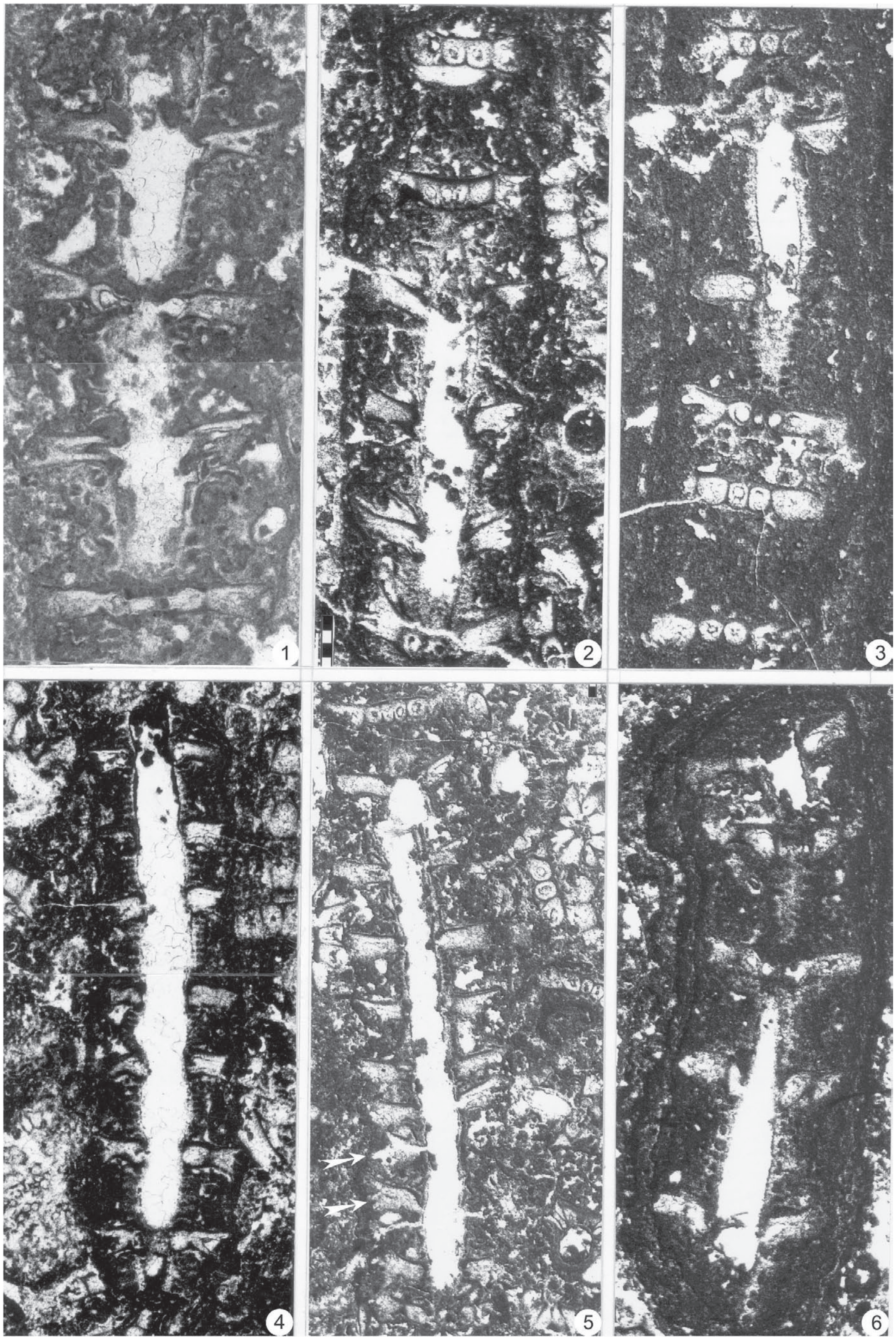

Plate I

1-6 *Clypeina lagustensis* n. sp.

