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REAPPRAISAL OF THE GENUS *MUDERONGIA* COOKSON & EISENACK, 1958

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ABSTRACT

The original morphographic concept of the genus *Muderongia* proposed by Cookson and Eisenack (1958) is maintained, transferring the species having five well developed horns, with two at the antapical position to a new genus, *Pseudomuderongia*. Out of 14 known species of *Muderongia* only six are retained and others are discussed. Following reallocations are proposed: *Odontochitina* ? *imparilis* (Duxbury) comb. nov., *Australisphaera digitata* (Duxbury) comb. nov., *A. nicholsii* (Nichols & Jacobson) comb. nov., *Pseudomuderongia asymmetrica* (Brideaux) comb. nov., and *P. testudinaria* (Burger) comb. nov.

INTRODUCTION

The dinocyst genus *Muderongia* Cookson & Eisenack (1958) is well known from the Lower Cretaceous sediments of Europe, Canada and Australia. Its representation in Indian subcontinent is very meagre. Jain (1977), for the first time, reported a single cyst from the Lower Albian sediments of Cauvery Basin, southern India. His single specimen recovery of *Muderongia* in a rich dinocyst asesmblage from Dalmiapuram Formation posed the question of reworking or the dwindling phase of *Muderongia* era in lower Albian. To testify the above statement, the senior author continued the efforts to recover these cysts from other sediments in the area. Fortunately two samples which form the material for the present study proved productive and yielded many *Moderongia* cysts. One of these comes from a shallow test pit dug near Tappy in Trichinopolly district (Fig. 1). The stratigraphic position of the sample is not precisely known. It seems most probable that this sample might be equivalent to the sandstone and conglomerate bed unconformably underlying the Dalmiapuram grey-shales, observed in the Kallakkudi limestone quarry II (Jain and Subbaraman, 1969 ; p. 549). Further this might also have some relationship with the Barremian marine intercalations reported from Terani, Trichinopolly district (Mamgain, Sastry and Subbaraman, 1973).

The other sample was collected from a shallow bore hole, drilled near Puduvoyal (Chingleput district) in Palar Basin (Fig. 1). This basin lies between Cauvery Basin, in the south, and Godavari-Krishna in the north. The outcrop of sedimentary rocks in Palar Basin are poor. Over the basement lies the Lower Permian and the succeeding beds include only the

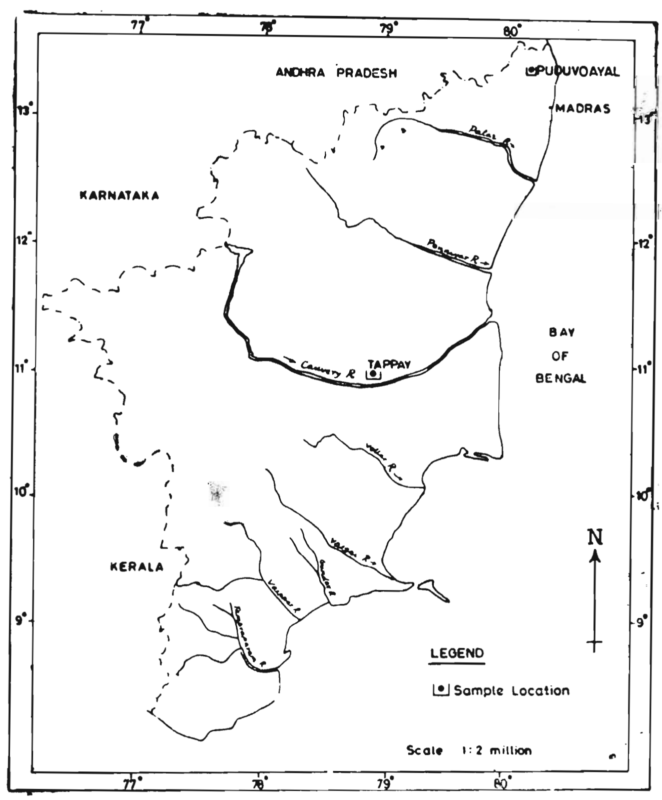

Fig. 1. Map of the area showing location of samples.

Lower Cretaceous sediments viz., Sriperumbudur and Satyavedu beds. The Sriperumbudur beds range in age from Neocomian to Aptian having marine intercalations deposited under shallow and brackish water conditions probably close to the shore line (Sastri *et al*, 1974).

MATERIAL AND METHOD

1. *Sample No.* 3114 ; Location near Tappy, Trichinopolly district, Cauvery Basin ; *Lithology* : Hard, bluish grey calcareous sandstone with shell fragments seen on the surface.

