

REVISION AND RE-DOCUMENTATION OF M. AIROLDI'S SPECIES OF *ARCHAEOOLITHOTHAMNIUM* FROM THE TERTIARY PIEDMONT BASIN (NW ITALY)

GRAZIA VANNUCCI*, MICHELE PIAZZA*, PATRIZIA FRAVEGA* & DANIELA BASSO**

Received October 14, 1999; accepted April 16, 2000

Key-words: Fossil Sporolithaceae, identification, *Sporolithon*, Late Oligocene, Taxonomy, Stratigraphy.

Riassunto. Airoldi (1930, 1932) descrisse ventitré specie di Corallinales fossili (Rhodophyta) provenienti dall'Oligocene del Bacino Terziario del Piemonte (Italia nord-occidentale), tredici di queste erano nuovi taxa. Vengono qui ridescritti e ridocumentati *Archaeolithothamnium praeerithraeum* Airoldi 1932 e *Archaeolithothamnium statiellense* Airoldi 1932. L'analisi delle caratteristiche dei compartimenti sporangiali ha permesso di attribuire le due specie al genere *Sporolithon*.

Abstract. Airoldi (1930, 1932) described twenty-three fossil Corallinales (Rhodophyta) from the Oligocene of the Tertiary Piedmont Basin (NW Italy), containing thirteen new species. In this paper *Archaeolithothamnium praeerithraeum* Airoldi 1932 and *Archaeolithothamnium statiellense* Airoldi 1932 are re-documented and re-described. The features observable in the sporangial compartments allowed to attribute both species to the genus *Sporolithon*.

Introduction.

The present paper is the second contribution to the revision of Airoldi's original collection housed at the Paleontological and Geological Museum, Genova University. Details on the history of the collection have been already given in Basso et al. (1998). The species originally attributed by M. Airoldi to the genus *Archaeolithothamnium*, *A. praeerithraeum* and *A. statiellense*, are here revised on the basis of the original type material, descriptions and illustrations.

Material and methods.

The collection of fossil calcareous algae at the University of Genova was rearranged in 1967 and new numbering was added to most thin sections. The new number is written before the original given by Airoldi,

e.g. the thin section originally numbered 43 by Airoldi, is now labelled 162/43. No new labels were added to the original numbering on the corresponding rock fragments. In some cases, several rock fragments were preserved together under the same number. Further SEM observations and new thin sections were obtained only from fragments thought to be used by Airoldi for his thin sections. SEM preparations followed the methods of Braga et al. (1993).

Specimens questionably or incompletely identified by Airoldi have not been considered in this work.

The generic and suprageneric classification scheme, the thallus nomenclature, and growth form definitions follow Woelkerling (1988), Verheij (1993), Woelkerling et al. (1993), and Townsend et al. (1995).

The list of synonyms and citations for each species includes only papers where descriptions and/or illustrations are given. Type localities are quoted from the original papers of Airoldi. All available published data for each species have been included in the section "Stratigraphic and geographic distribution"; stratigraphic ranges have been refined and revised as far as possible. When known, formation names has been included.

Herbarium abbreviations are taken from Holmgren et al. (1990).

Systematic Palaeontology

Division **Rhodophyta** Wettstein 1901

Class **Rhodophyceae** Rabenhorst 1863

Order **Corallinales** Silva & Johansen 1986

Family **Sporolithaceae** Verheij 1993

* Dipartimento per lo Studio del Territorio e delle sue Risorse dell'Università di Genova, Corso Europa 26, 16132 Genova, Italy - e-mail: mpiazza@dipteris.unige.it

** Dipartimento di Scienze geologiche e geotecnologie, Piazza della Scienza 4, Milano, Italy - e-mail: d.basso@e35.gp.terra.unimi.it

The Sporolithaceae have been separated from the Corallinaceae (Verheij, 1993) on the basis of two main characters: the cruciately arranged tetraspores and the tetrasporangia occurring in sori instead of conceptacles. In particular, the cruciate tetrasporangia of Sporolithaceae develop within calcified sporangial compartments whereas zonate tetrasporangia of Corallinaceae develop in non calcified sporangial compartments grouped in calcified chambers (conceptacles). The last character is recognizable also in fossil specimens and has been used for the circumscription of the genus *Archaeolithothamnium* Rothpletz 1891 (synonym of *Sporolithon* Heydrich 1897; Moussavian & Kuss, 1990).

Two genera have been described so far: *Sporolithon* and *Heydrichia* Townsend, Chamberlain and Keats 1994.

In living specimens of Sporolithaceae, the diagnostic characters for the generic attribution are: 1) the presence/absence of "sporangial complexes", 2) the number of stalk cells from which the tetrasporangia are borne, 3) the position of the spermatangial system within the gametangial conceptacle and 4) the presence/absence of a dorsal enlargement of the pit plug caps (Keats & Chamberlain, 1993; Verheij, 1993; Keats & Chamberlain, 1995; Townsend et al., 1995). Characters 2, 3 and 4 are very unlikely to be preserved in the fossil material. The occurrence of the "sporangial complexes" is reported only for *Heydrichia* (Townsend et al., 1994). A sporangial complex consists of a tetrasporangium with 1-5 subtending stalk cells enclosed in a sporangial compartment and a group of modified filaments that surround the sporangium and form the complex "wall" (Townsend et al., 1995, p. 98).

Since the wall of the sporangial complex is calcified (Townsend et al., 1995, fig. 19c), its attributes could be used for the separation of *Heydrichia* from other fossil Sporolithaceae. The following observations should allow to identify a "sporangial complex": the cells of the filaments of the sporangial complex wall are shorter than those composing the cell filaments around the sporangia of *Sporolithon* ("paraphyses" following Verheij, 1993). Since the two genera have tetrasporangial chambers of comparable size (62-111 μm height in *H. woelkerlingii* Townsend, Chamberlain and Keats, the type species of *Heydrichia*; about 70-112 μm height in Australian species of *Sporolithon*, with the exception of *S. episoredion*: 180-200 μm height; Townsend et al., 1994; Townsend et al., 1995), *Sporolithon* has a lower number of cells in the filaments delimiting each sporangium. In particular, Southern Australian and Indonesian species of *Sporolithon* have 3-9 cells composing each paraphysis (Townsend et al., 1995, Verheij, 1993), whereas 8 to 12 cells compose the filaments of the sporangial complex wall of *Heydrichia* (Keats & Chamberlain, 1995). For the same reason, in *Heydrichia* the cells of the filaments of the sporangial complex wall have more or less the

