
Some observations on dinoflagellate cyst genus *Alterbidinium* Lentin & Williams 1985

Khowaja-Ateequzzaman, Rahul Garg & K. P. Jain

Khowaja-Ateequzzaman, Garg, Rahul & Jain, K. P. 1991. Some observations on dinoflagellate cyst genus *Alterbidinium* Lentin & Williams 1985. *Palaeobotanist* 39(1) : 37-45.

A detailed study of dinoflagellate cysts belonging to *Alterbidinium* Lentin & Williams 1985, recovered from Trichinopoly Formation (Turonian-Santonian), Cauvery Basin, southern India, revealed new information that the 2a intercalary periarchoepyle and endoarchaeopyle are dissimilar in shape represented by steno-iso-deltaform and eury-deltaform respectively. The genus *Alterbidinium* and its two species, viz., *A. acutulum* (Wilson) Lentin & Williams 1985 and *A. minus* (Alberti) Lentin & Williams 1985, are emended and a new species, *A. papillatum*, is proposed.

Key-words—Dinoflagellate cyst, Cretaceous, Cauvery Basin (India).

Khowaja-Ateequzzaman, Rahul Garg & K. P. Jain, Birbal Sabni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारांश

आल्टरबीडीनियम लेन्टिन व विलियम्स 1985 घूर्णीकशाभ पुटी प्रजाति पर कुछ प्रेक्षण

खोवाजा-अतीकुज्जमाँ, राहुल गर्ग एवं कृष्ण प्रसाद जैन

दक्षिणी भारत में कावेरी द्रोणी के त्रिचनापल्ली शैल-समूह (तुरोनियन-सॅन्तोनियन) से उपलब्ध आल्टरबीडीनियम लेन्टिन व विलियम्स 1985 नामक घूर्णीकशाभ पुटी प्रजाति का विस्तृत अध्ययन किया गया है। जिससे यह नई जानकारी मिली है कि 2 अ अन्तर्वेशी पेरीआर्कियोपाइल एवं अन्तःआर्कियोपाइल के आकार में विभिन्नता है तथा ये क्रमशः स्टीनो/समडेल्टा-प्ररूपों एवं यूरीडेल्टारूपों से निरूपित हैं। आल्टरबीडीनियम प्रजाति एवं इसकी दो जातियाँ अर्थात् आ० एच्यूटुलम (विल्सन) लेन्टिन व विलियम्स 1985 एवं आ० माइनस (अल्बर्टाई) लेन्टिन व विलियम्स 1985 संशोधित की गई हैं तथा आ० पेपिलेटम नामक एक नव जाति प्रस्तावित की गई है।

VOZZHENNIKOVA (1967, p. 150-151) instituted the genus *Albertia* to include some distinctive peridinioid dinoflagellate cysts. This name was found to be a junior homonym of *Albertia* Schimper 1837 by Lentin and Williams (1976, p. 47) who consequently substituted a new name *Alterbia* pro *Albertia* Vozzhennikova 1967 and also proposed generic emendation. They accordingly preferred the transfer of several species of *Deflandrea* Eisenack 1938 emend. Lentin & Williams 1976 and the type species of *Senegalinium*, *S. bicavatum* Jain & Millepied 1973 and of *Andalusiella*, *A. mauthei* Riegel 1974 to *Alterbia*.

Later Lentin and Williams (1977, p. 5) revised their earlier concept and distinguished *Alterbia*, *Andalusiella* and *Senegalinium* as separate and distinctive genera. On the ground that *Alterbia* included the type species of two earlier validly

published taxa, they considered *Alterbia* Lentin & Williams 1976 to be illegitimate but unfortunately retained the same name *Alterbia* Lentin & Williams 1976 pro *Albertia* Vozzhennikova 1967 (Sans *S. bicavatum* & *A. mauthei*). Since *Alterbia* Lentin & Williams 1976 was nomenclaturally illegitimate, Lentin and Williams (1985, p. 11) subsequently rejected its generic emendation and further pointed out that *Alterbia* Lentin & Williams 1977 actually became a junior homonym of *Alterbia* Lentin & Williams 1976. They, therefore, proposed *Alterbidinium* nom. subst. pro *Alterbia* Lentin & Williams 1977 (non *Alterbia* Lentin & Williams 1976). Thus they rectified the nomenclatural controversies but did not update its diagnosis which therefore remains exclusively linked with the following original diagnosis provided by Vozzhennikova (1967, p. 150-151), "Theca

pentagonal, rhomboid, subdivided into almost equal parts. Epitheca bellshaped, triangular with a small apical horn. Hypotheca with one or two unequal antapical horns. Transverse furrow equatorial, annulate; longitudinal furrow situated on the hypotheca and attaining the antapex. Internal body has the same outline as that of theca. Pylome triangular with rounded or truncated angles, thus appearing some what trapeziform" (translation by Lees, 1971, p. 234).

MATERIAL

Samples yielding *Alterbidinium* specimens belong to the Trichinopoly Formation (Turonian-Santonian), Cauvery Basin, southern India. Locality and stratigraphic details of the samples collected from the Cretaceous sequence exposed in the Ariyalur area, Trichinopoly District, are given below:

1. *Locality*—Tappay Village.

