Five new species of Bartonian (Eocene) corals: Jaca Basin, Pyrenees, Spain

Alvaro ALTUNA[1], German ÁLVAREZ-PÉREZ[2], Pere BUSQUETS[2], Vicente ETAYO[1]

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Abstract: This paper deals with five new cnidarian species found in the Bartonian (Middle Eocene) of the Belsué-Atares and Pamplona Formations (Jaca Basin, Pyrenees).

The cnidarians are found on top of siliciclastic sediments deposited during a Bartonian regressive process that advanced from east to west. Moving up the stratigraphic record, the coral facies are found progressively further to the west. During this regressive process, many minor high-frequency transgressive episodes took place. The corals developed during these episodes of inundation.

The new species identified and systematically described are: *Millepora subpirenaica* n. sp. (Hydrozoa, Milleporina); *Stylocoenia sanctaorosiae* n. sp., *Stylophora binacuaensis* n. sp., *Leptoseris santaciliaensis* n. sp. and *Alveopora ataresensis* n. sp. (Anthozoa, Scleractinia). *Millepora subpirenaica, Stylocoenia sanctaorosiae* and *Leptoseris santaciliaensis* are widely distributed in the Jaca Basin. *Stylophora binacuaensis* and *Alveopora ataresensis* are more restricted. The identification of the genus *Leptoseris* within the Middle Eocene (Bartonian) implies an extension of the stratigraphic range of this genus, previously considered to date back only to the Oligocene.

Key words: Milleporina, Scleractinia, Eocene foreland basins, Pyrenees, Spain

Contents

[1] Sociedad Navarra de Paleontología. C/ González Tablas 4-2° D, 31004 Pamplona, e-mails: alboral@euskalnet.net, bylliblanca@arrakis.es

[2] Departament d'Estratigrafia, Paleontologia i Geociències Marines. C/ Martí Franques s/n, Zona Universitaria de Pedralbes, 08028 Barcelona, e-mails: galvarez@xtec.net, pere.busquets@ub.edu

1. INTRODUCTION

The coral facies of the Middle Eocene found in the Belsué-Atarés and Pamplona Formations, in the south-Pyrenean Foreland Basin of Jaca, have been the subject of considerable interest in terms of their situation and characterization (MALLADA, 1887; DALLONI, 1910, 1930; PUIGDEFÁBREGAS, 1975; CANUDO et al., 1991; TOLEDO, 1992; MILLÁN et al., 1994; HOGAN & BURBANK, 1996; MONTES-SANTIAGO, 2002).

However, their abundant coral fauna, though well known for many years, has been poorly studied and the few works consist merely of lists of species. DE VILLALTA (1956) cites a new genus and various new species in Bernués (La Gabardiella), which have never been described nor illustrated and, thus, cannot be considered as valid taxa. The original samples are currently reposited in the Museum of Mineralogy of the Diputació de Barcelona. Having examined the original samples, they are considered by us to be synonymous with previously described species. In our first work on the corals of the Belsué-Atarés and Pamplona Formations (ÁLVAREZ–PÉREZ et al., 2001) a list of species identified in the studied outcrops was presented, and the identification of new species was announced. In this paper, we give detailed descriptions of five new species.

2. LOCATION AND GEOLOGICAL SETTING

2.1. Stratigraphy

The Belsué–Atarés Fm. (PUIGDEFÁBREGAS, 1975) and Pamplona Fm. (MANGIN, 1959–1960) form part of the Middle and Upper Eocene (Bartonian and lower Priabonian) sedimentary succession that characterizes the Jaca Basin. These formations are part of a depositional system, schematically represented in Fig. 1a, that filled the basin from E to W, with alluvial and fluvial deposits (Campodarbe Fm.) changing to deltaic systems (Belsué-Atarés Fm.) and shelf systems (Pamplona Marls) (PUIGDEFÁBREGAS, 1975). Different authors have studied the Jaca Basin. CANUDO et al. (1991) place the coral facies within a sequence they name SD6, which includes the upper part of the Arguís Marls and the Belsué–Atarés Fm., leaving open the upper limit of the sequence. They place the Bartonian-Priabonian boundary in this sequence. TOLEDO (1992) concluded that the Jaca Sequence corresponds to a tectonic event of second order (5–7 m.y.), punctuated by eustatic discordances of third order (1.5 m.y). He defines three sequences. The corals are found in the uppermost, for which he does not establish a clear upper boundary. MILLÁN et al. (1994) identified four depositional sequences. The levels with carbonates containing the corals are placed in the high-level sedimentary system tract of the fourth sequence, often at the upper limit of the sequence. These authors observed that this limit of the sequence often corresponds with the contact between the Belsué-Atarés Fm. and the Campodarbe Fm., situating this sequence within the upper part of the lower Priabonian. HOGAN & BURBANK (1996) identified the magnetostratigraphic polarity units registered in this basin and

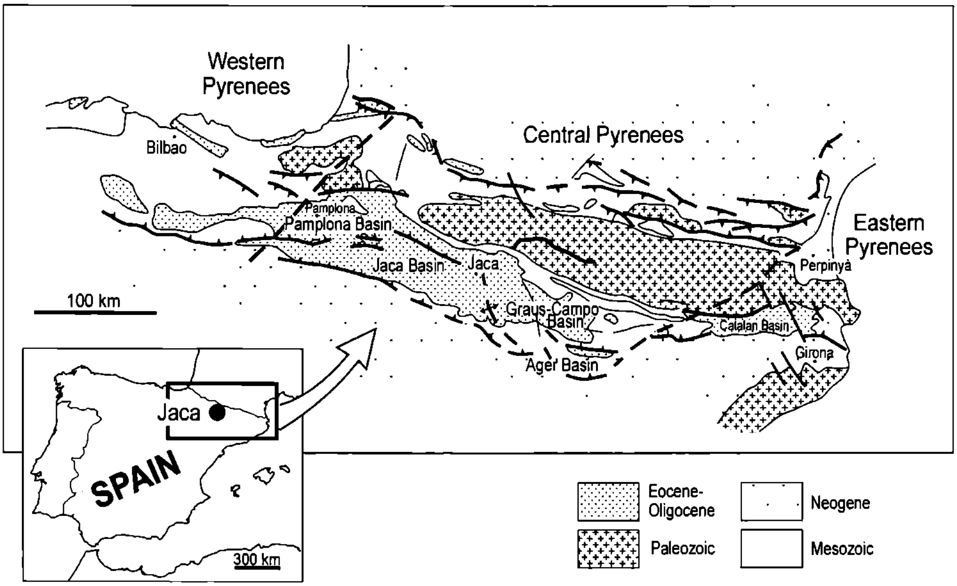

Fig. 1a: The Jaca Basin within the Pyrenees (modified after BARNOLAS & ZAMORANO, 1990).