2. *Sample No.* 2691 ; Bore hole-PUD-146 ; *Location* : Puduvoyal, Chingleput district, Palar Basin ; *Position of sample* : total 46 samples were collected from the 764.20 metres deep sequence, only a single sample collected at a depth between 441.2 to 444.2 meters proved productive ; *Lithology* : Hard, grey and compact carbonaceous shale admixed with ash grey clay.

The conventional acid/Alkali treatment followed by acetolysis is preferred to isolate the dinocyst microflora. The detailed dinocyst microfloral analysis with geologic interpretations will be published later elsewhere.

The figured slides are housed at the museum, Birbal Sahni Institute of Palaeobotany, Lucknow. The coordinates are referred to Carl Ziess Jena Amplival microscope.

SYSTEMATIC DESCRIPTION

Genus *Muderongia* COOKSON & EISENACK, 1958

1958 *Muderongia* COOKSON & EISENACK, pp. 40-41.
1961 *Muderongia* COOKSON & EISENACK, in Alberti, p. 18.
1978 *Muderongia* COOKSON & EISENACK, in STOVER & EVITT, pp. 66-67.
1978 *Muderongia* COOKSON & EISENACK, in SARJEANT, p. 34.
1980 *Muderongia* COOKSON & EISENACK, in WILSON & CLOWES, p. 70.

Type species : *Muderongia mcwhaei* Cookson & Eisenack, 1958, p. 41 ; pl. 6, fig. 2.

Remarks : Cookson and Eisenack (1958, pp. 40-41) instituted the genus *Muderongia* with the following description, "Test flattened, bilaterally symmetrical, composed of a thin outer membrane and an internal body or capsule. The outer membrane prolonged into four equidistant horns and crossed by a narrow shallow girdle. A longitudinal furrow is not developed."

From the above mentioned original description of the genus, two significant observations can be pointed out on the morphology of these cysts ; firstly the bilateral symmetry of the cyst and secondly the development of four equidistant horns (Fig. 2-A).

Alberti (1961, in English translation of the Preamble and systematic section by Sarjeant, p. 18) further diagnosed the genus and stated "Cyst flattened, its outline rhombic to almost oval, with an apical horn and two usually unequally long antapical horns, of which one may be reduced. Lateral horns long, rectangular to the longitudinal axis of the cyst or somewhat inclined directed backward from it (?) notched at the free ends. Transverse furrow (=transverse band) occasionally present. Very delicate tabulation sometimes indicated. Surface of the cyst smooth, rarely small spines, which broaden at the base. Inner body always (?) present. Apical part of the cyst commonly sketched with an irregular broken line". Alberti's diagnosis brought a major change in the morphological concept of the genus *Muderongia* that it possesses two antapical horns rather than one as was proposed by Cookson and Eisenack (1958), though Cookson and Eisenack (1958, p. 41) touched this point while describing the type species *M. mcwhaei* on which the generic circumscription is based that "near the points of origin of the horns, small more irregular outgrowths may develop". They considered this character to be more specific rather than generic and maintained the presence of only one antapical horn in *Muderongia*.

Stover and Evitt (1978, p. 67) modified the description of *Muderongia* giving the details of shape (Ceratoid), wall relationship (Cornucavate), wall features (no parasutural features), paratabulation (4′, 6″, 6c, 6‴, 1_p, 1⁗), archaeopyle (Type tA) and paracingulum (position indicated).

They mentioned the development of two cingular and two antapical horns. The position of lateral horns, whether cingular, subcingular or post cingular, is controversial though the explanation of Wall and Evitt (1975, p.32) is most convincing where they compared the lateral horns of *Muderongia* with that of living *Ceratium cardinianum* suggesting postcingular in position composed of plates 1‴-2‴ and 4‴-5‴.

Wall and Evitt (1975, p. 25) concluded that the horns of *Ceratium* project from specific locations in the cell which correspond with apical, antapical and one or two lateral sub-cingular positions. The antapical horn is formed by one antapical and one posterior intercalary plate. They further mentioned that it could be inaccurate to refer to 'two antapical' horns in *Ceratium*. Genus *Muderongia* has been referred to be ceratoid as it contains four strong horns in apical, antapical and lateral positions and the subrhombic shape of the cyst (Wall & Evitt, 1975, p. 32).

The observations of Dörhöfer and Davies (1980, p. 14 ; Fig. 36 C,I,D,F) clearly indicate that the dinocysts they studied from Arctic Canada and Germany possess a combination archaeopyle (AI), two extra intercalary paraplates, two almost bilaterally symmetrical postcingular horns and two antapical horns with concavity. Their placement of these cysts under *Muderongia* and specially to *M. simplex* is unwarranted for the obvious reasons that the genotype of *Muderongia* and the holotype of *M. simplex* are devoid of intercalary paraplates and two antapical horns. The presence of intercalary paraplates in their specimens, if considered true, then the forms must be given a separate taxonomic status even other than what has been proposed in this paper as *Pseudomuderongia* and hence does not effectively alter the morphological concept of *Muderongia* earlier proposed by Cookson and Eiseanck (1958).