Stratigraphic position—Base of Trichinopoly Formation.

Lithology—Clay lense in fossiliferous bluish grey to brownish gritty to conglomeratic calcareous sandstone, rich in bivalves.

2. *Locality*—Kunnam Village.

Stratigraphic position—Middle part of Trichinopoly Formation.

Lithology—Fine grained grey to bluish calcareous sandstone nodule in grey to yellowish brown calcareous sandy shales underlying the highly fossiliferous bluish grey shell limestone.

About 200 well-preserved specimens of *Alterbidinium* are studied under Nomarski Differential Interference Contrast to interpret the type of archaeopyle and paratabulation. The archaeopyle terminology followed in the text refers to Bujak and Davies (1983) and Evitt (1985, p. 133-134). The type and figured slides are housed in the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow, India. All coordinates refer to Olympus BH-2 microscope.

SYSTEMATIC DESCRIPTIONS

Alterbidinium Lentin & Williams 1985 emend. herein

- 1967 *Albertia* Vozzhennikova, p. 150-151.
 1976 non-*Alterbia* Lentin & Williams, p. 47 (nom. subst. pro *Albertia* Vozzhennikova 1967).
 1977 *Alterbia* Lentin & Williams 1976, In: Lentin & Williams, p. 5.
 1985 *Alterbia* Lentin & Williams 1977, In: Lentin & Williams, p. 11.
 1985 *Alterbidinium* Lentin & Williams, p. 14 (nom. subst. pro *Alterbia* Lentin & Williams 1977 non *Alterbia* Lentin & Williams 1976).

Type species—*Alterbidinium acutululum* (Wilson) Lentin & Williams 1985.

Emended diagnosis—Cyst proximate, dorso-ventrally compressed, circumcavate; pericyst ambitus pentagonal to subpentagonal with an apical and two unequal antapical horns, right antapical horn reduced; endocyst subspherical to broadly pentagonal; periphragm and endophragm smooth or with ornamentation of low relief; periparacingulum generally present, annulate; paratabulation present or absent; archaeopyle intercalary, independently developed on periphragm and endophragm, dissimilar in shape; periarchoepyle hexa 2a, steno/iso-deltaform, perioperculum free or adnate; endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate.

Alterbidinium papillatum sp. nov.

Pl. 1, figs 1-7; Pl. 2, figs 5-6; Text-figs 1A-B, 2A-B, 3A-B

Diagnosis—Cyst proximate, dorso-ventrally compressed, circumcavate, pericyst ambitus pentagonal with an apical horn and two symmetrically placed unequal antapical horns, right antapical horn reduced; periphragm thin, papillate, papillae more pronounced on dorsal surface, intratabular; endocyst subpentagonal, endophragm thicker than periphragm, smooth; periparacingulum annulate; paratabulation peridinioid, ?4', 3a, 7", Xc,

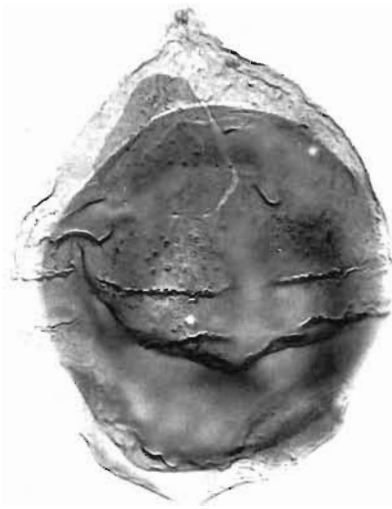
PLATE 1

- 1-7 *Alterbidinium papillatum* sp. nov.
 1-3. Dorsal high, dorsal low and ventral views respectively; slide no. BSIP 10263; Coordinates : 7.0 × 135.5, × 1000 (paratype).
 4-7. Holotype specimen in dorsal high, dorsal low, ventral low and ventral high views respectively showing distribution of intratabular papillae on periphragm and dissimilar periar-

- chaeopyle and endoarchaeopyle; slide no. BSIP 10264; Coordinates : 17.0 × 147.0, × 1000.
 8,9. *Alterbidinium minus* (Alberti) Lentin & Williams 1985, in dorsal and ventral views respectively; slide no. BSIP 10262; Coordinates : 3.7 × 123.1; × 1000.