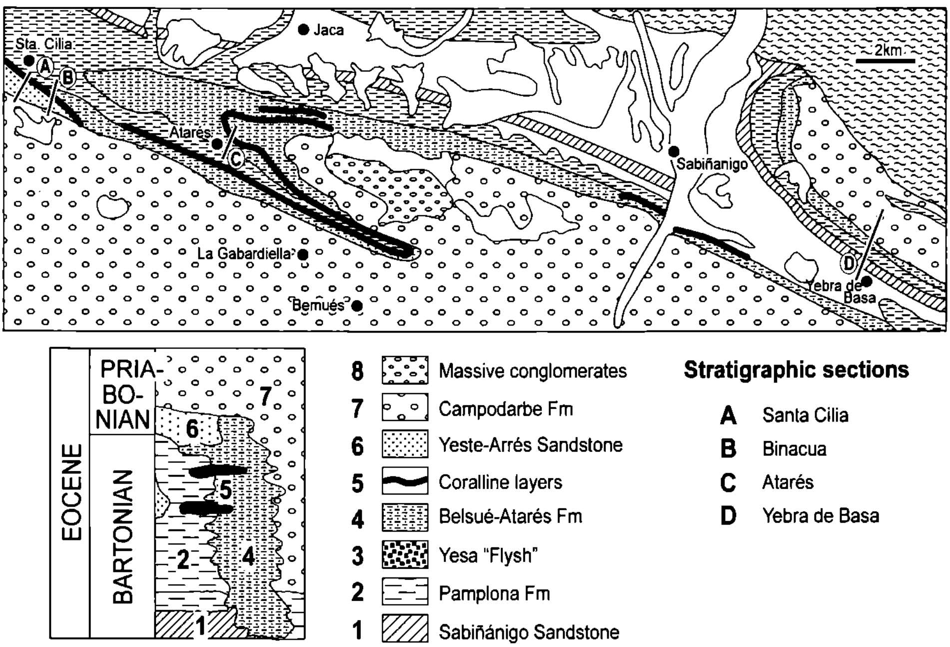

Fig. 1b: Detailed map of Jaca area showing the outcrops where new species have been identified, and the position of stratigraphic sections in Fig. 2 (modified after PUIGDEFÁBREGAS, 1975).

placed the coral facies in Chron 17, within which the Bartonian-Priabonian boundary lies. In his doctoral thesis on the sedimentary infill of the Jaca Basin, MONTES-SANTIAGO (2002) includes the coral facies in the Sabiñánigo mega-sequence, corresponding to the Sabiñánigo-Belsué sequence within the Bartonian. In this paper we use the ages accepted by MONTES-SANTIAGO (2002). According to PUIGDEFÁBREGAS (1975), the locations of the coral facies become stratigraphically higher, the further one moves to the west, because regression advanced from E to W. Many high-frequency transgressive episodes took place during this regressive process. MILLÁN et al. (1994) considered them as parasequences that would represent high order cycles (100,000 years), although they are not well identified in terms of their lateral extension.

2.2. Coral facies

The coral facies associated with the Belsué-Atarés and Pamplona Formations are related to high frequency transgression cycles and can be subdivided into three types:

1. Horizons of some centimeters in thickness situated between pro-delta marls and deltaic front sands, or directly on top of sandbanks. The corals are found in life-position or overturned.
2. Small patch reefs of up to three meters in thickness, developed on the top of marls situated in the transition phase from deltaic front sands to pro-delta marls.
3. Coral fauna belonging to the previous sub-environments, transported and included in the debris flows and interbedded with the pro-delta marls.

3. MATERIAL AND METHODS

An initial identification of the species with location of the outcrops was undertaken by ÁLVAREZ-PÉREZ et al. (2001). The outcrops where these new species were found are (UTM 30N) at: Atarés x 06 94678, y 47 11055, z 762 m; Binacua x 06 89107, y 47 12692, z 771 m; Santa Cilia x 06 87284, y 47 1317 6, z 718 m and Yebra de Basa x 07 24311, y 47 08320, z 995 m (Fig. 1).

The external morphology of the samples has been studied with the aid of a binocular microscope. It was not possible to study the internal structure since all the samples studied, irrespective of the subenvironment from which they were taken, were subjected to recrystallisation.

The morphometric data are, where possible, based on the measurement of at least 50 specimens.

Samples were coated with a 16 nm layer of gold using an Emitech K550 sputter-coater and a "DSM Zeiss 940 A" Scanning Electron Microscope (SEM) was used for observation and microphotography.

In the text the following abbreviations are used: GCD = maximum calices diameter; LCD = minimum calices diameter. MGSCB: Geological Museum of the Seminari Conciliar in Barcelona. MZNA: Museum of Zoology of the Universidad de Navarra. SNP: Navarra Paleontological Society. CGAP: G. Álvarez-Pérez collection.

4. SYSTEMATICS
(by Alvaro Altuna and German Álvarez-Pérez)

Class Hydrozoa Owen, 1843
Order Milleporina Hickson, 1901
Family Milleporidae Fleming, 1828
Genus *Millepora* Linné, 1758

Type Species *Millepora alcicornis* Linné, 1758

Millepora subpirenaica n. sp.
Plate 2, Figs. 3, 4, 6, 7

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Holotype: Specimen from Binacua reposited in the MGSCB with the catalog number 68073. **Paratypes:** 4 specimens reposited in the MZNA with catalog numbers TS-647, TS-648, TS-649, TS-650; 3 specimens reposited in the MGSCB with catalog numbers 68071, 68072, 68075. **Additional material:** 29 specimens reposited in the SNP and 359 in the CGAP.
Type locality: Binacua (Fig. 1). Stratigraphic section in Fig. 2.
Type formation: Belsué-Atarés Fm. (Puigdefábregas, 1975) in the Jaca Basin.
Derivation of name: from the southern Pyrenees.
Diagnosis: Branching colonies of vertical laminae fan-shaped in form, some 2.8 cm in height forming a broad plate (Pl. 2, Figs. 3, 4). Small fixation base (Pl. 2, Fig. 4). Gastropores and dactylopores situated on both sides of the laminae (Pl. 2, Figs. 3, 4). Ampullae in small half-moon shaped protuberances, set on the lamina base (Pl. 2, Figs. 4, 6). Finely granulated coenosteum (Pl. 2, Figs. 3, 7).
Description: Colonies in thin, smooth laminae, with a slightly undulating upper edge (Pl. 2, Figs. 3, 4), rising from the substratum with a small fixation base and laminae reaching some 2.8 cm in height (Pl. 2, Fig. 4). The distal extreme has vertical folds that produce new laminae forming a broad plate (Pl. 2, Figs. 3, 4). The gastropores and dactylopores are very similar (Pl. 2, Figs. 3, 7) and are arranged on both sides of the laminae (Pl. 2, Figs. 3, 4). They are cylindrical, covered by transverse tabulae, and are distributed irregularly (Pl. 2, Figs. 3, 4, 7). The cyclosystems are difficult to distinguish (Pl. 2, Fig. 7). The ampullae appear at the base of many branches (Pl. 2, Fig. 4) forming half-moon shaped protuberances (Pl. 2, Fig. 6). Finely granulated coenosteum between the pores (Pl. 2, Figs. 3, 7). The tubes of the coenosarc are very small in diameter and form an irregular internal network of interconnected channels.
Dimensions (average values in mm): Laminae: height: 17.5; width: 9.4; thickness: 2.0. Gastropores: diameter: 0.58. Dactylopores: diameter: 0.187.
Stratigraphic distribution: Bartonian (Middle Eocene).
Geographic distribution: The distribution of this species extends beyond the Jaca Basin, as suggested by its identification in the Bartonian outcrop of Vinya Macià, in Castellolí (Barcelona).
Related species: In the studied outcrops the species *Millepora mammillosa* d'Achiardi, 1867, *M. reussi* Kühn, 1925, and *M. dalmatina* Oppenheim, 1901, have also been identified.