1, 4-5 Longitudinal sections. Figs. 4-5, short stalks connecting fertile laterals to the main stem are visible in places. Fig 4 shows pronounced thallus micritization. Slides: fig. 1, LSL-43/15, x 34; fig. 4, LSL-43/18, x22; fig. 5, LSL-43/27, x 17.

2 Longitudinal-tangential section. SlideLSL-43/27, x 25.

3, 6 Oblique sections. Both sections show the micritized outer part of the thallus and short, bent (knee like), stalks in the proximal parts of fertile laterals. Slides: fig. 3, LSL-43/23, fig. 6, LSL-43/36, x 25.

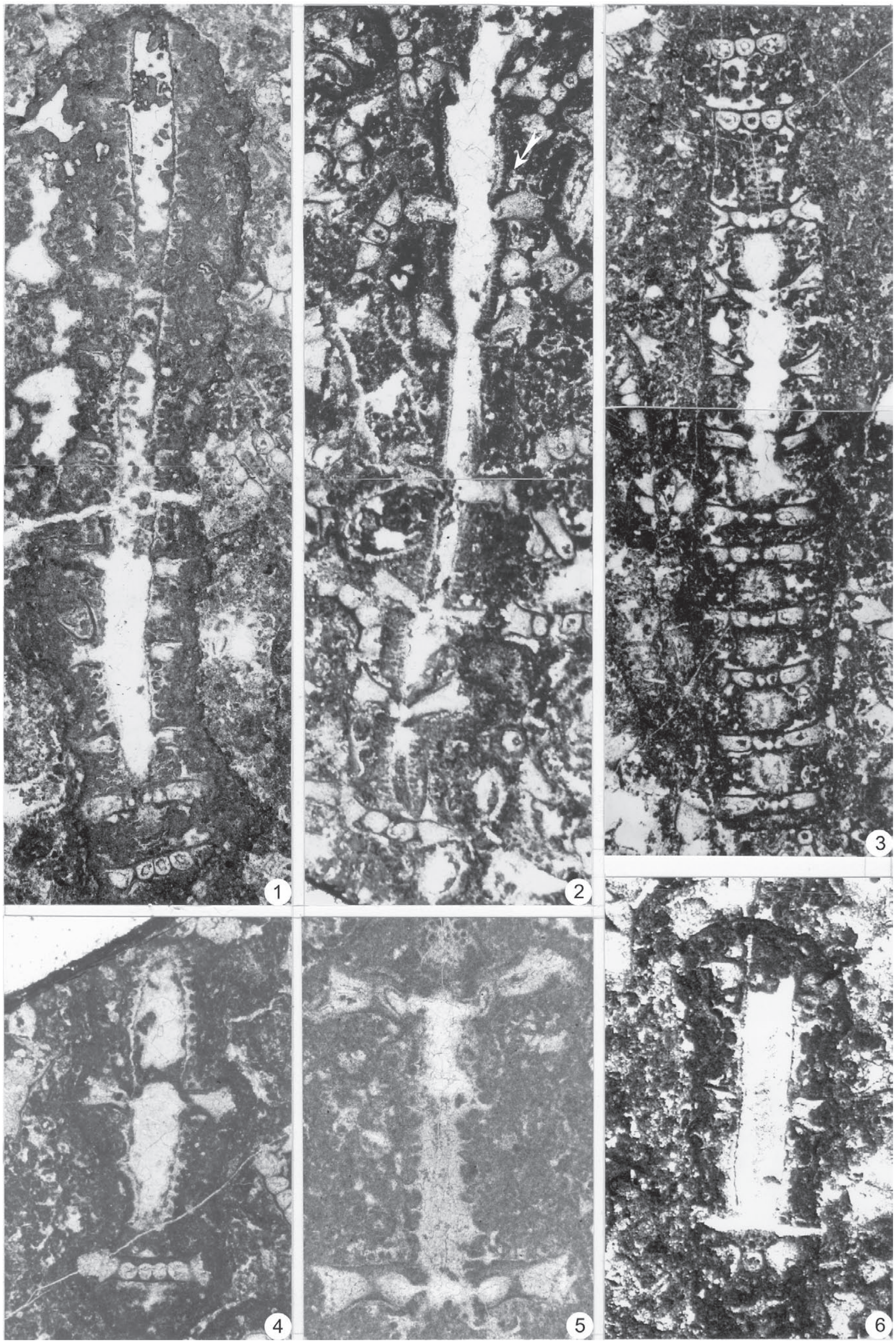

Plate II

1-6 *Clypeina lagustensis* n. sp.
1-2 Longitudinal sections. Fig 2, holotype with remotely spaced fertile whorls. Slides: fig. 1, LSL-46/16, fig. 2, LSL-43/27, x 22.
3 Tangential-longitudinal section showing clearly pronounced, alternating barrel-like swellings and constrictions of the central cavity. At places, short stalks in the proximal parts of fertile laterals are visible. Slide: LSL-43/19, x 22.
4 Oblique section, showing remotely spaced fertile whorls. Slide LSL-43/1, x 22.
5 Tangential-longitudinal section, showing remotely spaced fertile whorls. Slide LSL-43/1, x 34.
6 Longitudinal section. Slide LSL-43/21, x 34.