One of the most important characteristics of *Muderongia* is the position of its apical and antapical horns. Apical and antapical horns of *Muderongia* are always in a straight median line (Plate I—2, Fig. 2—A). In other genera like *Palaeocystodinium* too, which has a single antapical horn, its position is at the lower axis in a straight median line with apical horn at the upper axis of the cyst. It has been observed that the position of antapical horns in those dinocyst genera which have two antapical horns is always away from the axis, one on either side of it. Furthermore, a perusal of monograph of Lentin and Williams (1975) on fossil Peridinioid dinoflagellate cysts clearly indicates that the development of two antapical horns always possesses an antapical concavity and the median line divides the cyst into two equal halves. The formation of antapical concavity is always lacking in *Muderongia mcwhaei*. It has also been observed that genera like *Deflandrea*, *Ginginodinium*, *Luxadinium*, *Palaeoperidinium*, *Spinidinium*, *Wetzeliella*, *Wilsonidinium* etc. which possess two antapical horns always have two antapical paraplates, whereas in *Muderongia* there is only one antapical paraplate, supporting development of a single antapical horn (wall & Evitt 1975 p. 32).

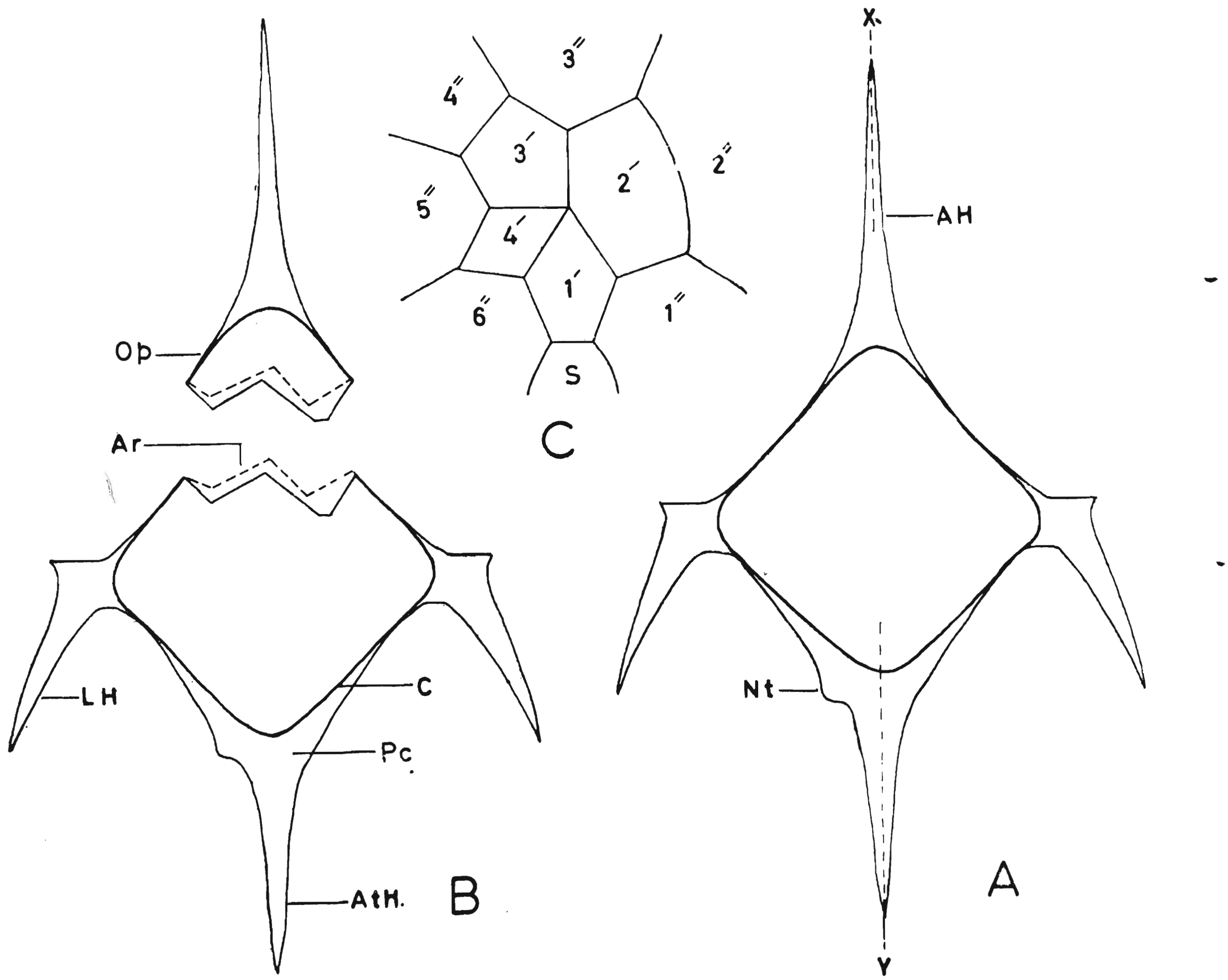

Fig. 2. Diagrammatic representation of *Muderongia mcwhaei* cyst: (A) Cyst in dorsal view showing the presence of a single antapical horn along the longitudinal median axis; Apical horn (AH), notch (Nt), longitudinal median axis (XY), (B) Cyst in ventral view showing archaeopyle sutures (Ar) and outgoing operculum (Op), two lateral horns (LH), a central body, (C) antapical horn (AtH) with braod pericoel (Pc); (C) showing the possible epicystal paratabulation derived in relation to the sulcal notch (s) and the available archaeopyle sutures having a gonyaulacacean pattern.

In the light of the above discussion it is concluded that the true *Muderongia* cyst is characterised as follows :

"Cyst dorsoventrally flattened, bilaterally symmetrical, cavate to cornucavate, shape rhombic to subrhombic, inner body (capsule) present; periphragm smooth to slightly ornamented, prolonged into four equidistant horns ; apical and antapical horns always along the longitudinal median line lying opposite to each other ; lateral horns two, postcingular ; sulcal notch offset, paratabulation may or may not be present, where present represents gonyaulacacean type 4',6", 6c, 6"', 1_p, 1"" ; archaeopyle apical, type (tA)".

The suggestion of Dörhöfer and Davies (1980, p. 14) that the genus *Cantulodinium* Alberti (1961) is synonymous to *Muderongia* is not acceptable. Alberti's (1961, p. 23, pl. 3, figs. 20-23 ; pl. 12, fig. 3) description and illustration distinctly point out that the *Cantulodinium* cysts are not rhombic or subrhombic in shape and there is a possibility of the presence of an intercalary archaeopyle. It is, therefore, maintained as a distinct genus.