The characteristics used to distinguish the new species from those previously described are the form and relative size of the pores, and the presence or absence of ampullae, characteristics that we consider to be sufficient to justify the differentiation of this species.

Millepora subpirenaica differs from:

- *M. mammillosa,* in growth pattern, the latter forming encrusting rounded masses, and in the absence of the small excrescences that appear between the pores in *M. mammillosa*. Finally, the ampullae of *M. subpirenaica* are visible, unlike those of *M. mammillosa.*
- *M. reussi,* in its growth form, the latter is a branching colony, and in the location of the pores which are situated on top of small papillae in *M. reussi*. Additionally, the ampullae of *M. subpirenaica* are visible, unlike those of *M. reussi.*
- *M. dalmatina* and *M. cylindrica* REUSS, 1864, in its growth pattern, the latter two having small branching forms, as well as in differing arrangements of the pores. In *M. subpirenaica* pores are sited on both sides of the laminae, while in *M. dalmatina* and *M. cylindrica* they are found on the tops of small cylindrical papillae. In addition, *M. dalmatina* and *M. cylindrica* have ampullae that are not visible, unlike those of *M. subpirenaica.*
- *M. depauperata* REUSS, 1864, in its growth form, the latter having small compressed branches, and many pores surrounded by weakly raised margins. In addition, *M. depauperata* has ampullae that are not visible, unlike those of *M. subpirenaica.*
- *M. samueli* D'ARCHIAC, 1846, in its growth pattern, the latter appearing in encrusting masses. The pores of *M. subpirenaica* differ from those of *M. samueli* by not exhibiting small protuberances at the bases. Also, the ampullae of *M. subpirenaica* are visible, unlike those of *M. samueli* (D'ARCHIAC, 1846).
- *M. tornquisti* BOSCHMA, 1951, in its growth pattern, the latter having slightly flattened branches. In addition the gastropores and dactylopores of *M. tornquisti* can be clearly differentiated. In addition, the ampullae of *M. subpirenaica* are visible, unlike those of *M. tornquisti* (BOSCHMA, 1951).

Class Anthozoa EHRENBERG, 1834
Subclass Hexacorallia HAECKEL, 1866
Order Scleractinia BOURNE, 1900
Suborder Astrocoeniina FELIX, 1898
Family Astrocoeniidae KOBY, 1890
Genus *Stylocoenia* MILNE-EDWARDS & HAIME, 1848

Type species: *Astrea emarciata* LAMARCK, 1816

Stylocoenia sanctaorosiae n.sp.
(Pl. 1, Figs. 1, 2, 3, 4, 6)

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Holotype: Specimen from Yebra de Basa reposited in the MZNA with the catalog number TS-651. **Paratypes:** 4 specimens reposited in the MZNA with the catalog numbers TS-652, TS-653, TS-654, TS-655; 2 specimens reposited in the MGSCB with the catalog