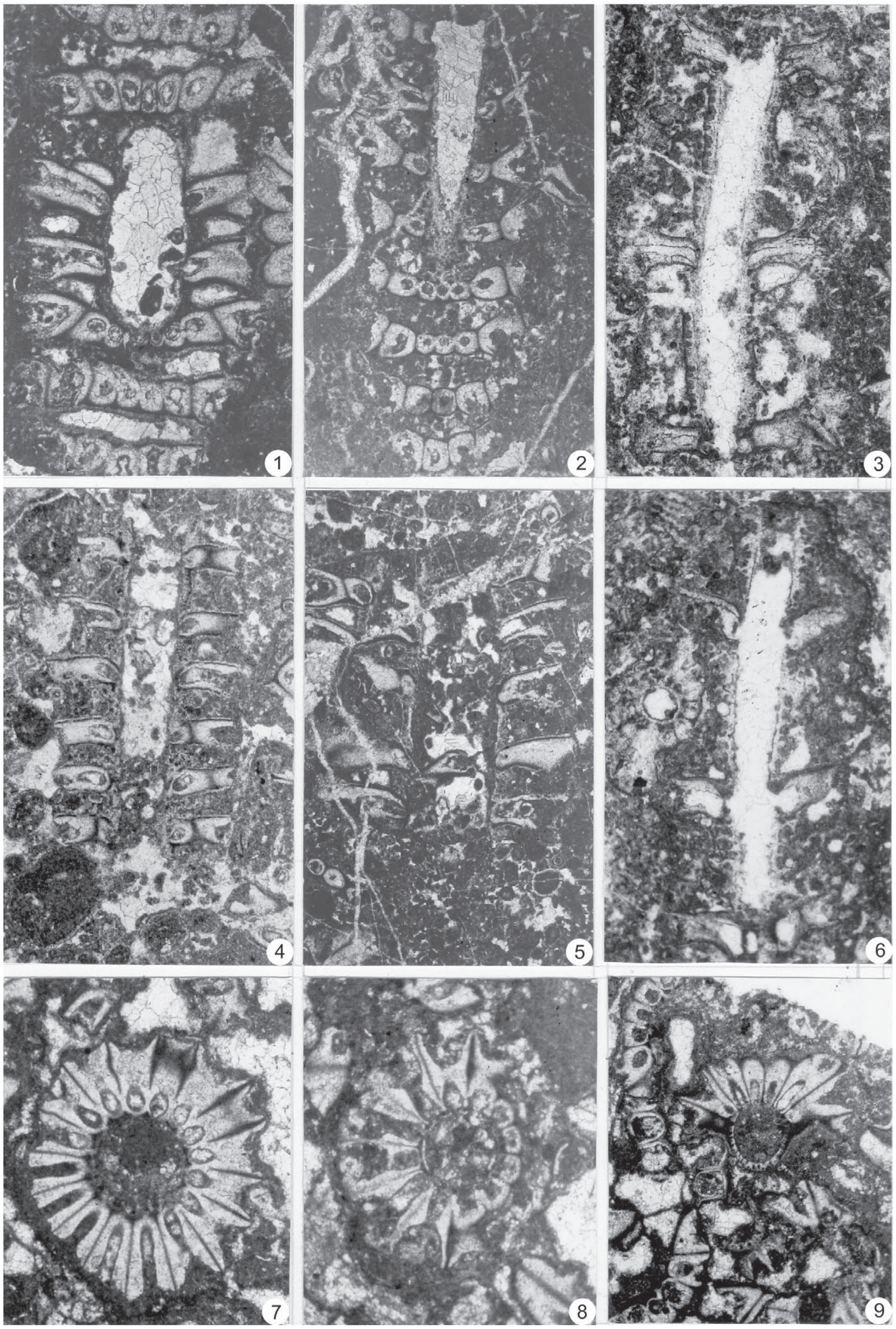

Plate III

1-2, 4-5, 7-9	*Clypeina jurassica* FAVRE
3, 6	*Clypeina lagustensis* n. sp.
1	Oblique section. Slide OG-6462, x 22.
2	Tangential-oblique section. Slide OG-6462/1, x 17.
4-5	Longitudinal sections. Slides: fig 4, OG-6462, x 22; fig. 5, OG-6462/1, x 17.
7	Transverse section. Slide i-4593/1, x 34.
8-9	Transverse, slightly oblique, sections. Slide: i-4593/1, fig. 8, x 34; fig. 9, x 22.
3, 6	Longitudinal sections, showing remotely spaced fertile whorls and short stalks of fertile laterals. Slide LSL-43/17, x 28.