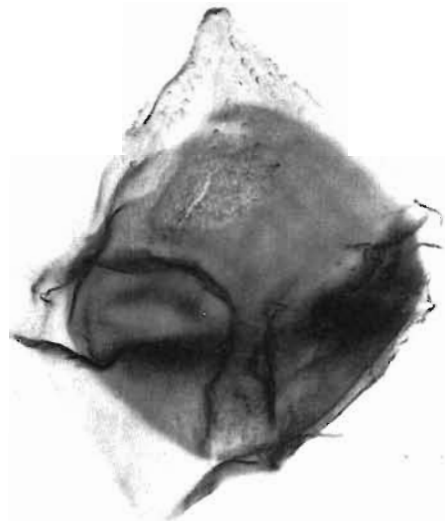
1



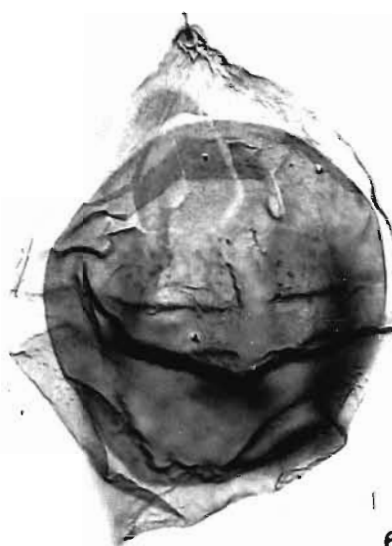
4



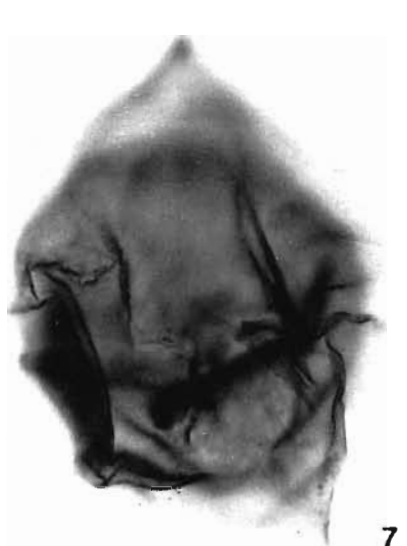
5



2



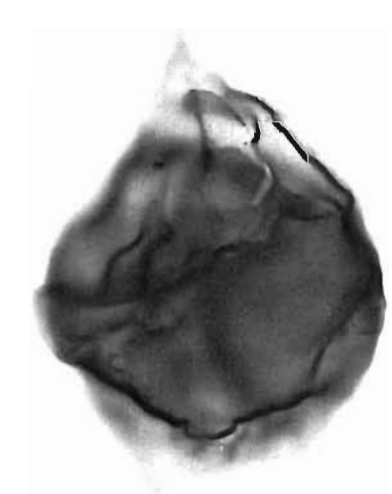
6



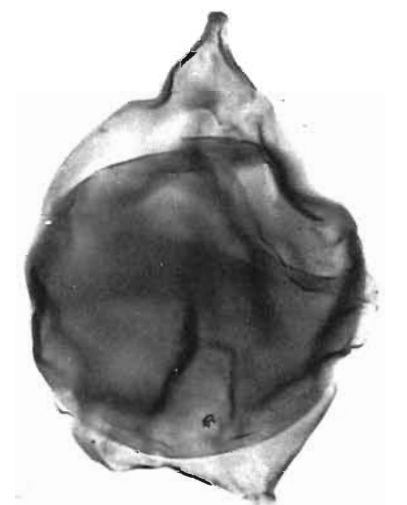
7



3

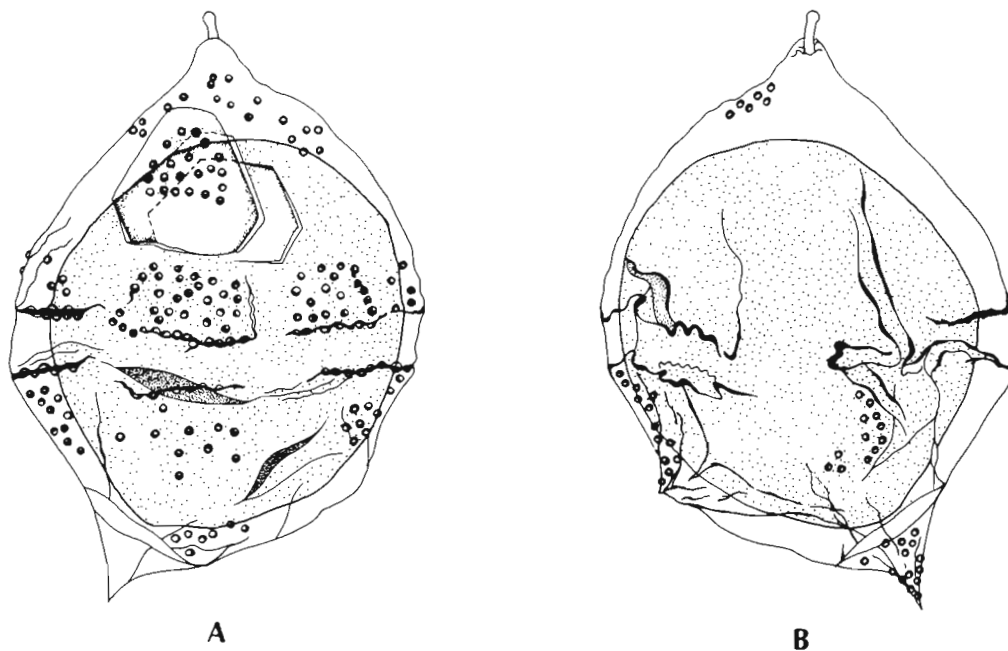


8



9

PLATE 1



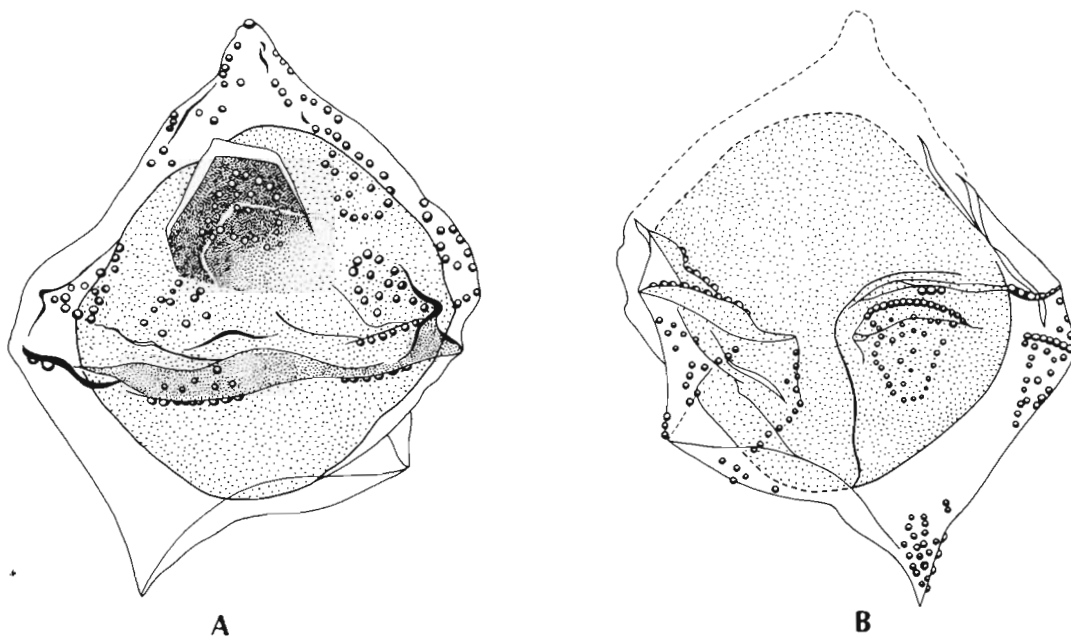
Text-figure 1—*Alterbidinium papillatum* sp. nov.—**A**. Dorsal view showing papillate intratabular ornamentation and dissimilar periarchaeopyle and endoarchaeopyle; **B**. Ventral view showing parasulcal area and reduced right antapical horn (camera lucida drawings of holotype specimen, ca $\times 1000$).