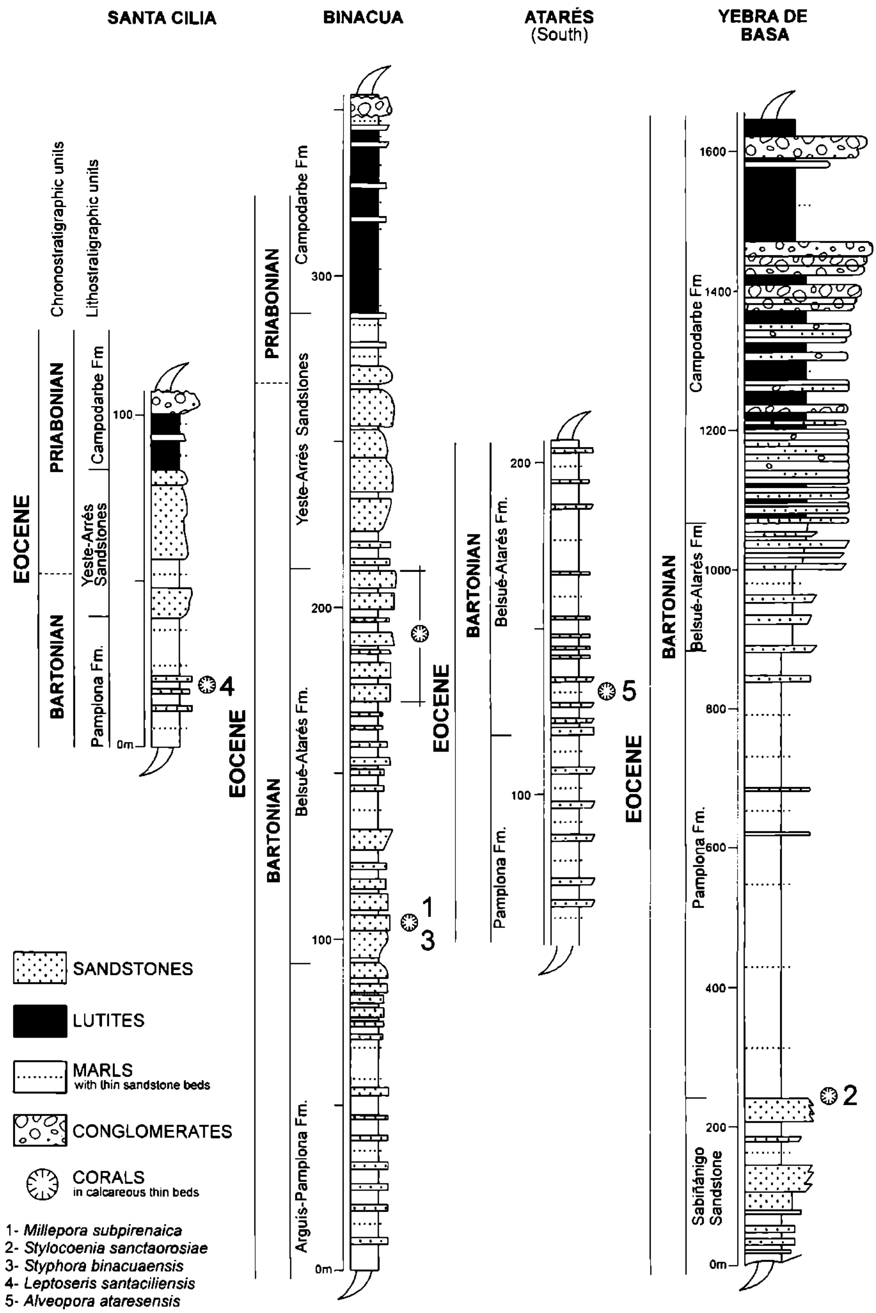

Fig. 2: Modified sections of Montes-Santiago (2002) showing the stratigraphic horizons in which the new species are found. The chronostratigraphic units are due to Montes-Santiago (2002) and the lithostratigraphic units are those of Puigdefábregas (1975).

numbers 68352, 68353. **Additional material:** 50 specimens reposited in the SNP and 51 in the CGAP.
Type locality: Yebra de Basa (Fig. 1). Stratigraphic section in Fig. 2.
Type formation: Pamplona Fm. (Mangin, 1959–1960).
Derivation of name: after the church at Santa Orosia.
Diagnosis: Cerioid spherical colonies (Pl. 1, Fig. 1); some of them have a rudimentary fixation.
Epitheca with distinct transverse folds (Pl. 1, Figs. 3, 4). Polygonal-shaped corallites, with two cycles of septa arranged in octameral symmetry and with a diameter of less than 2 mm (Pl. 1, Figs. 1, 2). The intercorallite pillars are prismatic and lined with crests and marked grooves (Pl. 1, Figs. 3, 4, 6).
Description: Spherical or slightly flattened cerioid colony (Pl. 1, Fig. 1). Rudimentary fixation peduncle (Pl. 1, Fig. 3). Lower face marked by well developed intercorallite pillars (Pl. 1, Figs. 1, 2, 3, 4, 6). Epitheca with remarkable transverse folds (Pl. 1, Figs. 3, 4). Small polygonal calices separated by a paraseptothecal bold wall (Pl. 1, Figs. 1, 2). The fossa of the calice is shallow (Pl. 1, Fig. 2). Fine compact septa in two cycles arranged in octameral symmetry with S1 > S2 (Pl. 1, Figs. 1, 2). The S1 forms a concave arch before joining the base of the central columella (Pl. 1, Fig. 2). The lateral faces are smooth or with small isolated granules. This arrangement is not visible. The S2 are limited to a series of spines attached to the wall and are smooth (Pl. 1, Fig. 2). Styliform columella, laterally compressed in the direction of the two main opposed septa; only exceptionally they stand out above the edge of the calice (Pl. 1, Figs. 1, 2). Often, the base extends beyond the inner edge of the septa to which it is joined and resembles a star. Intercorallite pillars of variable size and density. They appear above the wall at the point where 2–5 contiguous calices join (Pl. 1, Fig. 2). They are prismatic and marked by 5–9 parallel crests separated by a well-marked groove (Pl. 1, Figs. 3, 4, 6). Extratentacular budding.
Dimensions (average values in mm): Colonies: main axis: 24.1; lesser axis: 18.0; height: 18.7. Calices: LCD: 0.7; GCD: 1.3. Intercorallite pillars: diameter: 0.89; height: 1.18. Walls: thickness: 0.22.
Stratigraphic distribution: Bartonian (Middle Eocene).
Geographic distribution: Jaca Basin, abundant in the Basa valley.
Related species: *S. macrostyla* Reuss, 1870, *S. taurinensis* (Michelin, 1842) and *S. aurelii* Álvarez-Pérez, 1993.
The characteristics used to distinguish this new species from those previously described are number of septal cycles, septal symmetry, intercorallite pillar form, number of crests and, in some cases, the colony and holoteca form. These characteristics are considered to be sufficient to differentiate this species.
Stylocoenia sanctaorosiae differs from:
- *S. macrostyla,* in terms of the dimensions of the calices (that of the latter are larger), and in the septal symmetry and number of cycles. *S. macrostyla* has three septal cycles arranged in octameral symmetry. Finally, *S. macrostyla* also differs in having cylindrical intercorallite pillars with 8–16 crests, with a height of 4 mm.
- *S. taurinensis,* by its growth pattern, the latter being found in branching colonies. In addition, though *S. taurinensis* also has two cycles of septa, these are arranged in hexameral symmetry. Unlike *S. sanctaorosiae, S. taurinensis* has intercorallite pil-

lars that are conical in form and elliptical in section, and 6–8 crests that are forked at the base (MICHELIN, 1842; ZLATARSKI, 1961a).

- *S. aurelii*, by its growth pattern, the latter appearing in branching colony form. In addition, *S. sanctaorosiae* has calices that are larger in diameter, and, albeit *S. aurelii* also has two cycles of septa, but they are arranged in hexameral symmetry. Finally, *S. aurelii* has very abundant conical intercorallite pillars that are elliptical in section, and 7–8 crests that are forked at the base (ÁLVAREZ-PÉREZ, 1993).
- *S. emarciata* (LAMARCK, 1816) and *S. emarciata* v. *major* FELIX, 1909, in different intercorallite pillars and crests. In *S. emarciata* and *S. emarciata* v. *major* pillars are conical in form and elongated elliptical in section, and there are 16–20 crests forked at the base.
- *S. maxima* DUNCAN, 1863, by different arrangement of the septa which of decameral symmetry in *S. maxima*. In addition, unlike *S. sanctaorosiae*, *S. maxim* has intercorallite pillars with 20 crests.
- *S. monticularia* SCHWEIGER, 1819, by its symmetry. In contrast to *S. sanctaorosiae* the arrangement the two cycles of septa in *S. monticularia* is hexameral. In addition, *S. monticularia* has larger intercorallite pillars.
- *S. sanmigueli* SOLÉ-SABARÍS, 1942, in its growth pattern, the latter forming a hemispherical colony with a fixation base. In addition, *S. sanmigueli* has a markedly circular holotheca, and 10 septa arranged in just one cycle (SOLÉ-SABARÍS, 1942).
- *S. monocycla* (D'ACHIARDI, 1866), *S. neutra* BARTA-CALMUS, 1973 and *S. vicary* Haime, 1852, in terms of the size of the calices, which are larger in *S. sanctaorosiae*. In addition, the three corals mentioned above have three cycles of septa arranged in hexameral symmetry, and smaller intercorallite pillars.
- *S. saxulensis* D'ACHIARDI, 1866, reagrding the size of the calices, which are larger in *S. sanctaorosiae*. Also, *S. saxulensis* has septa arranged in hexameral symmetry.
- *S. delicata* OPPENHEIM, 1901, which is similar to *Glyphastraea* DUNCAN (ZLATARSKI, 1963b)