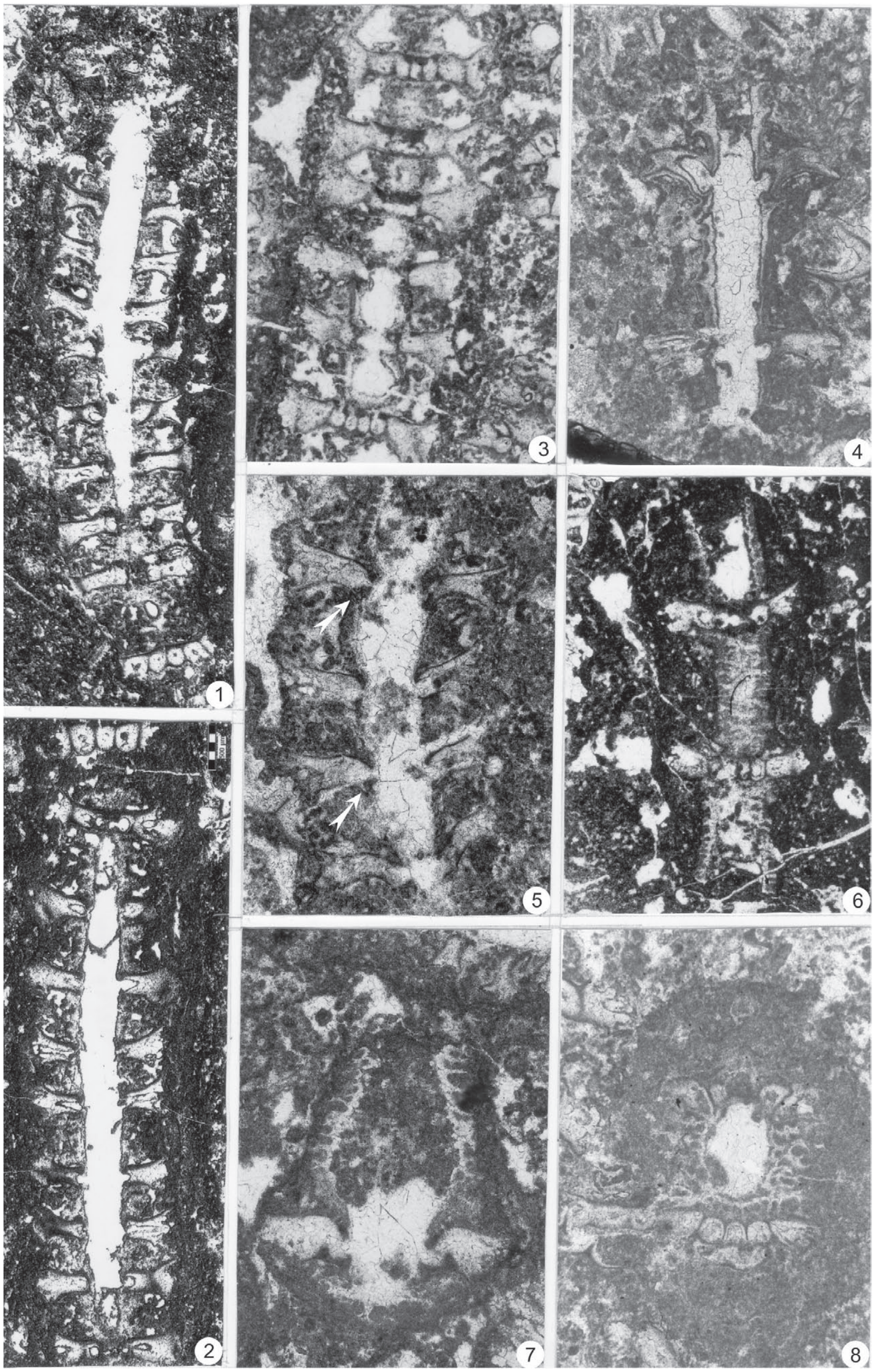

Plate IV

1-8 *Clypeina lagustensis* n. sp
1, 3 Longitudinal-tangential sections. Slides: fig. 1, LSL.43/22, x 17; fig. 3, LSL-43/17, x 22.
2, 4-5 Longitudinal sections. Slides: fig. 2, LSL 43/22, x 14; fig. 4 LSL-43/17, x 34; fig. 5, LSL-43/4, x 34.
6 Longitudinal-tangential section. Slide LSL-43/3, x 22.
7 Fragment of a longitudinal section. Slide LSL-43/3, x 34.
8 Oblique section cutting a whorl and a part of stalk; clearly visible pores and groups of sterile laterals. Slide LSL-43/1, x 34.