Muderongia mcwhaei Cookson and Eisenack, 1958
(Pl. I—1-5 ; Pl. II—1-7; Pl. III—1, 3-9)

Original description : "The test is roughly rhomboidal in outline and prolonged into two straight median horns (apical and antapical respectively) and curved and downwardly directed, lateral horns of varying length ; near the points of origin of the horns, smaller more irregular outgrowths may develop.

The capsule has a smooth, moderately thick wall and entirely fills the central cavity of the test, sometimes even extending into proximal ends of the horns. The girdle is represented by two fine, closely-opposed, straight lines which completely cross the equator of the test.

Frequently extreme distal region of the test becomes detached by split which develops beneath the base of the apical horn" (Cookson and Eisenack, 1958, p. 41).

More than 300 specimens from the present material are identified to be *M. mcwhaei.* They exhibit remarkable variation in morphological features. A normal *Muderongia mcwhaei* cyst is discussed below (Fig. 2) with special reference to conical outgrowths or so-called reduced second antapical horn.

Shape : Capsule rhombic to subrhombic.

Wall : The endophragm is always smooth, periphragm is generally smooth except along the horn margins (Plate I—2), where coni or spine like projections may be developed (Plate III—3, 7). Pericoel well developed at the point of horn origin and is best developed at antapex. Both peri- and endophragm are appressed except at horn bases (cornucavate), at times slightly free from each other giving a cavate appearance.

Paracingulum : Sometimes indicated by faint parallel lines.

Archaeopyle : The archaeopyle studied in more than 200 specimens confirms that the sutures are always zig-zag pointing towards the development of 4 apical and six precingular paraplates (Plate I—2; Fig. 2—B-C). It does not indicate any other paraplate development which may show a combination type (AI) as suggested by development which Dörhöfer and Davies (1980, pl. 36,figs. G to F).

Horns : The horns are always four in number, one on each apical, antapical, right lateral and left lateral sides. The apical and antapical horns develop opposite to each other along the longitudinal median axis (Fig. 2—A). The apical horn is biggest of all the horns and is longer than overall length of the cyst body. It is mostly smooth or sometimes even dentate (Plate III—7).

The lateral horns are smaller than apical and antapical horns, variable in size, ranging from one third of the body width to nearly as long as its complete width. They originate at right angles to the median axis, developing a prominent notch distally from where it is directed antapically. Both shape and size of the lateral horns are very variable (Fig. 3—A-L). The surface is smooth to dentate having coni like projections (Plate III—7).