Family Pocilloporidae GRAY, 1842
Genus *Stylophora* SCHWEIGER, 1819

Type species: *Madrepora pistillata* ESPER, 1797

Stylophora binacuaensis n. sp.
(Pl. 2, Figs. 8, 9, 10, 11)

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Holotype: Specimen from Binacua reposited in the MZNA, with the catalog number TS- 656. **Paratypes:** 10 specimens reposited in the MZNA with catalog numbers TS-657, TS-658, TS-659, TS-660, TS-661, TS-662, TS-663, TS-664, TS-665, TS-666; 2 specimens reposited in the MSCGB with catalog numbers 68080, 68081. **Additional material:** 50 specimens reposited in the SNP and 100 in CGAP.
Type locality: Binacua (Fig. 1). Stratigraphic section in Fig. 2.
Type formation: Belsué-Atarés Fm. (PUIGDEFÁBREGAS, 1975) in the Jaca Eocene Basin.
Derivation of name: from the locality of Binacua.

Diagnosis: Branching colonies. Short, thin branches with a rounded or pointed tip, frequent anastomosis (Pl. 2, Figs. 8, 9). Circular or elliptical calices, less than 1 mm in diameter, with a well-marked edge (Pl. 2, Figs. 9, 10, 11). Three cycles of septa arranged in hexameral symmetry with S1>S2>S3, the last being almost always incomplete (Pl. 2, Figs. 10, 11). Septothecal walls (Pl. 2, Figs. 10, 11). Costae are reduced to 3–4 small granules aligned to a continuation of the septa (Pl. 2, Figs. 10, 11).
Description: Plocoid branching colonies fixed on an inappreciable base (Pl. 2, Fig. 8). Fan-shaped colonies branching in one single plane or in all directions, forming plaques of variable sizes (Pl. 2, Figs. 8, 9). Branches with a rounded or pointed tip, circular or elliptical in section (Pl. 2, Figs. 8, 9), larger diameter in the distal parts than in the proximal, with total or partial fusion (Pl. 2, Figs. 8, 9), annular coenosteum, with small, conical, spiny or laminar granules, abundant and irregularly distributed (Pl. 2, Figs. 10, 11). Numerous corallites, with a tendency, in young branches, to arrange themselves in a helicoidal way (Pl. 2, Fig. 10). Circular or elliptical calices with an edge that clearly stands out above the coenosteum (Pl. 2, Figs. 10, 11). Shallow fossa of the calice (Pl. 2, Figs. 10, 11). Two complete cycles of septa and a third which is almost always incomplete, rudimentary and formed of lamines, arranged with hexameral symmetry (Pl. 2, Figs. 10, 11). The 6 S1 reach the center of the calice and join the columella (in the young calices they form a concave arch) (Pl. 2, Fig. 11). Straight or slightly undulating axial edge (Pl. 2, Fig. 11). The 6 S2 are finer and shorter; the S3 are much finer and more rudimentary (Pl. 2, Fig. 11). Lateral faces of septa and upper edge are smooth. Fine styliform columella, sunken within the calice; it may appear flattened laterally forming a plane of symmetry (Pl. 2; Fig. 11). Differentiated septothecal wall (Pl. 2, Figs. 10, 11). Costae reduced to three or four small granules (Pl. 2, Fig. 10, 11). Extratentacular budding.
Dimensions (average values in mm): Colonies: height: 14.2. Main Branch: diameter: 4.1. Branches: diameter at the base: 2.5; diameter at the end: 1.7. Calices: LCD 0.446. GCD: 0.612. Septa: S1: length: 0.275; width (mid-zone): 0.037; S2: length: 0.229; width (mid-zone): 0.377; S3: length: 0.108; Columella: length: 0.147. width: 0.057; Costal granules (µm): thickness: 111; density: 4–5 / mm.
Stratigraphic distribution: Bartonian (Middle Eocene).
Geographic distribution: Jaca Basin.
Related species: *S. herzegowinensis* Oppenheim, 1901, and *S. contorta* (Leymerie, 1846) are co-occurring.
The characteristics used to distinguish the new species from those previously described are shape and relative size of the calices, number of septal cycles, and septal symmetry. These characteristics are considered to be sufficient to differentiate species.
Stylophora binacuaensis differs from:
- *S. herzegowinensis* in the appearance of the calices. Unlike *S. binacuaensis* calices in *S. herzegowinensis* are sunk within the coenosteum. In addition, *S. herzegowinensis* has just two septal cycles arranged in hexameral symmetry.
- *S. contorta* in different sizes of the calices, those of *S. binacuaensis* are smaller. Additionally, *S. contorta* has also two septal cycles arranged in hexameral symmetry.
- *S. alloiteaui* Grange, 1956, *S. alpina* (d'Orbigny, 1850), *S. annulata* Reuss, 1864, *S. conferta* Reuss, 1868, *S. distans* Leymerie, 1846, *S. minuta* Duncan, 1880, *S. minutissima* Vaughan, 1900, *S. parvistella* Chevalier, 1961, *S. rugosa* d'Archiach, 1850, by a diverg-

ing number of septal cycles, all of them having only one septal cycle arranged in hexameral symmetry.
- *S. affinis* DUNCAN, 1863, *S. cambridgensis* WELLS, 1934, *S.* sp. cf. *cambridgensis* WELLS, 1934, *S. compresa* DUNCAN, *S. falloti* GRANGE, 1956, *S. faudonensis* GRANGE, 1956, *S. italica* (D'ACHIARDI, 1866), (VAUGHAN, 1919), *S. microstyla* (MENEGHINI) D'ACHIARDI, 1866, *S. montium* OPPENHEIM, 1912, *S. ponderosa* VAUGHAN, 1900, *S. tuberosa* (CATULLO, 1856), *S.* sp. 1 BARTA-CALMUS, 1973, *S.* sp. 2 BARTA-CALMUS, 1973 and *S. willoughbyi* WELLS, 1945 by different numbers of septal cycles. All these corals have only two septal cycles arranged in hexameral symmetry.
- *S. thirsiformis* (MICHELOTTI, 1847), by the size of the calices, the latter having very large calices. *S. thirsiformis*, in addition, has only two developed septal cycles and one incomplete septal cycle, all of them are arranged in hexameral symmetry. The septa of the third cycle are developed as spines.
- *S. granulata* DUNCAN, 1864, by the morphology of calices. In *S. granulata*, calices are very deep, and surrounded by a raised ring. *S. granulata* also has three complete septal cycles arranged in hexameral symmetry (DUNCAN, 1873).