5''', 1p, 2''' ; archaeopyle intercalary, independently developed on periphragm and endophragm, periarchaeopyle hexa 2a, steno-deltaform, perioperculum adnate, endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate.

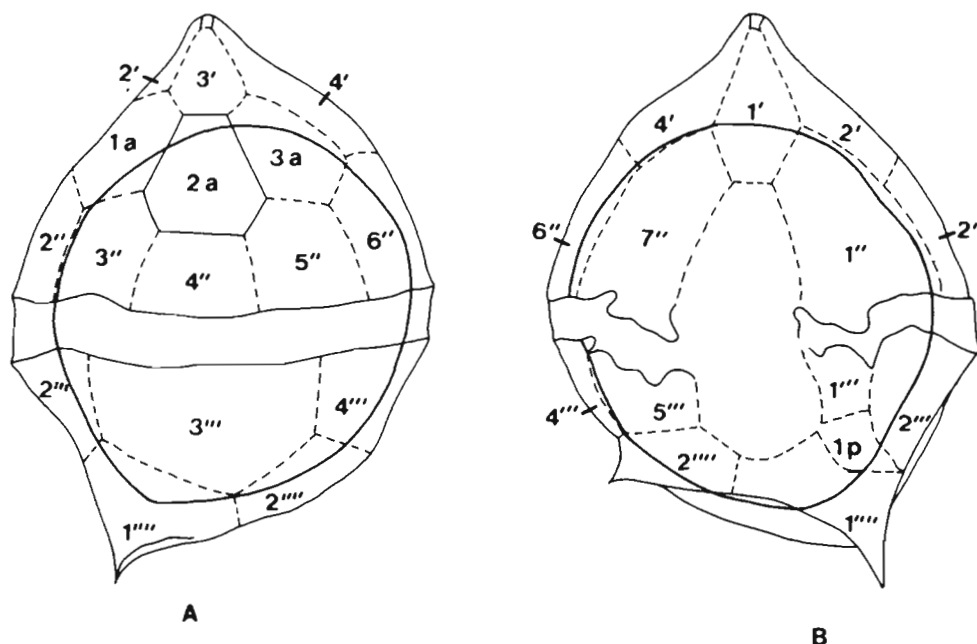
Shape—Cyst proximate, dorso-ventrally compressed; pericyst ambitus pentagonal with a

broad based apical horn having a short apicular process at the tip (sensu Wiggins, 1975, p. 98) and two symmetrically placed unequal antapical horns, right antapical horn reduced; endocyst subpentagonal.

Wall relationship—Apical and antapical pericoels prominent, connected through ambital



Text-figure 2—*Alterbidinium papillatum* sp. nov.—**A**, **B**. Paratype specimen in dorsal and ventral views respectively showing intratabular papillate ornamentation on periphragm (camera lucida drawings, ca $\times 1000$).