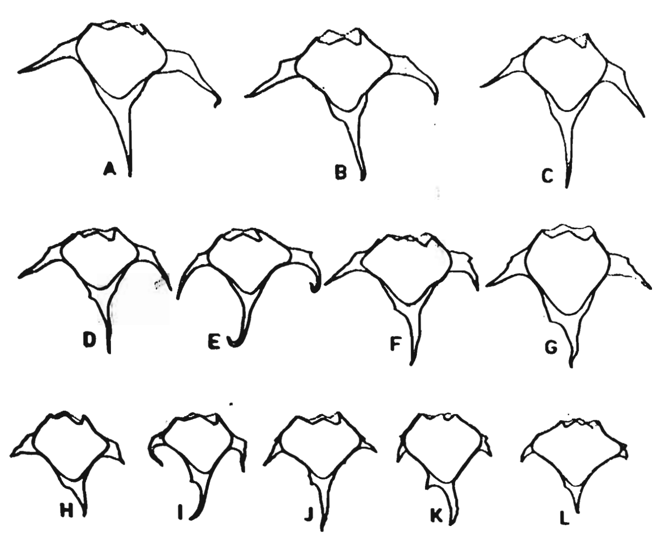

Fig. 3. (A-L) Diagrammatic representation of *Muderongia mcwhaei* cyst showing variations in lateral horn shape, size and surface ornamentation.

The single antapical horn develops just opposite to the apical horn. It is smaller than apical and is bigger than lateral horns, usually as long as that of the body length, simple, and tapering. In case of tapering type, a pouch like structure is developed proximally forming variable degree of pericoel extension (Fig. 4—A-M) but cornucavate situation is mostly

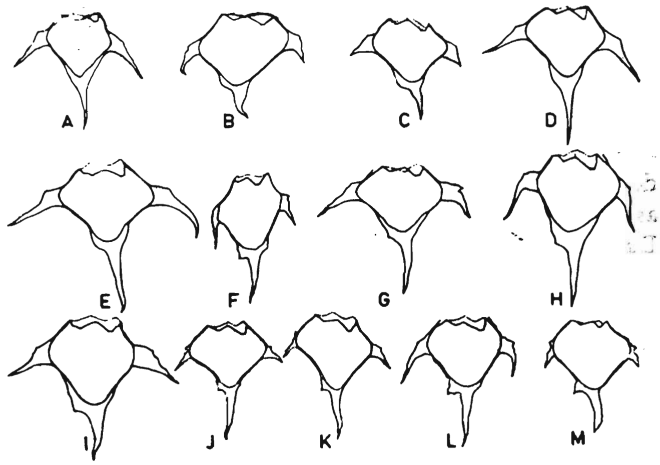

Fig. 4. (A-M) Diagrammatic representation of *Muderongia mcwhaei* cyst showing variations in antapical horn shape, size and surface ornamentation.

maintained. In some specimens the pouch shows the development of slight convexities or outbuldges (Plate I—2; Plate II—1; Fig. 4—B-E) while in others the outbuldges are pointed conical at par with lateral horn notch. The antapical horn always remains just opposite to the apical horn and an antapical concavity is never developed as is commonly seen in many peridinoid and pseudoceratoid cysts. Whenever an outbuldge or antapical horn notch is developed on one side, it is always on the right side opposite to the sulcul notch side. We are of the opinion that the development of outbuldge or notch along the proximal extremity of antapical horn is a specific character and not an additional antapical horn.

Dimensions :

Overall cyst size	160-400 μm ×85-156 μm
Size of capsule	55-125 μm ×85-115 μm
Length of apical horn	70-140 μm
Length of lateral horns	20-105 μm
Length of antapical horn	50-120 μm

In view of the above discussion, it will be worthwhile to critically re-assess the taxonomic status of some of the following, so far known species of the genus *Muderongia* reported from various parts of the world.

1. *Muderongia asymmetrica* Brideaux, 1977
2. *M. crucis* Neale & Sarjeant, 1962
3. *M. digitata* Duxbury, 1980
4. *M. extensiva* Duxbury, 1977
5. *M. imparilis* Duxbury, 1980
6. *M. mcwhaei* Cookson & Eisenack, 1958 (type species).
7. *M. pariata* Duxbury, 1983
8. *M. perforata* Alberti, 1961
9. *M. simplex* Alberti, 1961
10. *M. staurota* Sarjeant, 1966
11. *M. tetracantha* (Gocht) Alberti, 1961
12. *M. testudinaria* Burger, 1980
13. *M. tomaszowensis* Alberti, 1961
14. *M. nicholsii* Nichols & Jacobson, 1982.

Recently Becheler (1983) published drawings and descriptions of thirteen species of *Muderongia*. She included *M. pannosa* Duxbury (1980) which has now been transferred to *Australisphaera*, *A. pannosa* by Duxbury (1983).