DE VILLALTA, 1956, cites two new species, *Stylophora bernuesensis* ALLOITEAU, 1956 and *S. multigranulata* ALLOITEAU, 1956, which have never been described or illustrated. We have examined the original samples, and in our opinion *S. bernuesensis* belongs to *S. contorta* and *S. multigranulata* to *S. herzegowinensis*.

Family Poritidae GRAY, 1842

Genus *Alveopora* DE BLAINVILLE, 1830

Type species: *Madrepora daedalea* FORSKAL, 1775

Alveopora ataresensis n. sp.
(Pl. 1, Fig. 11; Pl. 2, Figs. 1, 2, 5)

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Holotype: Specimen from Atarés reposited in the MZNA with the catalog number TS-667 **Paratypes:** 3 specimens from Binacua, reposited in the MZNA, with catalog numbers TS-668, TS-669, TS-670; 3 specimens reposited in the MGSCB with catalog numbers 68077, 68078, 68079. **Additional material:** 17 specimens in the SNP and 59 specimens in CGAP.

Type locality: Atarés (Fig. 1). Stratigraphic section in Fig. 2.

Type formation: Belsué-Atarés Fm. (PUIGDEFÁBREGAS, 1975) in the Eocene Jaca Basin (Bartonian).

Derivation of name: named after the locality of Atarés.

Diagnosis: Massive or ramose cerioid colonies (Pl. 1, Fig. 11). Thick branches. Polygonal corallites (Pl. 2, Figs. 1, 2). The bases of the calices are closed by sub-horizontal tabular dissepiments (Pl. 2, Fig. 1). The maximum corallites have 1–3 highly developed asymmetric septa (Pl. 2, Fig. 2). Button-shaped asymmetric columella. Wall has small perforations aligned vertically (Pl. 2, Figs. 1, 2).

Description: Cerioid colonies, massive or ramose (Pl. 1, Fig. 11). Branches, rounded to a greater or lesser extent, divided dichotomically, elliptical in section. Polygonal, irregular corallites with 4 to 6 well-defined sides which are of distinct sizes (Pl. 1, Fig. 11; Pl. 2, Figs. 1, 2). Deep calices, wider at the top than at the bottom, which is closed by large endothecal tabular dissepiment (Pl. 2, Fig. 1). Septa generally displayed in two complete cycles with a third cycle represented by nearly horizontal spines, displayed in parallel lines attached to the wall (Pl. 2, Fig. 2). Generally, two opposite S1 septa appear, which join forming a lamina that gives the calice a bilateral symmetry, with three S1 septa arranged on the same side of the calice (Pl. 2, Fig. 2). The 6 S2 are barely visible and generally consist of fine lines of septal spines. Hexameral symmetry. Conical columella, not very prominent developed, with an elliptical base. Prominent wall, triangular in section, robust and wide at the base, with an undulating upper edge perforated with very small orifices (Pl. 1, Fig. 11; Pl. 2, Fig. 1), uniformly distributed and aligned vertically following the axis of the calice. Extratentacular budding.

Dimensions (average values in mm): Branches: diameter: 11.6; length: 30.8. Calices: LCD: 1.7. GCD: 2.3. Endothecal laminae: vertical distances: 0.95. Columella: diameter: 0.75. Wall: distances of the rows of perforations: 0.5.

Stratigraphic distribution: Bartonian (Middle Eocene).

Geographic distribution: Jaca Basin.

Related species: The characteristics used to distinguish this new species from those previously described are the shape and relative size of the calices, number of cycles, and septal symmetry. These characteristics are considered to be sufficient to differentiate this species.

Alveopora ataresensis differs from:

- *A. gracilis* Tornquist, 1905, in terms of the size and form of the calices. In *A. gracilis,* these are larger, and more rounded, and have a thinner wall.
- *A. chiapenacae* Frost & Langenheim, 1975, in terms of the size of the calices. In *A. ataresensis* these are smaller. In addition, *A. chiapenacae* has 4 to 7 irregularly developed septal spines (Frost & Langenheim, 1975).
- *A. rudis* Reuss, 1864, in terms of the number of septa cycles. In *A. rudis,* there is just a single cycle of septa arranged in hexameral symmetry (Reuss, 1864).
- *A sepulta* d'Achiardi, 1868, in terms of its growth pattern and calice size. *A sepulta* is found in encrusting colonies, and its calices are larger than those of *A. ataresensis*.
- *A. somaliensis* Azzaroli, 1958, in terms of growth pattern, calice size and number of septa cycles. *A. somaliensis* grows in encrusting colonies, has smaller calices than *A. ataresensis* and two cycles of septa (Azzaroli, 1958).

The Miocene species:

- *A. daxensis* Chevalier, 1961, in terms of calices size and number of septa cycles. The calices *A. daxensis* are smaller than those of *A. ataresensis* and it has only two cycles of septa.
- *A. meridionalis* Chevalier, 1961, in terms of growth pattern and calice size. *A. meridionalis* forms rounded colonies, and has larger calices than those of *A. ataresensis.* In addition, the S1 of *A. meridionalis* are more developed, reaching the central columella (Chevalier, 1961).

Family Agariciidae Gray, 1847

Genus *Leptoseris* Milne-Edwards & Haime, 1849

Type species: *Leptoseris fragilis* Milne-Edwards & Haime, 1849

Leptoseris santaciliaensis n. sp.
(Pl. 1, Figs. 5, 7, 8, 9, 10)