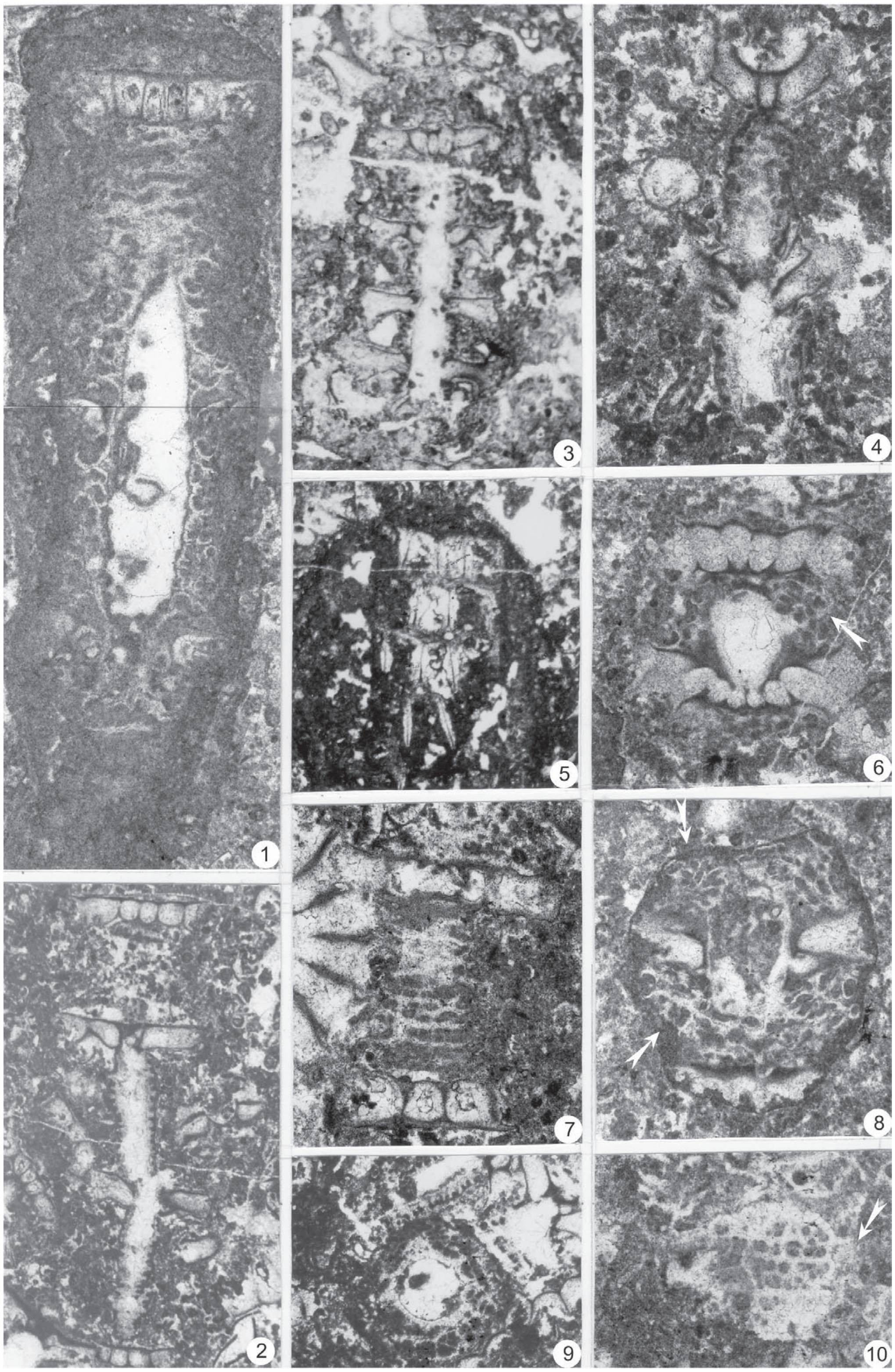

Plate V

1-10 *Clypeina lagustensis* n. sp.
1 Oblique section. Clearly visible proximal calcification of the thallus with sterile laterals grouped in bundles. Slide LSL-43/5, x 34.
2-3 Longitudinal sections. Slides: fig. 2, LSL-43; fig.3, LSL-43/17, x 22.
5 Fragment of a near-surface tangential section. Slide LSL-43/21, x 22.
6 Oblique section. Between fertile whorls, sterile laterals, grouped into bundles, forming clumps. Slide LSL-43/4, x 34.
7 Tangential section near central cavity. Sterile laterals lined in rows, starting to form bundles, grouped into clumps. Slide LSL-43/6, x 34.
8 Oblique section showing two whorls of fertile laterals, with groups of bundles of sterile laterals in between, irregularly spaced on the stem.
9 Transverse section of stem between fertile whorls, showing groups of sterile lateral bundles. Slide LSL-43/28, x 22.
10 Tangential section of stem between fertile whorls, showing rows of groups of sterile lateral bundles. Slide LSL-43/7, x 34.