Text-figure 3—*Alterbidinium papillatum* sp. nov.—**A, B.** Diagrammatic representation of paratabulation in dorsal and ventral views respectively, ca \times 1300.

pericoel (circumcavate), endocyst shifted more towards dorsal side where periphragm and endophragm appressed in the precingular and postcingular areas.

Wall features—No parasutural features; periphragm thin, papillate, papillae intratabular, pronounced on perioperculum, precingular, postcingular and antapical paraplate areas on dorsal surface (Text-figs 1A, 2A-B); ventral surface bears numerous irregular folds (Text fig. 1B); periparacingulum marked by two parallel ridges and a furrow running high over endocyst, bearing papillae arranged in two single discontinuous rows on the margins of the ridges, paracingular paraplates indiscernible; endophragm thicker than periphragm, smooth; perisulcus marked by a depression.

Paratabulation—Peridinioid, incompletely discernible on individual specimens; pericyst paratabulation formula ?4', 3a, 7'', Xc, 5''', 1p, 2'''' (Text-fig. 3A-B).

Archaeopyle—Intercalary, independently developed on periphragm and endophragm, periarchoepyle hexa 2a, steno-deltaform, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin).

Holotype—Pl. 1, figs 4-7; Slide no. BSIP 10264; coordinates: 17.0×147.0 .

Type locality—Kunnam Village.

Age—Turonian-Santonian.

Dimensions:

	Holotype	Range
Pericyst:	$70 \times 52 \mu\text{m}$	$68.75 \times 50.58 \mu\text{m}$
Endocyst:	$46 \times 46 \mu\text{m}$	$45.48 \times 46.52 \mu\text{m}$

Periarchoepyle

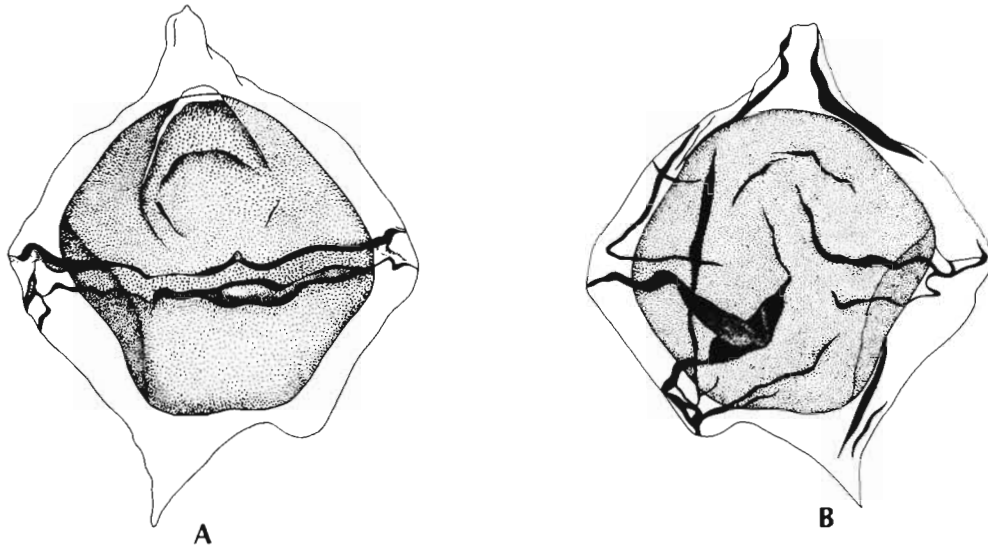
Transverse Archeopyle Index (TAI)	0.33
Longitudinal Archeopyle Index (LAI)	0.46
Archeopyle Ratio (AR)	1.1
Archeopyle Signum (AS)	2.5

Endoarchaeopyle

Transverse Archeopyle Index (TAI)	0.32
Longitudinal Archeopyle Index (LAI)	0.44
Archeopyle Ratio (AR)	0.56
Archeopyle Signum (AS)	1.8

Comparison—*Alterbidinium papillatum* sp. nov. is characterized mainly in having intratabular papillate ornamentation on pericyst which differentiates it from all the known species of the genus. Manum (1963, p. 58-59, pl. 2, figs 1-5; text-fig. 2) described some dinoflagellate cysts as *Deflandrea* cf. *scheii* from the Cretaceous of Graham Island, Arctic Canada. These forms resemble the present specimens in having intratabular ornamentation and overall shape but differ mainly in having parasutural ridges.

Alterbidinium acutulatum (Wilson) Lentin & Williams
1985 emend. herein
Pl. 2, figs 1-4, 7-9; Text-fig. 4A-B



Text-figure 4—*Aterbidinium acutulatum* (Wilson) Lentin & Williams 1985 emend. herein—**A**. Dorsal view showing psilate periphragm and endophragm having dissimilar archaeopyles; **B**. Ventral view (camera lucida drawings of specimen, Pl. 2, figs 1-4, ca $\times 1000$).