Taxonomic comments :

1. *Muderongia* cf. *mcwhaei* Cookson & Eisenack, illustrated and described by Alberti (1961, p. 22; pl. 2, fig. 7) appears to be a form that can be best placed under *Australisphaera* due to its thin wall (phragma), pentagonal shape and lack of an inner body.

2. Duxbury (1980, p. 127; pl. 5, figs. 2, 4, 5; text-fig. 11) instituted a new species of *Muderongia*, *M. imparilis* having a thin walled spheroidal inner body with three well developed horns, and a fourth horn has been described as much reduced, the apical horn is very long. These features except, for the development of the reduced fourth horn which Duxbury (1977, p. 129) himself at the end describes it to be absent, thus suggests nearest comparison with *Odontochitina*. It is therefore, provisionally transferred to *Odontochittina*, *O. imparilis* (Duxbury) comb. nov. (=*Muderongia imparilis* Duxbury, 1980, pp. 127-128; pl. 5, figs. 4-5; text-fig. 11B).

3. Gocht (1957, p. 1968; pl. 18, figs. 7-9) described some froms as *Pseudoceratium tetracanthum* from Germany. Later Alberti (1961) transferrred this species to *Muderongia* illustrating four specimens (pl. 2, figs. 14-18) as *M. tetracantha* (Gocht), having well developed elbows and notching in lateral horns. But in reference to the personal communication of Gocht referred in Davey (1974, p. 67) the forms earlier referred to as *Pseudoceratium tetracanthum* do not possess marked elbows/ notching. In view of this, Davey (1974, p. 67) suggested to transfer Alberti's specimens to a new species. Duxbury (1977) followed the suggestion and placed Alberti's specimens under a new species, *M. extensiva*, leaving *M. tetracantha* restricted to the original *Pseudoceratium tetracanthum* Gocht specimens and a few of his own specimens (Duxbury 1977, pl. 15, fig. 5). *Muderongia crucis* Neale & Sarjeant (1962, pp. 449-450; pl. 20, figs. 2 & 6) is morphologically similar to*Muderon-*

gia tetracantha (Gocht) Alberti (1961) sensu Davey (1974, p. 67) and Duxbury (1980), except for the fact that *M. crucis* forms are slightly larger in size than *M. tetracantha*. The former appears to be a size variant of the latter. Duxbury (1980) also observed the similar findings and is thus treated as its junior synonym.

4. Duxbury (1983, pp. 35-36; pl. 3, fig. 15; text-fig. 15) proposed a new species of *Muderongia*, *M. ? digitata*. He himself is doubtful for its placement. The shape of the cyst is quite similar to *Australisphaera pannosa* Duxbury (1983). The single layered wall also suggests its closest affinity with *Australisphaera* Davey (1978). It is therefore, transferred to *Australisphaera*, *A. digitata* (Duxbury) comb. nov. (=*Muderongia ? digitata* Duxbury, 1980, pp. 35-36; pl. 3, fig. 15; text-fig. 15).

5. A closer comparative analysis (Table-1) of the three species of *Muderongia* viz., *M. simplex*, *M. tomaszowensis* and *M. perforata* instituted by Alberti (1961, pp. 18-21) clearly shows that these are conspecific. Since *M. simplex* has been described first in the sequence, thus has priority over the others. *M. perforata* and *M. tomaszowensis* are, therefore, junior synonyms of *M. simplex*.

6. Becheler (1983, p. 14) reported a species of *Muderongia*, *M. nicholsii*. The cyst is devoid of any inner body and possesses five horns; it is therefore, transferred to *Australisphaera*, *A. nicholsii* (Nichols & Jacobson) comb. nov. (=*Muderongia nicholsii* Nichols & Jacobson, 1982, p. 23; pl. 1, fig. 5). Pocock (1980; pl. 3, figs. 1-3) referred three specimens from Aptian of Canada, to *Muderongia*. These cysts possess five horns and single layered wall without inner body, suggesting their closest affiliation with *Australisphaera*.

7. Brideaux (1977, p. 40; pl. 15, figs. 2-10) instituted a new species *Muderongia asymmetrica* from the Lower Cretaceous of Richardson mountains, District of Mackenzie, Canada. From the illustrations and diagnosis of *M. asymmetrica*, it is evident that the cysts are pentagonal or elongate in shape, having a very thin inner body, and five horns (two antapicals). These features preclude the possibility to assign morphological relationship with *Muderongia*. It is proposed to describe such forms under a new form genus.

8. Thusu (1978, pl. 1 figs. 3 & 5) illustrated and described two specimens as *Muderongia asymmetrica* and *M. mcwhaei* from Spitsbergen. His specimens are poorly preserved and thus the recognition of an inner body in these cysts is difficult. The cysts are thin walled having five horns. Due to doubtful nature of the inner body and the presence of five horns, the specimens are most likely referable to the genus *Australisphaera*.