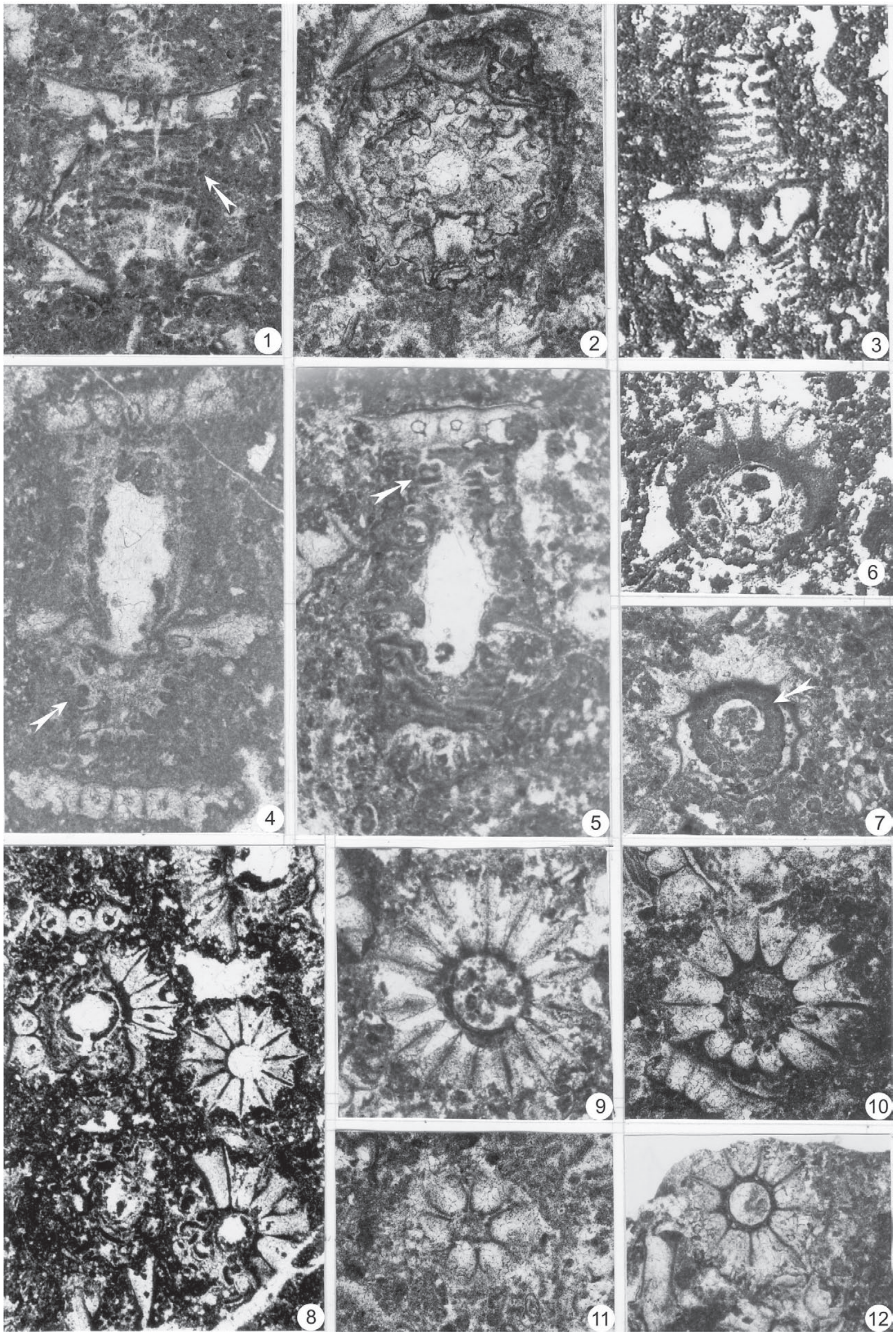

Plate VI

1-12 *Clypeina lagustensis* n. sp.

1 Tangential section, showing rows (whorls) of sterile laterals between fertile whorls,starting to group into bundles and form clumps. Slide LSL-43/15, x 28.

2 Transverse section of the stem between whorls, showing pronounced calcification of the clumps and envelopes. Slide LSL-43/27, x 34.

3 Tangential section showing rows of sterile laterals between fertile whorls. Slide LSL-43/22, x 38.

4 Oblique section with visible calcite cups of sterile laterals tufts between fertile whorls. Slide LSL-43/1, x 34.

5 Oblique section with visible rows of bundles grouped in clumps and calcitic cups of sterile laterals, depending on the depth and position of section. Slide LSL-43/9, x 34.

6-7 Transverse, slightly oblique sections, cutting through parts of the fertile whorls and a part of the stem with sterile laterals. Slides: fig. 6, LSL-43/10, x 22; fig. 7, LSL-43/15, x 34.

8-12 Transverse sections, showing a varying number of fertile laterals per whorl. Slides: fig. 8, LSL-43/20, x 22; fig. 9, LSL-43/10; fig. 10, LSL-43/8; fig. 11, LSL-43/6; fig. 12, LSL-43/18; all x 34. v