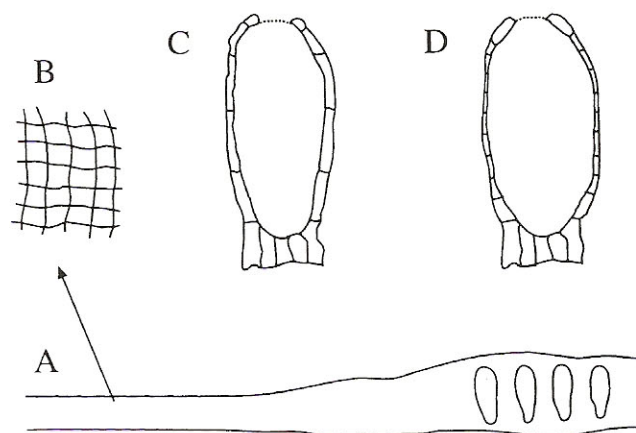


Fig. 1 - Features of the sporangia of fossil specimens, considered diagnostic for generic separation within the Sporolithaceae: A - Schematic shape of a sporolithacean sorus in longitudinal section. B - Cells of vegetative thallus surrounding the sorus, position indicated by the arrow. C - Schematic shape and size of cells surrounding the sporangium in the genus *Sporolithon*. Note cell length about 2-3 times that in B. D - Schematic shape and size of cells surrounding the sporangium in the genus *Heydrichia*. Note stretched cells and cell length comparable with B.

same length of the cells in the surrounding peripheral region, whilst in *Sporolithon* the cells in paraphyses are about 2-3 times longer than those in the surrounding peripheral region (Fig. 1c). Moreover, the stretched, plate-like cells (Fig. 1d) that are visible in longitudinal section of the sporangial complex in *Heydrichia* (Townsend et al., 1994; Keats & Chamberlain, 1995) should be conserved and apparent in the fossil.

Old sporangial chambers can be buried in the thallus in *S. episoredion* (Adey, Townsend and Boykins) Verheij, *S. molle* (Heydrich) Heydrich, *S. ptychoides* Heydrich, *S. erythraeum* (Rothpletz) Kylin (Keats & Chamberlain, 1993; Verheij, 1992, 1993) and in most fossil species whereas they are sloughed off in *S. durum* (Foslie) Townsend and Woelkerling and *S. episporum* (Howe) Dawson (Townsend et al., 1995). No buried tetrasporangial sori have been found in *Heydrichia* (Townsend et al., 1994; Keats & Chamberlain, 1995).

In *Sporolithon ptychoides*, *S. molle*, *S. erythraeum* and in the fossil *S. brevium* (Lemoine) Aguirre & Braga, *S. glangeaudii* (Lemoine) Aguirre & Braga and *S. liberum* (Lemoine) Aguirre & Braga a calcified septum has been described dividing the stalk cell from the tetrasporangium in mature sori (Woelkerling & Townsend in Woelkerling, 1988, fig. 247, 248; Keats & Chamberlain, 1993, fig. 13; Verheij, 1993, fig. 17; Aguirre & Braga, 1998). The occurrence of this feature in other species of *Sporolithon* is unknown. It has never been observed in *Heydrichia* (Townsend et al., 1994; Keats & Chamberlain, 1995).

	<i>Sporolithon</i>	<i>Heydrichia</i>
Ratio: cell length in the filaments lining the sporangium / cell length in the surrounding peripheral region	> 1 absent	$\cong 1$ present
Stretched cells in the filaments lining the sporangium		
Buried sporangia	present or absent	absent
Calcified septum between the stalk cell and the sporangium	present or absent	absent
Layer of elongated cells at the base of sori	present or absent	absent

Tab. 1 - Characters proposed in the present study to distinguish fossil genera of Sporolithaceae. Sources of information are detailed in the text.

The occurrence of a basal layer of elongate cells in areas where sporangia develop has been documented in *S. durum*, *S. episoredion*, *S. episorum*, *S. ptychoides* (Townsend et al., 1995; Verheij, 1993; Keats & Chamberlain, 1993) and in the fossil *S. aschersonii* (Moussavian & Kuss, 1990), *S. brevium* and *S. glangeaudii* (Aguirre & Braga, 1998), whereas it seems absent in *S. molle* and *S. erythraeum* (Verheij, 1993). This character is considered diagnostic at species level within the genus *Sporolithon* (Verheij, 1993; Bassi, 1995, 1998; Townsend et al., 1995). The occurrence of this feature in other fossil species of "*Archaeolithothamnium*" is unknown until their revision with modern criteria will be undertaken. A layer of elongated cells at the base of sporangia has never been observed in *Heydrichia* (Townsend et al., 1994; Keats & Chamberlain, 1995).

Therefore, the characters that can help to separate *Sporolithon* from *Heydrichia* in fossil material are summarized in Table 1.

Genus *Sporolithon* Heydrich 1897

Type-species: *Sporolithon ptychoides* Heydrich 1897

Six characters associated with the structure and the size of tetrasporangia have been used for separating different species of *Sporolithon* (Keats & Chamberlain, 1993; Verheij, 1993; Townsend et al., 1995): 1) the number of cells to which sporangial sorus is raised above the surrounding thallus surface (further explanation is given in Keats & Chamberlain, 1993); 2) the number of cells

in paraphyses; 3) the occurrence of a basal layer of elongate cells in the region of tetrasporangia development; 4) the length and diameter of tetrasporangial chambers; 5) the occurrence of a calcified septum separating the tetrasporangium from the subtending stalk cell; 6) the fate of old sporangia; 7) the sporangial pore diameter and 8) the ratio of secondary pit-connections to cell fusions. All these features are observable in the fossil material, though the latter two would require an exceptionally good preservation of the fossil specimens. Whenever possible, all these characters will be described below, even if their diagnostic value seems to need further discussion, because of their great infraspecific variability (Townsend et al., 1995, tab. 2).

Sporolithon praeerythraeum (Airoidi 1932) comb. nov.

Fig. 2; Pl. 1, 2; Tab. 2

Basionym: *Archaeolithothamnium praeerithraeum* Airoidi 1932, p. 63, pl. IX, fig. 2.

Other references:

1970 *Archaeolithothamnium praeerithraeum* - Francavilla et al., p. 662, pl. LXXXIV, fig. 2.

1983 *Archaeolithothamnium praeerithraeum* - Bakalova, p. 50 pl. I, fig. 2.

Holotype. Coll. Airoidi, one rock fragment labelled 1 and related thin section 1.

Paratype. Coll. Airoidi, three rock fragments collected at Sassello and related thin section 4, relabelled 146/1 during the 1967 revision (Basso et al., 1998).

Type locality. Late Rupelian - Chattian of Bric Cochera (Tagliolo, Southern Tertiary Piedmont Basin, Molare Formation).

<i>S. praeerythraeum</i>		<i>Holotype</i>	
		range	mean (s.d.)
Ventral core	L	12-30	18.03 (3.72) n=36
	D	5-13	8.92 (1.86) n=36
Peripheral region	L	8-25	15.20 (3.84) n=50
	D	7-12	8.34 (1.14) n=50
Sporangia	D	30-48	38.23 (4.31) n=22
	H	58-100	69.27 (11.53) n=22
	ratio H/D	1.25-2.78	

Tab. 2 - *Sporolithon praeerythraeum*. Biometry of holotype. Measures in μm . L= length, D=diameter, H= height, n=number of observations.