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Holotype: Specimen from Santa Cilia reposited in the MZNA with catalog number TS-671. **Paratypes:** 4 specimens reposited in the MZNA with catalog numbers TS-672, TS-673, TS-674,TS-675; 4 specimens reposited in the MGSCB with catalog numbers 68069, 68070, 68074, 68076. **Additional material**: 79 specimens reposited in SNP and 400 reposited in CGAP.
Type locality: Santa Cilia. Stratigraphic section in Fig. 2.
Type formation: Pamplona Fm. (Mangin, 1959–1960) in the Eocene Jaca Basin (Bartonian).
Derivation of name: named after the locality of Santa Cilia.
Diagnosis: Laminar, unifacial colonies (Pl. 1, Figs. 7, 8, 10). Laminae with thin and irregularly divided edges (Pl. 1, Fig. 8). Lower face with folds, covered with granulated costae (Pl. 1, Fig. 7). Differentiated central corallite (Pl. 1, Fig. 5). Superficial calices, less than 2 mm in diameter, and with 10–26 septa with thick and thin ones alternating (Pl. 1, Figs. 9, 10). Distally and laterally granulated septa (Pl. 1, Fig. 9). Small papillary columella (Pl. 1, Fig. 9). Discontinuous and poorly developed collines (Pl. 1, Figs. 8, 9, 10). Circumoral intratentacular budding (Pl. 1, Fig. 8).
Description: Laminar, unifacial colonies (Pl. 1, Fig. 8). Laminae with thin and irregularly divided edges (Pl. 1,. Fig. 8). The lower face has longitudinal folds, corresponding to the collines of the upper face, covered with fine radial costae, compressed, and divided dichotomically with sharp granular teeth in their distal margins (Pl. 1, Fig. 7). Thick fixation peduncle which a corresponding central calice (Pl. 1, Fig. 5). Superficial calices arranged concentrically, extending upwards in a fan-shape (Pl. 1, Figs. 8, 10). Bilateral symmetry (Pl. 1, Fig. 9). Well defined and differentiated, shallow fossa of the calice (Pl. 1, Fig. 9). 10–26 septa arranged in three cycles with thick and thin ones alternating (Pl. 1, Figs. 9, 10). The S1 are thicker and higher and decline vertically to the interior of the calice, reaching the columella; the S 2 are finer and shorter; the S3 even more so (Pl. 1, Fig. 9). The columella, which is hardly visible, is formed by one or more papillae (Pl. 1, Fig. 9). Circumural intratentacular budding (Pl. 1, Fig. 8).
Dimensions (average values in mm): Branches: length: 31.8; width: 2.9; thickness of base: 3.4; thickness of edge: 1.6. Calices: GCD: 0.81; LCD: 0.63: number of septa: 10–26. Central calice: cup: 5.98 x 1 mm; number of septa, 119. Costae: frequency: 3–7 / mm.
Stratigraphic distribution: Bartonian (Middle Eocene).
Geographic distribution: Jaca Basin.
Related species: The characteristics used to distinguish this new species from those previously described are the shape and relative size of the colonies, the form and frequency of costae of the lower face, the form and size of collines, the number of septa,

septal symmetry, the margins of the septa, and columella form. These characteristics are considered to be sufficient to differentiate this species.

Leptoseris santaciliaensis differs from:

- *L. antiqua* REUSS, 1869 in having undulating laminae, 18 short, thick, granulated and each other similar septa, and a spongy columella which are not characteristic of *L. santaciliaensis*.
- *L. meneghinii* DAINELLI, 1904, by the fact that it exhibits closely neighbouring cups, 30 similar septa, and a spongy columella (DAINELLI, 1904).
- *L. portoricensis* VAUGHAN, 1919, by poorly defined calices arranged in transverse series, 12–18 septa with alternating thick and thin ones, no columella, and 28 costae/cm on the lower face (VAUGHAN, 1919).

5. CONCLUSION

Five new species of fossil cnidarians from the Bartonian-Priabonian (Middle/Upper Eocene) of the Belsué-Atares and Pamplona Formations (Jaca Basin, Pyrenees) are described: *Millepora subpirenaica* n. sp. (Hydrozoa, Milleporina); *Stylocoenia sanctaorosiae* n. sp., *Stylophora binacuaensis* n. sp., *Leptoseris santaciliaensis* n. sp. and *Alveopora ataresensis* n. sp. (Anthozoa, Scleractinia).

Millepora subpirenaica, Stylocoenia sanctaorosiae and *Leptoseris santaciliaensis* are widely distributed in the studied area, while *Stylophora binacuaensis* and *Alveopora ataresensis* are more restricted.

The identication of the genus *Leptoseris* within the Middle Eocene (Bartonian) implies an extension of the stratigraphic range of this genus, previously considered to date back only to the Oligocene.

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Plate 1

Stylocoenia sanctaorosiae n. sp.

Fig. 1: Holotype. Spherical, cerioid colony.

Fig. 2: Holotype. Detail of the colony. Calice with septa and columella. Intercorallite pillars in adjacent calices

Fig. 3: Paratype 1. Colony base. Intercorallite pillars and small holotheca.

Fig. 4: Paratype 1. A detail of the Fig. 2. Intercorallite pillars.

Fig. 6: CGAP-12162 a. Calicinal polished section. Intercorallite pillars with costae in adjacent calices.

Leptoseris santaciliaensis n. sp.

Fig. 5: CGAP- 12319. Central corallite

Fig. 7: CGAP- 12319b. Lower face with radial costae divided dichotomically.

Fig. 8: CGAP- 12319 a. Unifacial, digitate folia.

Fig. 9: Holotype. A detail of the Fig. 10. Calices and granulated costosepta.

Fig. 10: Holotype. Superficial calices and colines poorly developed.

Alveopora ataresensis n. sp.

Fig. 11: Holotype. Massive, cerioid colony.

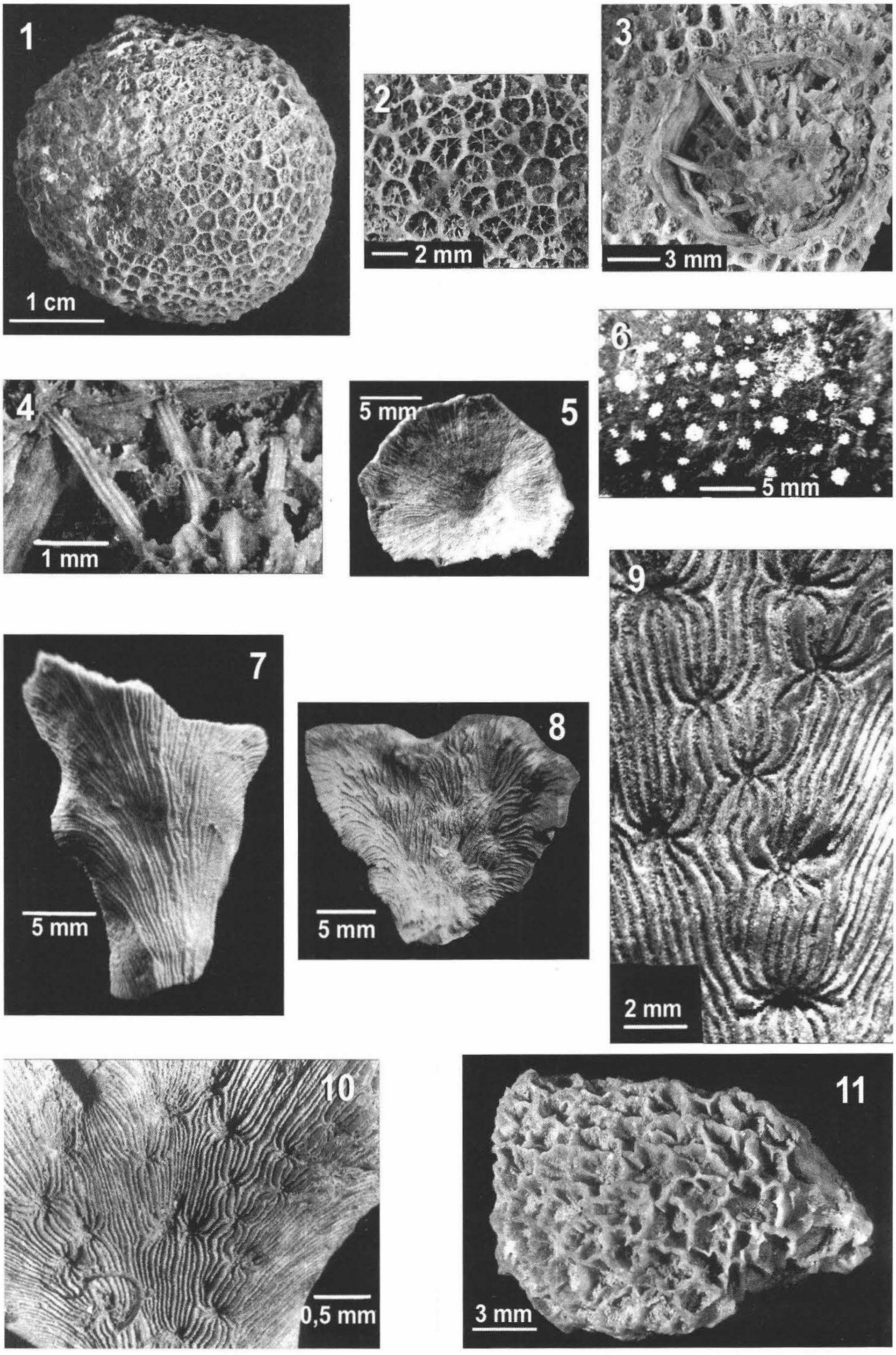
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Plate 2