- 1967 *Deflandrea acutula* Wilson, p. 225-226, figs 11, 12.
 1967 *Albertia recticornis* Vozzhennikova, p. 151, 152; pl. 77, figs 1-4; pl. 78, figs 1-3; pl. 79, figs 1, 2.
 1967 *Albertia curvicornis* Vozzhennikova, p. 151, pl. 76, figs 1-4.
 1976 *Alterbia recticornis* (Vozzhennikova) Lentin & Williams, p. 47.
 1976 *Alterbia acutula* (Wilson) Lentin & Williams, p. 48.
 1976 *Alterbia curvicornis* (Vozzhennikova) Lentin & Williams, p. 49.
 1979 *Alterbia acutula* (Wilson) Lentin & Williams 1976, In: Whitney, p. 125.
 1985 *Aterbidinium acutulatum* (Wilson) Lentin & Williams, p. 14.
 1990 *Aterbidinium acutulatum* (Wilson) Lentin & Williams 1985, In: Harker *et al.*, p. 103-104.
 1990 *Aterbidinium recticornis* (Vozzhennikova) Harker & Sarjeant, In: Harker *et al.*, p. 104.

Emended diagnosis—Cyst proximate, dorso-ventrally compressed, circumcavate; pericyst ambitus pentagonal with an apical and two

symmetrically placed unequal antapical horns, right antapical horn reduced; periphragm thin, smooth, endocyst subpentagonal, endophragm thicker than periphragm, smooth, periparacingulum present, annulate; paratabulation indicated by archaeopyle and periparacingulum only; archaeopyle intercalary, independently developed on periphragm and endophragm; periarachaeopyle hexa 2a, iso deltaform, perioperculum adnate; endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate.

Description:

Shape—Cyst proximate, dorso-ventrally compressed; pericyst ambitus pentagonal with a broad based apical horn and two symmetrically placed unequal antapical horns, right antapical horn reduced; endocyst subpentagonal.

Wall relationship—Apical and antapical pericoels connected through ambital pericoel (circumcavate); endocyst shifted more towards dorsal side where the periphragm and endophragm are appressed in precingular and postcingular areas.

Wall features—No parasutural features; periphragm and endophragm thin but endophragm thicker than periphragm; periparacingulum,

PLATE 2 →

- 1-4, 7-9. **Aterbidinium acutulatum* (Wilson) Lentin & Williams 1985 emend. herein:
 1-4. Same specimen in different foci; 1 dorsal high view showing periparacingulum; 2. dorsal low view showing psilate periphragm and dissimilar periarachaeopyle and endoarchaeopyle; 3, 4. ventral low and ventral high views respectively; slide no. BSIP 10265; Coordinates :

23/0 \times 152.5; all \times 1000.

- 7-9. Same specimen in right lateral high, right lateral low and left lateral views respectively; slide no. BSIP 10264; Coordinates : 7.1 \times 128.0; all, \times 1000.

- 5, 6. *Aterbidinium papillatum* sp. nov.; 5. slide no. BSIP 10263; Coordinates : 5.0 \times 143.5, \times 1000; 6. slide no. BSIP 10264; Coordinates : 11.9 \times 145.0, \times 1000.