9. Recently Burger (1980, p. 274; fig. 9B) proposed a new species of *Muderongia*, *M. testudinaria* from the Early Cretaceous of Carpentaria basin, northern Queensland.

This species is unique in possessing a pentagonal shape of the cyst rather than rhomboidal, the horns are not equidistantly placed, and antapical concavity is always present, two distinctly well developed antapical horns are present, though the cyst is cornucavate.

These forms differ from typical *Muderongia* in cyst shape, position and number of antapical horns. Since only four horned rhomboidal cysts are now maintained

CHARACTERSTIC FEATURES / TAXA	M. perforata Alberti (1961)	M. simplex Alberti (1961)	M. tomaszowensis Alberti (1961)
Orientation of cyst	Cyst flat	Cyst flat	Cyst flat
Shape of Cyst	Outline rhombic oval	Outline almost rhombic	Outline rhombic
Apical horn	± long apical horn, blunt at free end	± long apical horn, blunt at free end	± long (offset) apical horn, blunt at free end
Lateral horns	Two, strongly projecting, unequally long, notched at their free ends	Two, strongly projecting, unequally long, notched at their free ends	Two strongly projecting, unequally long, notched at their free ends
Antapical horns	One, with proximal notch, blunt at free end.	One, with prominent proximal notch, blunt at free end	One, with proximal notch, blunt at free end
Capsule	Present	Present	Present
Cyst size	123-166 μm x 104-116 μm	68-175 μm x 63-133 μm	135-175 μm x 104-140 μm

Table 1. Showing morphological characters of three species of *Muderongia* Cookson & Eisenack, 1958.

Geologic Age	Upp. Jurassic (?Upp. Kimm.)	Berriasian			Valanginian					Hauterivian						Barremian						Aptian			Lower Albian	
COUNTRIES / TAXA	ENGLAND	CANADA	ENGLAND	FRANCE	CANADA	ENGLAND	FRANCE	GERMANY	POLAND	BULGARIA	CANADA	ENGLAND	FRANCE	GERMANY	POLAND	CANADA	ENGLAND	FRANCE	GERMANY	POLAND	INDIA	AUSTRALIA	BULGARIA	CANADA	ENGLAND	INDIA
M. extensiva						●						●														
M. mcwhaei								●													●		●			●
M. periata																									●	
M. simplex	●		●	●	●	●		●	●	●		●					●									
M. staurota												●	●				●	●								
M. tetracantha		●						●	●		●	●		●	●	●	●		●	●	●	●		●		

Table 2. Palaeogeographic and geologic distribution of *Muderongia* species.

in the generic circumscription of *Muderongia*, it is proposed here to institute a new genus *Pseudomuderongia* to include *Muderongia* like cysts with five horns having antapical concavity and apical archaeopyle.

Genus *Pseudomuderongia* gen. nov.

Generic diagnosis: Cyst dorsoventrally flattened, bilaterally symmetrical, outline rhombic to pentagonal, composed of thin outer membrane and an inner body or capsule. Periphragm prolonged into one apical, two lateral and two antapical horns. Antapical concavity prominent. Archaeopyle apical, sutures zig-zag (tA), operculum free. Paracingulum present or absent.

Type species : Pseudomuderongia testudinaria (Burger) comb. nov. (=*Muderongia testudinaria* Burger, 1980; p. 274; figs. 9B & 10A-E).

Other reallocations: *Pseudomuderongia asymmetrica* (Brideaux) comb. nov. (=*Muderongia asymmetrica* Brideaux, 1977; p. 40; pl. 15; figs. 9-10). *Pseudomuderongia* sp. A. (=*Muderongia* sp. A., in Burger, 1980; p. 275; fig. 9A).

It is, therefore, concluded that only the following six species of *Muderongia* are acceptable : *M. extensiva* Duxbury (1977); *M. mcwhaei* Cookson & Eisenack (1958); *M. pariata* Duxbury (1983); *M. simplex* Alberti (1961); *M. staurota* Sarjeant (1966) and *M. tetracantha* (Gocht) Alberti (1961).