Alveopora ataresensis n. sp.

Fig. 1: CGAP.12333b. Calices and pores in the wall.

Fig. 2: CGAP 12333a. Calicinal polished section. Calices, septa and pores in the wall.

Fig. 5: CGAP-12351a. Polished section. Coenosteum tissue typical of the Poritidae.

Millepora subpirenaica n. sp.

Fig. 3: CGAP-11790 b. Plate with rounded tips. Small pores and granulate coenosteum.

Fig. 4: CGAP 12352 a. Pores and ampullae in colony base.

Fig. 6: CGAP-11790 c. Protuberances of the ampullae.

Fig. 7: SEM photo. Pores and finely granulate coenosteum.

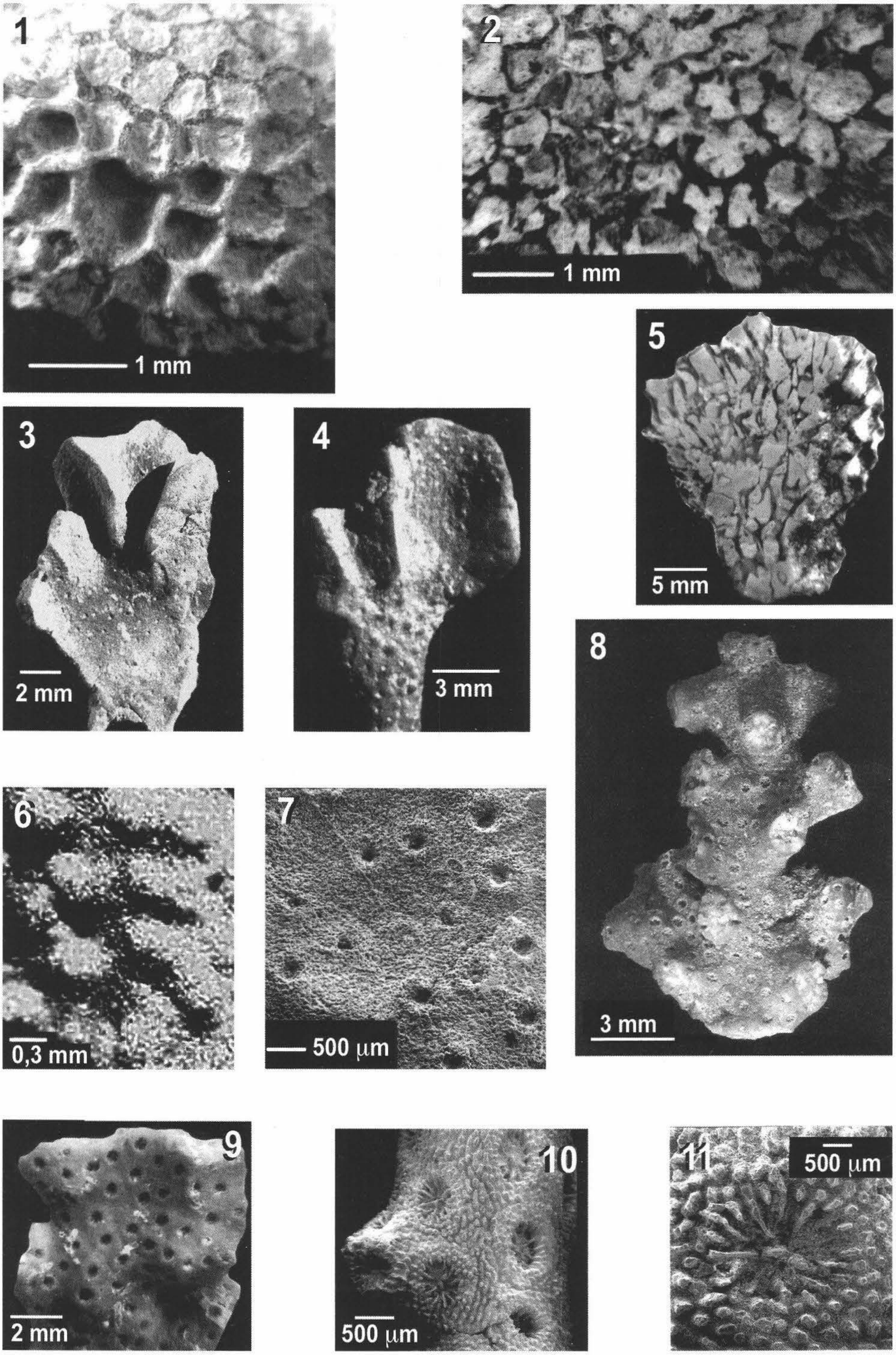
Stylophora binacuaensis n. sp.

Fig. 8: Holotype. Plocolid, ramose colony. Calices and granulated coenosteum.

Fig. 9: Paratype. Calice with septa. Granulated ceonosteum.

Fig. 10: Paratype (SEM photo). Calice with septa and columella. Granulated costae. Granulated ceonosteum.

Fig. 11: Paratype (SEM photo). Calice with three septal cycles and styliform columella. Costae formed by granules aligned with the septa.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