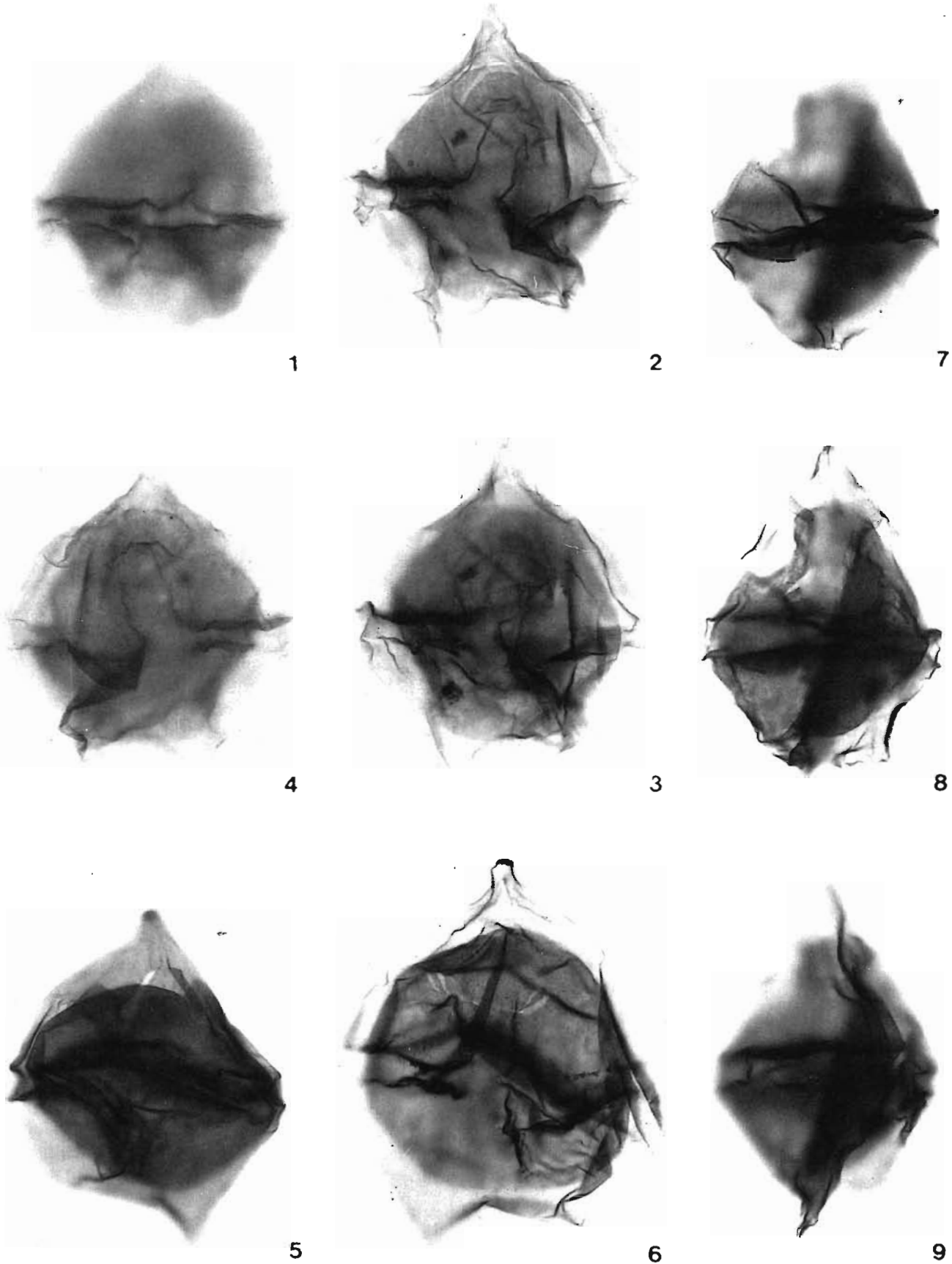


PLATE 2

annulate running high over endocyst, marked by two parallel ridges and a furrow in between; periparasulcus marked by a depression.

Paratabulation—Indicated by archaeopyle and periparacingulum only.

Archaeopyle—Intercalary, independently developed on periphragm and endophragm, periarchoepyle hexa 2a, iso-deltaform, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin).

Dimensions:

	<i>Holotype</i>	<i>Range</i>
Pericyst:	66 × 55 μm	62-70 × 52-57 μm
Endocyst:	42 × 42 μm	40-45 × 38-42 μm

Periarchoepyle

Transverse Archaeopyle Index (TAI)	0.40
Longitudinal Archaeopyle Index (LAI)	0.66
Archaeopyle Ratio (AR)	1.0
Archaeopyle Signum (AS)	3.6

Endoarchaeopyle

Transverse Archaeopyle Index (TAI)	0.35
Longitudinal Archaeopyle Index (LAI)	0.29
Archaeopyle Ratio (AR)	1.7
Archaeopyle Signum (AS)	1.5

Remarks—The emendation of the species is based on the study of the specimens recovered from Trichinopoly Formation, Cauvery Basin, India and on the face value of the holotype specimen documented by Wilson (1967) and the specimens illustrated by Vozzhennikova (1967) for *Alberbia recticornis*. Wilson (1967, p. 225) is of the opinion that the right antapical horn is long and the left antapical horn is absent, but its position is marked by a minor angularity on the margin of the pericyst. Wilson (personal communication, 7 May, 1990) now considers that the right antapical horn is reduced following the currently accepted procedure to determine the left and right antapical horns.

Recently, Harker and Sarjeant (In: Harker *et al.*, 1990; p. 103-104) awarded individual status to *Alterbidinium recticornis* and *A. acutululum* on a very imprecise ground that the attenuated hexagonal peripyle is "narrower" in the latter. Further, the "narrower" peripyle is not supported by any comparative dimensions met within the holotypes of these two species and the specimens of *A. acutululum* studied by them. This could be a case of size variation within the species and therefore their proposal is not acceptable.

Stratigraphic range—Turonian-Palaeocene.

Present record—Kunnam Village.

Alterbidinium minus (Alberti) Lentin & Williams
1985 emend. herein
Pl. 1, figs 8, 9

- 1959 *Deflandrea minor* Alberti, p. 98, pl. 9, figs 9-11.
1976 *Alterbia minor* (Alberti) Lentin & Williams, p. 49.
1985 *Alterbidinium minor* (Alberti) Lentin & Williams, p. 14.
1989 *Alterbidinium minus* (Alberti) Lentin & Williams 1985, In: Lentin & Williams, p. 13.

Emended diagnosis—Cyst proximate, dorso-ventrally compressed, circumcavate, pericyst ambitus pentagonal with an apical and two unequal antapical horns, right antapical horn reduced; periphragm thin, smooth; endocyst subpentagonal, endophragm thicker than periphragm, smooth; periparacingulum absent, paratabulation indicated by archaeopyle alone; archaeopyle intercalary, independently developed on periphragm and endophragm, periarchoepyle hexa 2a, steno-deltaform, perioperculum adnate, endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate.

Description:

Shape—Cyst proximate, dorso-ventrally compressed; pericyst ambitus pentagonal with an apical horn and two unequal antapical horns, right antapical horn reduced; endocyst subpentagonal.

Wall relationship—Apical and antapical pericoels prominent, connected through ambital pericoel (circumcavate); endocyst shifted more towards dorsal side where periphragm and endophragm appressed in the precingular and postcingular areas.