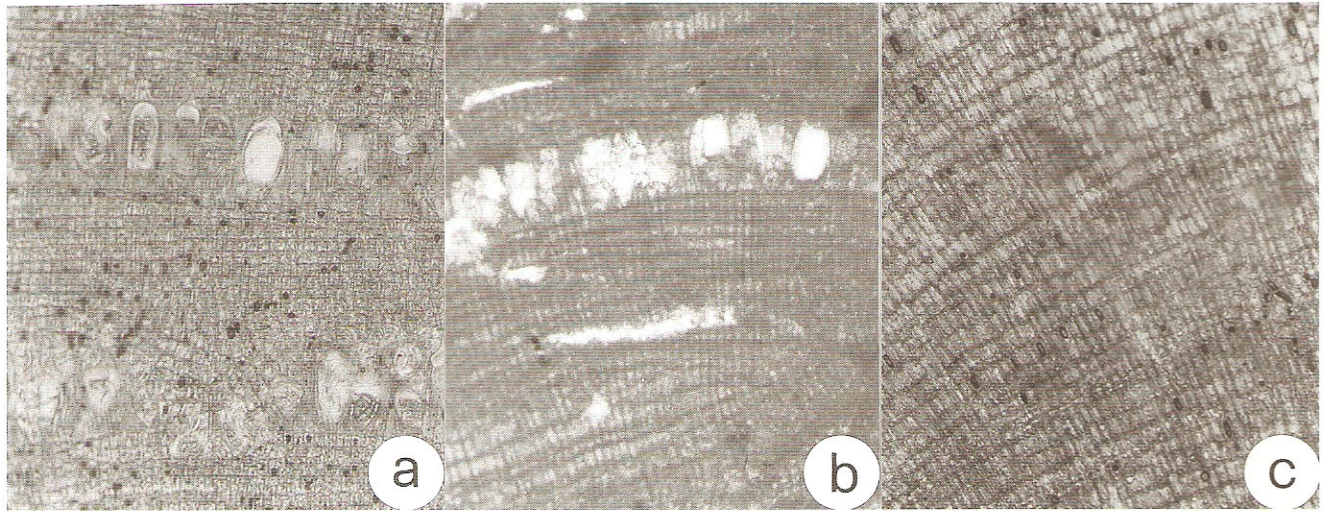


Fig. 2 - a: lectotype of *Sporolithon ptychoides* Heydrich, TRH, n.12, slide 14 (Red Sea), 130x; b: holotype of *Sporolithon praeerythraeum* (Airoidi) comb. nov., thin section 1, 130x; c: lectotype of *Lithothamnion erythraeum* Rothpletz, TRH, slide 730 (Red Sea), 130x.

Material. A SEM stub and a new thin section have been prepared from part of sample 1. The occurrence of another Airoidi's species (*Archaeolithothamnium* sp. Airoidi 1932, p. 65) was detected allowing the sure attribution of the fragment to the original thin section, however, it was impossible to locate *Archaeolithothamnium praeerythraeum* on the newly prepared thin section and SEM stub. Also two SEM stubs and a new thin section have been prepared from sample 4 (SEM stubs 31395b7 and 8895b2 and thin section 4N) which have been used for the description below. In his 1932 protologue, Airoidi did not explicitly designate the holotype, however, his original illustration (plate IX, fig.2c) shows details of a sorus which can be located in section 1. Section 1 is therefore the holotype (ICBN, Greuter et al., 1994, art. 9.1).

Description.

Thallus encrusting a coral fragment, lumpy, associated with a *Lithothamnion* sp. and *Archaeolithothamnion* sp. Airoidi 1932. The nodule is 1.5 cm in diameter. Plant non-geniculate, with a maximum thickness of 2000 μm in longitudinal section (LS). Thallus pseudo-parenchymatous, with a dorsiventral internal organization, monomerous, with a non-coaxial ventral core of filaments with thickness 20-120 μm (maximum 75 μm in the holotype). Cell of the ventral core L 12-30 x D 5-13 μm raising abruptly to form the peripheral region.

Peripheral region with maximum thickness of 1880 μm (maximum 650 μm in the holotype), composed of cell L 8-25 x D 7-12 μm . In most parts of the peripheral region a horizontal alignment of the cells is apparent (Pl. 1, fig. 6). This feature is not evident in portions of thallus obliquely cut (Pl. 1, fig. 7). As Airoidi (1932) pointed out, the peripheral region of the plant is characterised by single layers of cells 15-25 μm long (more frequently 18-22 μm), interspersed among other cells, whose length is in the range 8-12 μm (Pl. 1, fig. 5, 6; Pl. 2, fig. 3).

Cell fusions occur in the peripheral region (Pl. 2, fig. 3, 5). Secondary pit-connections have been also observed in the paratype and are much more common than cell fusions.

The epithallial cells have been observed as single layered flat cells, about 5 μm long (Pl. 2, fig. 2).

Elliptical sporangia (LS) formed within calcified compartments grouped in buried sori, D 30-48 x H 58-100 μm . Sporangial pore about 8-10 μm in diameter. A calcified septum separating the stalk cell from the sporangium is visible at the base of several sporangial compartments (Pl. 2, fig. 1). A basal layer of elongated cells occurs at the base of sporangia (Pl. 1, fig. 5, 7). Maximum cell length in these elongated cells (up to 30 μm long x D

PLATE 1

Sporolithon praeerythraeum (Airoidi) comb. nov.

- Fig. 1 - *Sporolithon praeerythraeum*. Holotype, thin section 1.
 Fig. 2 - *Sporolithon praeerythraeum*. Paratype, thin section 4, relabelled 146/1.
 Fig. 3 - Rock fragment labelled 1, from which thin section 1 was obtained, 0.8x.
 Fig. 4 - Rock fragments labelled 4, from which thin section 4 was obtained, 0.7x.
 Fig. 5 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Sporangia with basal layer of elongated cells, 200x. Bottom right the original Airoidi's drawing (Airoidi, 1932, pl. IX, fig. 2c).
 Fig. 6 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Sporangia and peripheral region with apparent horizontal alignment of cells. 130x.
 Fig. 7 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Sporangia with basal layer of elongated cells and peripheral region with prevailing vertical alignment of cells. 130x.



