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Adding proofs to Syracosphaera histrica-Calyptrolithophora papillifera life-cycle association

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Abstract: Two specimens of the coccolithophore Calyptrolithophora papillifera associated with single exothecal and endo-thecal coccoliths of Syracosphaera histrica, collected from the North Aegean Sea (NE Mediterranean), have been verified by Scanning Electron Microscopy. The two specimens strengthen previous reported hints that Syracosphaera histrica and Calyptrolithophora papillifera represent a life-cycle association, documenting accordingly the relationships between the different phases within the genus Syracosphaera.

Keywords: living coccolithophores, combination coccosphere

1. Introduction
Combination coccospheres containing both hetero- and holococcoliths have been recorded from field-samples, most possibly documenting the moment of transition between the two life cycle phases (e.g., Kampftner, 1941; Lecal-Schlauder, 1961; Kleijne, 1991; Thomsen et al., 1991; Samtleben & Schröder, 1992; Samtleben in Winter & Siesser, 1994; Alcobar & Jordan, 1997; Young et al., 1998; Cros et al., 2000; Cortés, 2000; Cortés & Bollmann, 2002; Geisen et al., 2002; Cros & Fortuño, 2002; Malinverno et al., 2008a, b; Triantaphyllou & Dimiza, 2003; Triantaphyllou et al., 2004, 2009; Triantaphyllou, 2010).

More complex combinations have also been reported, suggesting relationships of one hetero- with two or three holococcolith types (e.g., Cros et al., 2000; Geisen et al., 2004; Malinverno et al., 2008a, b; Triantaphyllou et al., 2009). Several mechanisms including complex life-cycles, and cryptic speciation visible only in the holococcolith phase, have been proposed in order to explain these multiple combinations (e.g., Cros et al., 2000; Geisen et al., 2002).

In this paper, we present two new specimens adding proofs to the hetero-holococcolithophore combination between Syracosphaera histrica and Calyptrolithophora papillifera. This documentation supports the previously proposed (Malinverno et al., 2008b; Triantaphyllou, 2010) evolutionary scheme for the Syracosphaera pulchra-Syracosphaera histrica-Syracosphaera protrudens plexus concerning the independent evolution of the multiple involved HET and HOL phases.

2. Materials and methods
The Syracosphaera histrica - Calyptrolithophora papillifera potential combination coccospheres evidenced in this study come from water samples collected with a rosette system deployment from the north Aegean Sea (sample M1-100m depth January 2011, sample 2AMT7-2m depth March 2014; for location see Dimiza et al., this volume, AMT7=M4), during R/V Aegeos cruises (Medecos and AegeanMartech projects) respectively. For each sampling depth, 2 liters of seawater were filtered on Whatman cellulose nitrate filters (47 mm diameter, 0.45 mm pore size), using a vacuum filtration system. Salt was removed by washing the filters with about 2 ml of mineral water. The filters were open dried and stored in plastic Petri dishes. A piece of each filter approximately 8x8 mm² was attached to a copper electron microscope stub using a double-sided adhesive tape and coated with gold. The filter was then examined with a Jeol JSM 6360 Scanning Electron Microscope (University of Athens, Department of Historical Geology and Palaeontology) and is kept in the collections of the Museum of Paleontology and Geology in the University of Athens. Coccolithophore densities (coccospheres/l) were calculated following the methodology of Jordan and Winter (2000).

3. Results
Total coccospheres at sample M1-100m reached 12.6 x 10³ cells/l, whereas absolute cell densities in sample 2AMT7-2m have been calculated as 28.3 x 10³ cells/l. The coccolithophore communities in both samples were dominated by Emiliania huxleyi, with abundances of 90% (M1-100m) and 70% (2AMT7-2m). Calyptrolithophora papillifera was a minor component in both samples (<0.5%), whereas Syracosphaera histrica was practically absent in M1-100m and reached 2.5% in sample 2AMT7-2m.

Two likely combination coccospheres were found, one in each of the studied samples (Pl. 1, figs 1–2), consisting of numerous body and circum-flagellar coccoliths of C. papillifera (holococcoliths). Both coccospheres show signs of S. histrica; one has a body coccolith with a well-developed spine (Pl. 1, fig. 1), the other has two exothecal coccoliths with rib-like slits in the central part (Pl.1, fig. 2).

4. Discussion
Cros et al. (2000) showed an SEM image of a possible combination coccosphere of S. histrica and C. papillifera (their Plate VIII Fig. 2). This was a collapsed coccosphere of C. papillifera surrounded by body, circum-flagellar and exothecal coccoliths of S. histrica. Later, Malinverno et al. (2008b) published a possible combination coccosphere of S. histrica and “Calyptrosphaera oblonga”, discussing in detail the problem of complex evolution or complex (multiple) life-cycles in Syracosphaera that might accordingly be raised. Indeed, “C. oblonga” is established as one of the holococcolithophore phases of Syracosphaera pulchra life-cycle (i.e. S. pulchra HOL oblonga type;
Young et al., 2003). The other is “Daktylethra pirus” that has also been repeatedly found in association with S. pulchra (Lecal-Schlauder, 1961; Saugestad, 1967; Saugestad & Heimdal, 2002; Geisen et al., 2002 in SEM), and so has transferred to this species as S. pulchra HOL pirus type (Geisen et al., 2002; Young et al., 2003). Based on the morphological affinities between S. pulchra and S. histricha, Young et al. (2003) and Geisen et al. (2004) have already considered them to be genetically close. Interestingly, Malinverno et al. (2008b) have provided some relatively poor evidence (only LM photograph) of possible “C. oblonga”- “D. pirus” combination, and Triantaphyllou (2010) argued about a link between ‘C. oblonga’ and C. papillifera. In addition, Triantaphyllou et al. (2009) have also shown a rather unambiguous combination coccosphere of S. pulchra HOL pirus type with S. protrudens, implying close relationship between S. pulchra and S. protrudens. Apparently, our new evidence on the S. histricha-C. papillifera association supports previous observations of Cros et al. (2000). Together with the suggested affinities between ‘C. oblonga’ and C. papillifera (Triantaphyllou, 2010), in combination with the relationship proposed between ‘C. oblonga’ and ‘D. pirus’ (Malinverno et al., 2008b), our data add to the implications concerning the Syracosphaera pulchra-S. histricha-S. protrudens plexus being associated with three holococcolithophore types (‘D. pirus’, ‘C. oblonga’ and C. papillifera), as these have tentatively been incorporated into a possible single coherent evolutionary scheme (Malinverno et al., 2008b). Obviously, further well supported data are urgently needed in order to proceed to a thorough taxonomical revision for all involved coccolithophore forms.

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References