Wall features—No parasutural features; periphragm thin, smooth; endophragm relatively thick, smooth, at times a short apicular process present (sensu Wiggins, 1975, p. 98), paracingulum absent.

Paratabulation—Indicated by archaeopyle alone.

Archaeopyle—Intercalary, independently developed on periphragm and endophragm; periarchoepyle hexa 2a, steno-deltaform, perioperculum adnate (adnation along adcingular margin); endoarchaeopyle hexa 2a, eury-deltaform, endoperculum adnate (adnation along adcingular margin).

Dimensions:

	<i>Range</i>
Pericyst:	60-65 × 45-50 μm

Endocyst: 40.45 × 40.45 μm

Periarchaeopyle

Transverse Archaeopyle Index (TAI)	0.34
Longitudinal Archaeopyle Index (LAI)	0.44
Archaeopyle Ratio (AR)	1.2
Archaeopyle Signum (AS)	2.3

Endoarchaeopyle

Transverse Archaeopyle Index (TAI)	0.33
Longitudinal Archaeopyle Index (LAI)	0.42
Archaeopyle Ratio (AR)	0.52
Archaeopyle Signum (AS)	1.6

Stratigraphic range—Turonian-Senonian.

Present record—Tappay Village.

Remarks—The emendation of the species is based on the study of specimens recovered from the Trichinopoly Formation, Cauvery Basin, India as well as on the face value of the holotype specimens documented by Alberti (1959, p. 98, pl. 9, figs 9-11).

REFERENCES

- Alberti, G. 1959. Zur Kenntnis der Gattung *Deflandrea* Eisenack (Dinoflag.) in der Kreide und in Alttertiär Nord- und Mitteldeutschlands. *Mitt. Geol. Staatsinst. Hamburg* **28** : 93-105.
- Bujak, J. P. & Davies, E. H. 1983. Modern and fossil Peridiniaceae. *AASP Contr. Ser.* **13** : 1-216.
- Eisenack, A. 1938. Die Phosphoritknollen der Bernsteinformation als Überlieferer tertiären Planktons. *Schr. phys.-ökon. Ges. Königsberg* **70** : 181-188.
- Evitt, W. R. 1985. Sporopollenin dinoflagellate cysts, their morphology and interpretation. *AASP Foundation, Texas* : 1-133.
- Harker, S. D., Sarjeant, W. A. S. & Caldwell, W. G. E. 1990. Late Cretaceous (Campanian) organic-walled microplankton from the interior plains of Canada, Wyoming and Texas: Biostratigraphy, palaeontology and palaeoenvironmental interpretation. *Palaeontographica* **B219** : 1-243.
- Jain, K. P. & Millipied, P. 1973. Cretaceous microplankton from Senegal Basin, N.W. Africa-1. Some new genera, species and combinations of dinoflagellates. *Palaeobotanist* **20** : 22-32.
- Lentin, J. K. & Williams, G. L. 1976. A monograph of fossil peridinioid dinoflagellate cysts. *Bedford Inst. Ocean. Rep. Ser.* B1-R-75-16 : 1-237.
- Lentin, J. K. & Williams, G. L. 1977. Fossil dinoflagellates: Index to genera and species, 1977 edition. *Bedford Inst. Ocean. Rep. Ser.* B1-R-77-8 : 1-209.
- Lentin, J. K. & Williams, G. L. 1985. Fossil dinoflagellates; index to genera and species, 1985 edition. *Canadian Tech. Rep. Hydrography Ocean. Sci.* no. **60** : 1-449.
- Lentin, J. K. & Williams, G. L. 1989. Fossil dinoflagellates: index to genera and species 1989 edition. *AASP Contr. Ser.* **20** : 1-473.
- Manum, S. 1963. Some new species of *Deflandrea* and their probable affinity with *Peridinium*. *Norsk Polarinstitut, Arbok* 1962 : 55-67.
- Riegel, W. 1974. New forms of organic-walled microplankton from an Upper Cretaceous assemblage in southern Spain. *Rev. Esp. Micropaleont.* **6** : 347-366.
- Vozzhennikova, T. F. 1967. Iskopaemye peridinei yurskikh, melovykh paleogenovykh Otlozheniy SSSR. *Akad. Nauk SSSR, Sib. Otd., Inst. Geol. Geofiz. Tr.* : 1-347 (Fossilized peridinioid algae in the Jurassic, Cretaceous and Palaeogene deposits of USSR. R. Lees, Trans., W.A.S. Sarjeant (Ed.), Boston Spa, Yorkshire, England, Natl. Lending Lib. Sci. Tech. 1971).
- Wiggins, V. D. 1975. The dinoflagellate family Pareodiniaceae: a discussion. *Geosci. Man* **11** : 95-115.
- Wilson, G. J. 1967. Microplankton from the Garden Cove Formation, Campbell Island. *N. Z. J. Bot.* **5** : 223-240.
- Whitney, B. L. 1979. A population study of *Alterbia acutila* (Wilson) Lentin & Williams from the Maestrichtian (Upper Cretaceous) of Maryland. *Palynology* **3** : 123-128.