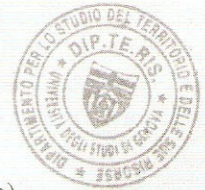
Collezione AIROLDI

Bacino Terziario del Piemonte

Campione n. 1

Località Bric Cochera (Tagliolo)

Archaeolithothamnium praeerithraeum Airoidi



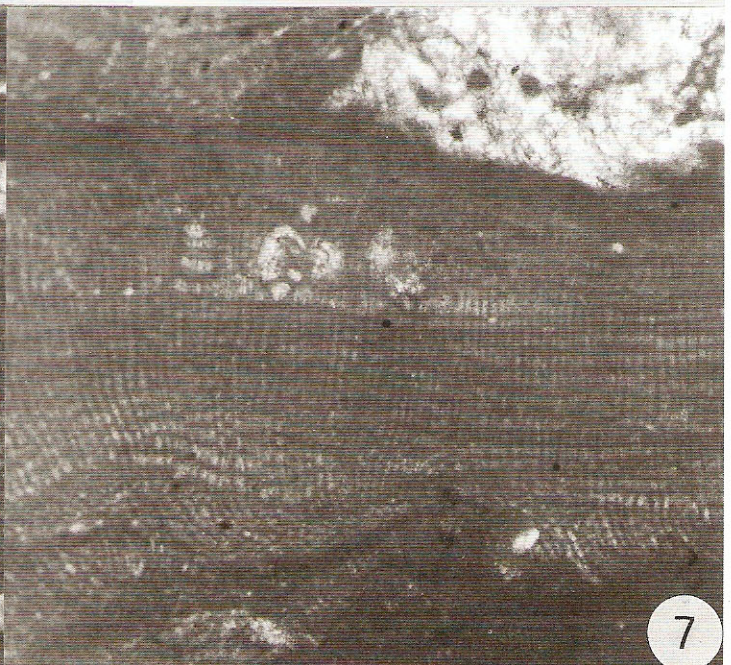
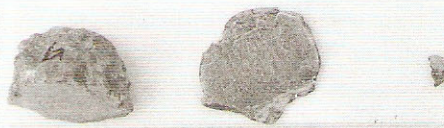
Collezione AIROLDI

Bacino Terziario del Piemonte

Campione n. 4

Località Sassello

Archaeolithothamnium praeerithraeum Airoidi



7-8 μm) exceeds that of other cells in the peripheral region. Sporangia are separated by sterile calcified filaments (paraphyses) composed of 3-6 cells. Surface of sori is raised 2-4 cells above the surrounding surface.

The paratype (section 146/1) shows some irregular cavities (Pl. 2, fig. 6), which Airoidi interpreted as possible cystocarpic conceptacles. Section 4N, newly cut from the original fragment, shows some pear-shaped to roundish chambers, D 120-340 x H 160-180 μm (included a 60 μm long pore-canal) which we also consider as carposporangial conceptacles (Pl. 2, fig. 7). A possible, obliquely cut, carposporangial conceptacle (Pl. 2, fig. 8) shows filamentous dark material at its base and in the pore-canal, which would represent the remains of carposporangial filaments (compare with Verheij, 1992, fig. 13).

Remarks.

The specific epithet chosen by Airoidi (1932) for *S. praeerythraeum*, which he incorrectly spelled *praeerithraeum*, refers to its resemblance of *S. erythraeum* (Rothpletz) Kylin 1956. However, the comparison with the lectotype material of *Lithothamnium erythraeum* Rothpletz 1893, housed at TRH (Woelkerling, 1993), has shown that it differs because of the absence of the layer of elongated cells at the base of the sorus, the non-raised sorus, the larger sporangia and the cells of the peripheral region (Woelkerling & Townsend in Woelkerling 1988, fig. 248; Verheij, 1993 and this paper, Fig. 2).

Sporolithon erythraeum and *Sporolithon ptychoides* Heydrich 1897 were considered conspecific (see Woelkerling & Townsend in Woelkerling 1988 for nomenclatural details) but successively, the two species have been separated by Verheij (1993). Consequently, we compared *S. praeerythraeum* with the lectotype of *S. ptychoides*, also housed at TRH: *S. ptychoides* resulted to have longer sporangial compartments and smaller cells in the peripheral region than *S. praeerythraeum*. Moreover, the typical occurrence of isolated layers of long cells which characterises *S. praeerythraeum* is lacking in *S. ptychoides* (Fig. 2).

Bassi (1995, 1998) presumes that some fossil species of *Sporolithon*, among which *S. praeerythraeum*, would be conspecific with *S. aschersonii* (Schwager) Moussavian & Kuss 1990. The shape of sporangial compartments is elliptical in *S. praeerythraeum* whilst is very characteristically club-shaped with smaller diameters for the sporangial compartments of *S. aschersonii* (Moussavian & Kuss, 1990). This is confirmed by the H/D ratio of the sporangial compartments which is 1.25-2.78 in *S. praeerythraeum* whilst is 1.8-3.73 in *S. aschersonii* (Moussavian & Kuss, 1990, pl. 1, fig. 5).

Stratigraphic and geographic distribution.

Late Eocene - NE Italy: Colli Berici (Francavilla et al., 1970). Late Eocene - Early Oligocene? - S Bulgaria: Parzenaka (Bakalova, 1983). Late Rupelian - NW Italy: Tertiary Piedmont Basin, Molare Formation (Airoidi, 1932).

Sporolithon statiellense (Airoidi 1932) comb. nov.

Pl. 3, 4; Tab. 3

Basionym: *Archaeolithothamnium statiellense* Airoidi 1932, p. 64, pl. IX, fig. 3.

Other references:

- 1932 *Lithophyllum arenularium* - Airoidi, p. 71, pl. X, fig. 6.
 1968b *Archaeolithothamnium statiellense* - Mastrorilli, p. 226, text fig. 26, pl. I, fig. 2.
 1980a *Archaeolithothamnium statiellense* - Fravega & Vannucci, p. 105.
 1987 *Archaeolithothamnium statiellense* - Fravega et al., p. 46.
 1988 *Archaeolithothamnium statiellense* - Fravega et al., p. 207.
 1997 *Sporolithon statiellense* - Vannucci et al., pl. 2, fig. c.

Holotype. Coll. Airoidi, three small rock fragments labelled 43 and related thin section re-labelled 162/43 in the 1967 revision.

Isotype. Coll. Airoidi, thin section 49, re-labelled 163/49 in the 1967 revision. One rock fragment labelled 160 and related thin section 160.

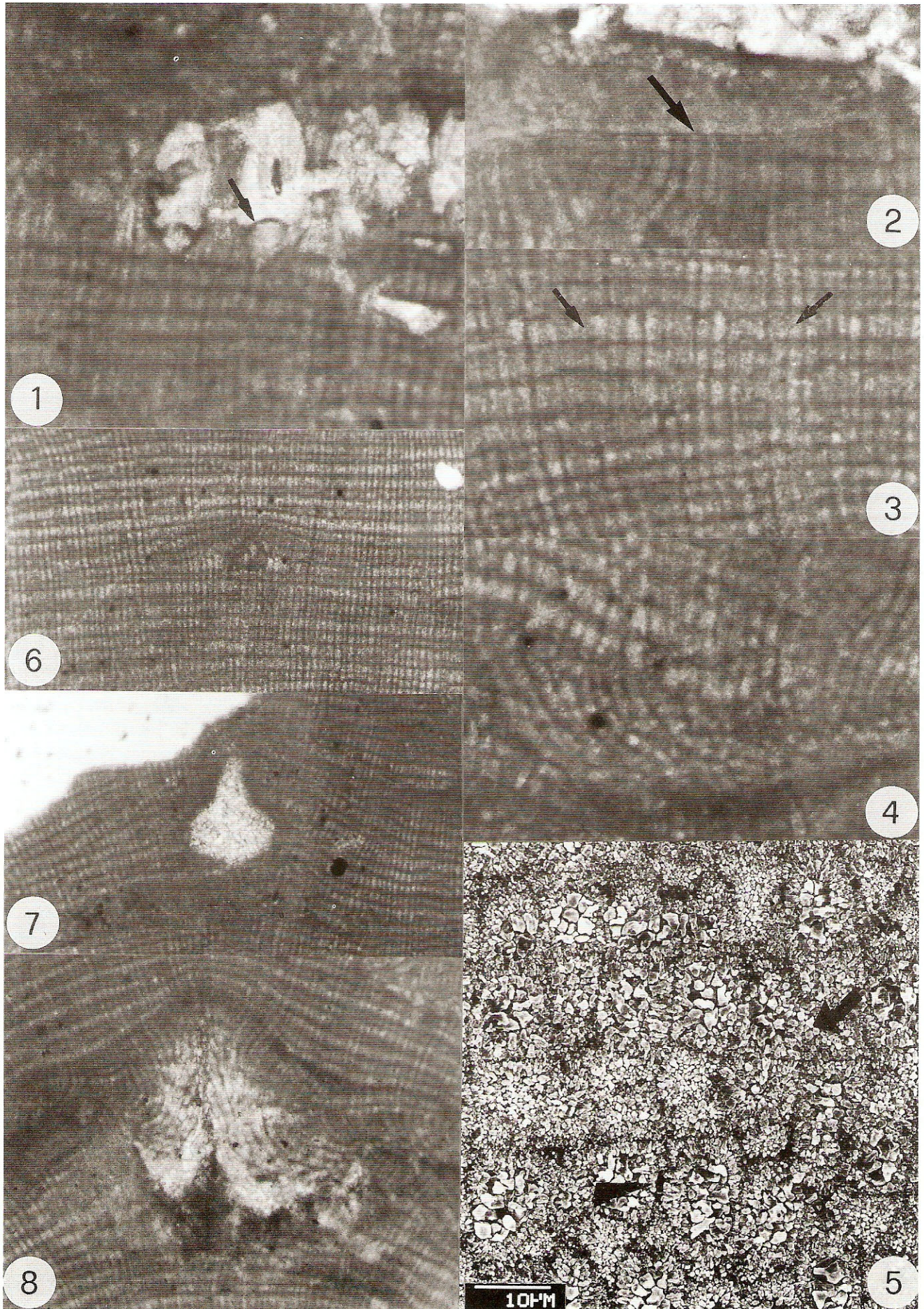
Type locality. Late Rupelian - Chattian of Rio Zunini (Southern Tertiary Piedmont Basin, Molare Formation).

Material. SEM stubs 31395B8 and 8895B4 and the new thin section 43N have been prepared from fragment 43. During the 1967 revision, other two new thin sections were prepared from sample 43 and 160 (thin sections Sa-II-43/439 and Sa-II-160/444 respectively).

PLATE 2

Sporolithon praeerythraeum (Airoidi) comb. nov.

- Fig. 1 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Sporangia with calcified septum (arrow). 340x.
 Fig. 2 - *Sporolithon praeerythraeum*. Holotype, thin section 1. A single layer of epithallial cells is visible at the surface of thallus (arrow). 340x.
 Fig. 3 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Short cell layers and long cell layers in peripheral region, cell fusions are also visible (arrows). 340x.
 Fig. 4 - *Sporolithon praeerythraeum*. Holotype, thin section 1. Non-coaxial ventral core. 340x.
 Fig. 5 - *Sporolithon praeerythraeum*. Paratype, SEM stub 8895b2. Cell fusions (arrow) and possible secondary pit-connection (arrowhead) in the peripheral region.
 Fig. 6 - *Sporolithon praeerythraeum*. Paratype, thin section 146/1. Female conceptacle. 130x.
 Fig. 7 - *Sporolithon praeerythraeum*. Thin section 4N. Carposporangial conceptacle in longitudinal section. 130x.
 Fig. 8 - *Sporolithon praeerythraeum*. Thin section 4N. Possible carposporangial conceptacle, oblique section. Dark material inside the conceptacle could represent remains of carposporangial filaments. 130x.



<i>S. statiellense</i>		<i>Holotype</i>	
		range	mean (s.d.)
Ventral core	L	12-45	23.34 (7.86) n=50
	D	8-15	10.10 (1.84) n=50
Peripheral region	L	10-22	17.02 (3.14) n=50
	D	8-15	11.42 (1.50) n=50
Sporangia	D	43-50	47 (3.56) n=4
	H	110-115	113 (2.45) n=4
	ratio H/D	2.20-2.60	

Tab. 3 - *Sporolithon statiellense* Airoidi. Biometry of holotype. Measures in μm . L= length, D=diameter, H=height, n= number of observations.

In the protologue, Airoidi did not explicitly select the holotype, however, his illustrations show details of a fertile portion of thin section 162/43, therefore this thin section is the holotype (ICBN, Greuter et al., 1994, art. 9.1).

Description.

Section 162/43 shows a crustose to lumpy algal nodule, composed of superposed thalli growing on a coral fragment (the nodule is 1.5 cm in diameter). *S. statiellense* has a thickness variable from 800 μm to 4 mm (several superposed thalli). The plant is partially included in coarse biogenic sandstone.

Plant non-geniculate, with maximum thickness of 2.6 mm (single thallus). Thallus pseudoparenchymatous with dorsiventral organization, monomerous, with a non-coaxial ventral core of cell filaments with a thickness of 40 to 120 μm .

In the ventral core, cell length is 12-45 μm , 8-15 μm in diameter. Longest cells are located at the base of the ventral core, smallest cells are at the transition to the peripheral region (Pl. 4, fig. 2).

The peripheral region has a maximum thickness of 2.5 mm, with regular, horizontally aligned cells (horizontal cell walls are more distinct than the vertical cell walls). Zones of cells with irregular shape are interspersed in the peripheral region (Pl. 4, fig. 1). The regular cells are 10-22 μm long and 8-15 μm in diameter: among them, layers of longest cells (20-22 μm) casually alternate with layers of cells 10-20 μm long (Pl. 4, fig. 4). The cells with irregular shape are up to 60 μm long and 18-20 μm in diameter and produce several zones of different thickness and limited width interspersed in the thallus. This character was also remarked by Mastrorilli (1968b) in the specimens from Ponzone. This feature appears to be related with the fate of old tetrasporangial compartments, becoming buried and filled up after releasing their spores (Pl. 4, fig. 5).

As Mastrorilli pointed out (1968b, pl. 1, fig. 2), some isolated layers of cells (10-18 μm long) in the peripheral region appear as light lines which are apparently due to the dissolution of the lateral walls of adjacent cells (Pl. 4, fig. 1). This character has been observed

PLATE 3

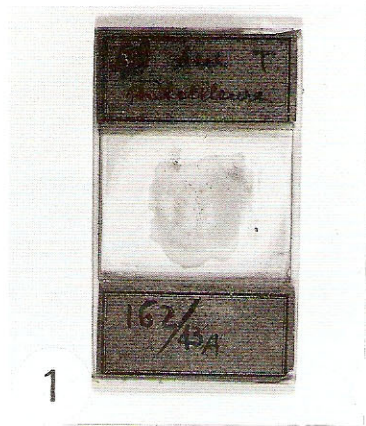
Sporolithon statiellense (Airoidi) comb. nov.

- Fig. 1 - *Sporolithon statiellense*. Holotype, thin section 43, relabelled 162/43.
 Fig. 2 - *Sporolithon statiellense*. Isotype, thin section 49, relabelled 163/49.
 Fig. 3 - Rock fragments labelled 43, from which thin section 162/43 was obtained. 0.9x.
 Fig. 4 - *Sporolithon statiellense*. Isotype, thin section 160.
 Fig. 5 - Rock fragment labelled 160, from which thin section 160 was obtained. 0.8x.
 Fig. 6 - *Sporolithon statiellense*. Holotype, thin section 162/43. Peripheral region with sporangia. 52x.
 Fig. 7 - *Sporolithon statiellense*. Holotype, thin section 162/43. Sporangia, 340x. Bottom left the original Airoidi's drawing (Airoidi, 1932, pl. IX, fig. 3b, d).
 Fig. 8 - *Sporolithon statiellense*. Holotype, thin section 162/43. Sporangia, 340x. Bottom left the original Airoidi's drawing (Airoidi, 1932, pl. IX, fig. 3c).

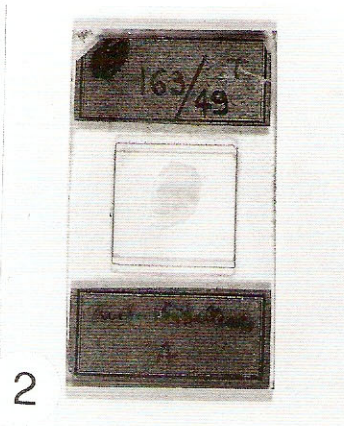
PLATE 4

Sporolithon statiellense (Airoidi) comb. nov.

- Fig. 1 - *Sporolithon statiellense*. Holotype, thin section 162/43. Peripheral region with interspersed zones with irregularly shaped cells and light lines probably due to the dissolution of lateral cell walls. 130x.
 Fig. 2 - *Sporolithon statiellense*. Holotype, thin section 162/43. Non-coaxial ventral core. 130x.
 Fig. 3 - *Sporolithon statiellense*. Isotype, SEM stub 8895B4. Cell fusions (arrow) and possible secondary pit-connections (arrowhead) in the peripheral region.
 Fig. 4 - *Sporolithon statiellense*. Holotype, thin section 162/43. Layers of longest cells interspersed in the peripheral region. 340x.
 Fig. 5 - *Sporolithon statiellense*. Holotype, thin section 162/43. Zones with irregular cells in the peripheral region probably related to the burial of old tetrasporangial compartments. 340x.



1



2

Collezione AIROLDI

Bacino Terziario del Piemonte

Campione n. 43

Località Sassello

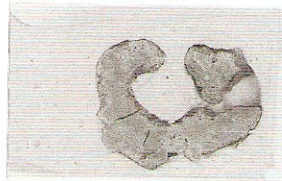
Archaeolithothamnium statiellense Airoidi



3



4



5

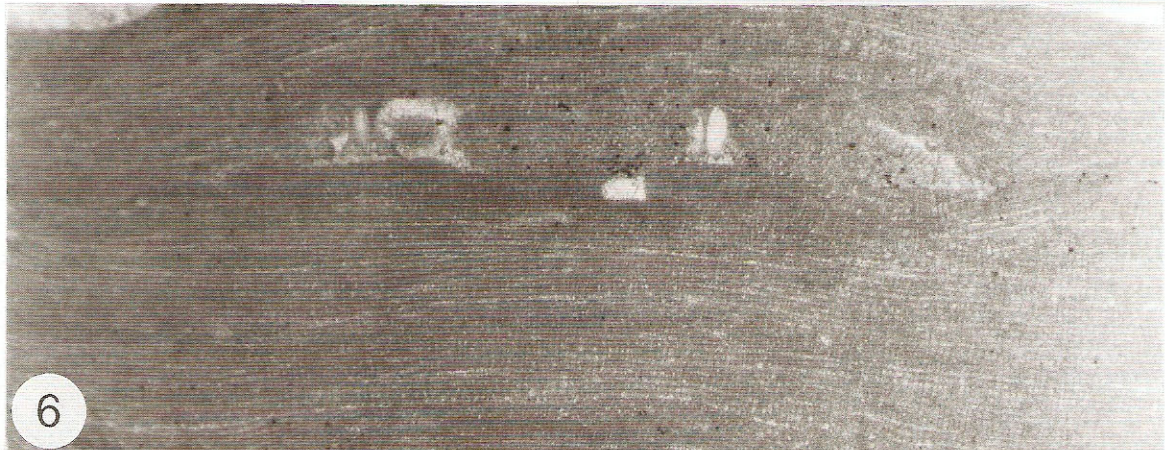
Collezione AIROLDI

Bacino Terziario del Piemonte

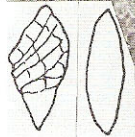
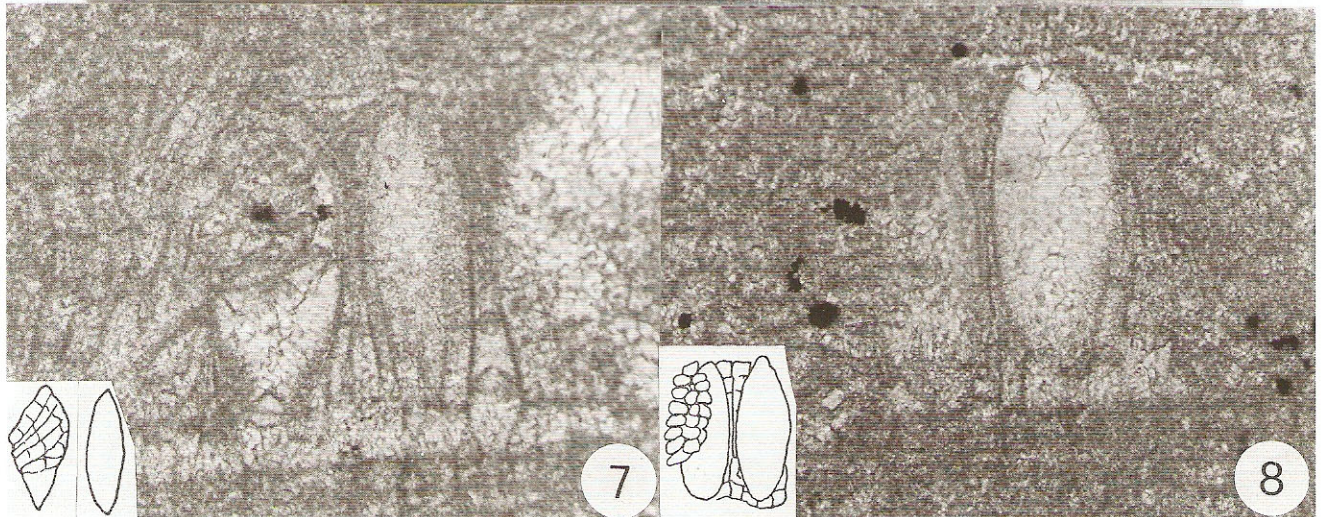
Campione n. 160

Località Sassello

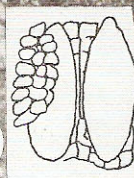
Archaeolithothamnium statiellense Airoidi



6



7



8



both in Airoidi's original material and in the specimens from Ponzone (Mastrorilli, 1968b).

Cell fusions have been uncommonly observed in the peripheral region. Secondary pit-connections also present (Pl. 4, fig. 3). A fragmentary, poorly preserved epithallial layer of flattened cells has been also observed.

In section Sa-II-43/439, five buried sporangial compartments occur; some of them are partially filled up by cell filaments. They are about 100 μm high and 50 μm in diameter. Sterile paraphyses separate these sporangial compartments, which are laterally bordered by the above described zones of irregularly shaped cells. The maximum length of the cells below the sporangial compartments is about 22 μm , therefore comparable to the longest cells of the peripheral region (Pl. 3, fig. 7, 8). The paraphyses are made of up to 9 cells.

Remarks.

Airoidi (1932, fig. 7, pl. II, fig. 6) describes some specimens which he thought to be conspecific with *Lithophyllum arenularium* Capeder 1900. The original Airoidi's material (thin sections 161/33 and 166/155; thin section 157 has been lost) of *L. arenularium* is sterile and the vegetative anatomy is very similar to *S. statiellense*. A confirmation that Airoidi misidentified his material as *L. arenularium* was found in thin section Sa II-33/438 (obtained from the same fragment from which section 161/33 was cut), where an isolated sporangial compartment occurs, about 90 μm in height and

45 μm in diameter, buried in a vegetative thallus and corresponding to the features observed in the type material of *S. statiellense*.

The dimensions of the ventral core cells reported by Mastrorilli (1968b) are quite smaller than those observed in the holotype. New measuring of the ventral core of Mastrorilli's specimens indicates that the cell length reaches 27 μm . Therefore, the dimensions recorded in Mastrorilli's paper have to be regarded as a misprint.

Stratigraphic and geographic distribution.

Oligocene - NE Italy: Berici hills - Asiago highland (Mastrorilli, 1973). Late Rupelian and Chattian - NW Italy: Tertiary Piedmont Basin, Molare Formation (Airoidi, 1932; Lorenz, 1964, 1969; Mastrorilli, 1968a, 1968b; Fravega & Vannucci, 1980a, 1980b; Fravega et al. 1987, 1988, 1994; Vannucci et al., 1993; Vannucci et al., 1997; Vannucci, personal data on Dego, Cairo Montenotte and Cascine areas).

Acknowledgments.

We are very grateful to the curator of the Foslie's herbarium in TRH, Dr. S. Sivertsen, for the loan of the type specimens of *Lithothamnium erythraeum* Rothpletz and *Sporolithon ptychoides* Heydrich. Sincere thanks are due to R. Townsend and W. Piller for their suggestions and improvements of the original manuscript. Funding provided by Università di Genova, Fondi per la Ricerca di Ateneo.

REFERENCES

- Aguirre J. & Braga J.C. (1998) - Redescription of Lemoine's (1939) types of Coralline algal species from Algeria. *Palaeontology*, v. 41, 3, pp. 489-507, London.
- Airoidi M. (1930) - Su di un nuovo genere di Corallinacea fossile dell'Oligocene ligure. *Rend. R. Acc. Naz. Lincei*, cl. Sc. fis., mat. nat., v. 12, n. 12, pp. 681-684, Roma.
- Airoidi M. (1932) - Contributo allo studio delle Corallinacee del terziario italiano I - Le Corallinacee dell'Oligocene ligure-piemontese. *Palaeontographia Italica*, v. 33, pp. 55-83, Siena.
- Bakalova D. (1983) - Paleogene Calcareous Algae of Division Rhodophyta from the Area of the Town of Asenovgrad, South Bulgaria (in Bulgarian). *Paleont., Strat. Lith.*, v. 18, pp. 43-68, Sofia.
- Bassi D. (1995) - *Sporolithon*, *Hydrolithon*, *Corallina* and *Halimeda* in the Calcare di Nago (Eocene, Trento, Northern Italy). *Ann. Univ. Ferrara (N.S.)*, s. Sci. Terra, v. 6, n. 2, pp. 9-25, Ferrara.
- Bassi D. (1998) - Coralline Red Algae (Corallinales, Rhodophyta) from the Upper Eocene Calcare di Nago (Lake Garda, Northern Italy). *Ann. Univ. Ferrara (N.S.)*, s. Sci. Terra, v. 7, suppl., pp. 5-51, Ferrara.
- Basso D., Fravega P., Piazza M. & Vannucci G. (1998) - Revision and re-documentation of M. Airoidi's species of *Mesophyllum* from the Tertiary Piedmont Basin (NW Italy). *Riv. Ital. Paleont. Strat.*, v. 104, 1, pp. 85-94, Milano.
- Braga J.C., Bosence W.J. & Steneck R.S. (1993) - New anatomical characters in fossil coralline algae and their taxonomic implications. *Palaeontology*, v. 36, 3, pp. 535-547, London.
- Capeder G. (1900) - Contribuzione allo studio dei *Lithothamnion* Terziari. *Malpighia*, v. 14, pp. 1-11, Genova.
- Francavilla F., Frascari Ritondale Spano F. & Zecchi R. (1970) - Alghe e Macroforaminiferi al limite Eocene-Oligocene presso Barbarano (Vicenza). *Giorn. Geol.*, v. 36, pp. 653-686, Bologna.
- Fravega P., Giammarino S., Piazza M., Russo A. & Vannucci G. (1987) - Significato paleoecologico degli episodi coralgalgi a Nord di Sassello. Nuovi dati per una ricostruzione

- paleogeografico-evolutiva del margine meridionale del Bacino Terziario del Piemonte. *Atti Soc. Tosc. Sc. Nat. Mem.*, ser. A, v. 94, pp. 19-76, Pisa.
- Fravega P., Giammarino S., Traverso G. & Vannucci G. (1988) - Insediamenti coralgali e loro significato nell'evoluzione delle conoidi oligoceniche della Val Lemme (Bacino Terziario del Piemonte). In Robba E. (Ed.) - Atti IV Simposio "Ecologia e Paleocologia delle Comunità Bentoniche". *Boll. Mus. Reg. Sc. Nat. Torino*, pp. 199-221, Torino.
- Fravega P., Piazza M., Stockar R. & Vannucci G. (1994) - Oligocene coral and algal reef and related facies of Valzemola (Savona, NW Italy). *Riv. It. Paleont. Strat.*, v. 100, 3, 423-456, Milano.
- Fravega P. & Vannucci G. (1980a) - Associazione a Corallinacee nella serie di Costa Merlassino (Alessandria) e suo significato ambientale. *Ann. Univ. Ferrara (N.S.)*, sez. IX - Sc. Geol. Paleont. - VI, suppl., pp. 93-117, Ferrara.
- Fravega P. & Vannucci G. (1980b) - Segnalazione di una nuova specie di *Lithophyllum*: *Lithophyllum sasselense* n. sp., nel "Rupeliano" superiore di Sassello (Bacino Ligure-Piemontese). *Quad. Ist. Geol. Univ. Genova*, v. 1, 3, pp. 31-37, Genova.
- Greuter W., Barrie F.R., Burdet H.M., Chaloner W.G., Demoulin V., Hawksworth D.L., Jørgensen P.M., Nicolson D.H., Silva P.C. & Trehane P. (1994) - International Code of Botanical Nomenclature (Tokyo Code) Adopted by the Fifteenth Intl. Botanical Congress, Yokohama, August-September 1993. V. of 389 pp. Koeltz Scientific Books, Königstein.
- Heydrich F. (1897) - Corallinaceae, insbesondere Melobesiae. *Berichte der Deutschen Botanischen Gesellschaft*, v. 15, pp. 34-71, Berlin.
- Holmgren P.K., Holmgren N.H. & Barnett L.C. (1990) - Index Herbariorum, part 1. The Herbaria of the World. 8th edn. New York Botanical Garden, X-693. *Regnum Vegetabile* Vol. 120, New York.
- Keats D.W. & Chamberlain Y.M. (1993) - *Sporolithon ptychoides* Heydrich and *S. episporum* (Howe) Dawson: two crustose coralline red algae (Corallinales, Sporolithaceae) in South Africa. *South African Journ. Bot.*, v. 59, pp. 541-550, Pretoria.
- Keats D.W. & Chamberlain Y.M. (1995) - *Heydrichia groeneri* sp. nov.: a new species of crustose coralline alga (Rhodophyta, Sporolithaceae) from South Africa and Namibia. *Phycologia*, v. 34, 1, pp. 51-57, Oxford.
- Kylin H. (1956) - Die Gattungen der Rhodophyceen. V. of 673 pp., CWK Gleerups, Lund.
- Lorenz C. (1964) - La série aquitaniennne de Millesimo (Italie, province de Savone). *Bull. Soc. Géol. France*, v. 6, ser. 7, pp. 192-204, Paris.
- Lorenz C. (1969) - Contribution à l'étude stratigraphique de l'Oligocène inférieur des confins Liguro-Piémontais (Italie). *Atti Ist. Geol. Univ. Genova*, v. 6, pp. 1-888, Genova.
- Mastrorilli V.I. (1968a) - Rinvenimento di Squamariacee nell'Oligocene del Bacino Ligure-Piemontese. *Atti Ist. Geol. Univ. Genova*, v. 5, 1, pp. 139-150, Genova.
- Mastrorilli V.I. (1968b) - Nuovo contributo allo studio delle Corallinacee dell'Oligocene Ligure-Piemontese: i reperti della tavoletta Ponzone. *Atti Ist. Geol. Univ. Genova*, v. 5, 2, pp. 153-406, Genova.
- Mastrorilli V.I. (1973) - Flore fossile a Corallinacee di alcune località venete tra i Berici e l'Altopiano di Asiago. *Atti Soc. ital. Sci. nat. Museo civ. Stor. nat. Milano*, v. 114, 3, pp. 209-292, Milano.
- Moussavian E. & Kuss J. (1990) - Typification and status of *Lithothamnium aschersoni* Schwager, 1883 (Corallinaceae, Rhodophyta) from Paleocene limestones of Egypt. A contribution to the synonymy and priority of the genera *Archaeolithothamnium* Rothpletz and *Sporolithon* Heydrich. *Berliner geowiss. Abb.*, s. A, v. 120, n. 2, pp. 929-942, Berlin.
- Rothpletz A. (1891) - Fossile kalkalgen aus den Familien der Codiaceen und der Corallinaceen. *Zeitschrift der Deutschen geologischen Gesellschaft*, vol. 43, 2, pp. 295-322, Berlin.
- Rothpletz A. (1893) - Ueber eine neue Pflanze (*Lithothamnium erythraeum* n. sp.) des Roten Meeres. *Bot. Zentralbl.*, v. 54, 14, pp. 1-2, Cassel.
- Townsend R.A., Chamberlain Y.M. & Keats D.W. (1994) - *Heydrichia woelkerlingii* gen. et sp. nov., a newly discovered non-geniculate red alga (Corallinales, Rhodophyta) from Cape province, South Africa. *Phycologia*, v. 33, pp. 177-186, Oxford.
- Townsend R.A., Woelkerling W.J., Harvey A.S. & Borowitzka (1995) - An account of the red algal genus *Sporolithon* (Sporolithaceae, Corallinales) in Southern Australia. *Austr. Syst. Bot.*, v. 8, pp. 85-121, Melbourne.
- Vannucci G., Piazza M., Fravega P. & Arnera V. (1993) - Le rodoliti del Miocene inferiore del settore SW del Bacino Terziario del Piemonte (Spigno Monferrato - Alessandria). *Atti Soc. Tosc. Sc. Nat., Mem.*, ser. A, v. 100, pp. 93-117, Pisa.
- Vannucci G., Piazza M., Pastorino P. & Fravega P. (1997) - Le facies a coralli coloniali e rodoficee calcaree di alcune sezioni basali della Formazione di Molare (Oligocene del Bacino Terziario del Piemonte, Italia nord-occidentale). *Atti Soc. Tosc. Sc. Nat. Mem.*, ser. A, v. 104, pp. 13-39, Pisa.
- Verheij E. (1992) - Structure and reproduction of *Sporolithon episoredion* (Adey, Townsend et Boykins) comb. nov. (Corallinales, Rhodophyta) from the Spermonde Archipelago, Indonesia. *Phycologia*, v. 31, 6, pp. 500-509, Oxford.
- Verheij E. (1993) - The genus *Sporolithon* (Sporolithaceae fam. nov., Corallinales, Rhodophyta) from the Spermonde Archipelago, Indonesia. *Phycologia*, v. 32, 3, pp. 184-196, Oxford.
- Woelkerling Wm. J. (1988) - The Coralline Red Algae: An Analysis of the Genera and Subfamilies of Nongeniculate Corallinaceae. V. of 268 pp., Oxford Univ. Press, Oxford.
- Woelkerling Wm. J. (1993) - Type collections of Corallinales (Rhodophyta) in the Foslie Herbarium (TRH). *Gunnaria* v. 67, 289 pp., Trondheim.
- Woelkerling Wm. J., Irvine L.M. & Harvey A.S. (1993) - Growth-forms in Non-geniculate Coralline Red Algae (Corallinales, Rhodophyta). *Aust. Syst. Bot.*, v. 6, pp. 277-293, Melbourne.