PALAEOGEOGRAPHIC AND GEOLOGIC DISTRIBUTION OF *MUDERONGIA*

With these records of *Muderongia* species in hand, the known palaeogeographic and geologic distribution has been tabutated (Table-2; Alberti, 1961; Bjaerke, 1978; Brideaux, 1977; Brideaux & McIntyre, 1975; Bujak & Williams, 1977; Byrnes, *et al.* 1975; Cookson & Eisenack, 1958; Davey, 1974, 1978a, 1978b, 1979a, 1979b, 1982; Davey & Verdier, 1974; Dodekova, 1975; Duxbury, 1977, 1978, 1983; Edgell, 1964; Evans, 1966; Fisher & Riley, 1980; Gitmez & Sarjeant, 1972; Habib, 1972; Haskell, 1970; Ingram, 1976; Millioud, 1976; Morgan, 1980; Neale & Sarjeant, 1962; Pocock, 1972, 1976, 1979; Raynaud, 1978; Reneville & Raynaud, 1981; Sargeant, 1966, 1978; Williams, 1978; Williams & Bujak, 1978; Wiseman, 1980; Woolam & Riding, 1983). The genus ranges in age from ?Upper Kimmeridgian to Aptian with a single record of *M. periata* Duxbury (1983) in Lower Albian. From the perusal of Table-2, it is evident that the genus had a humble beginning in Upper Jurassic with one single species followed by two in Berriasian. In Valanginian the quantitative increase is observed represented by four species. The same representation followed upto Barremian. Aptian shows the tapering end of *Muderongia*. The optimum of the genus ranges between Valanginian-Barremian.

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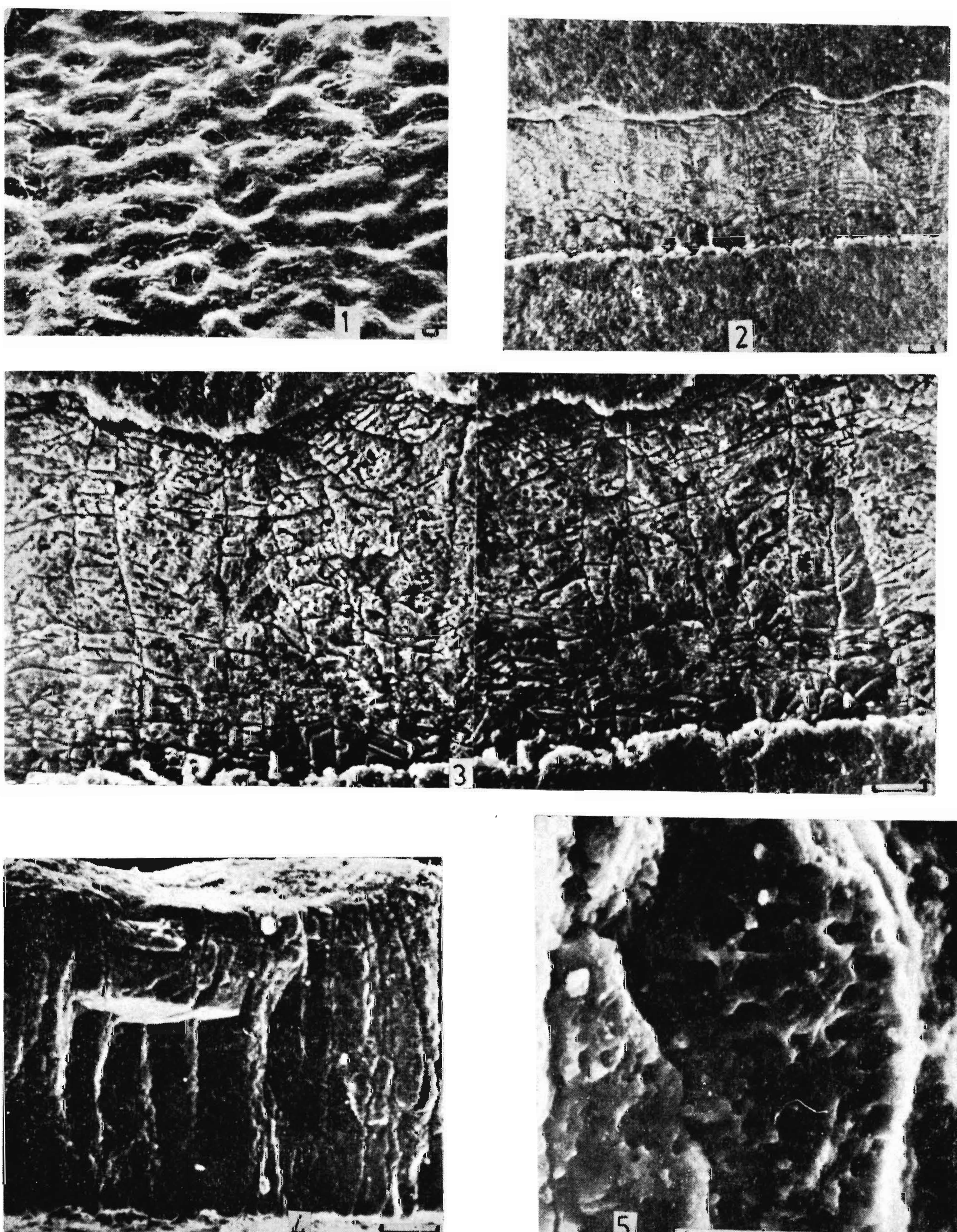
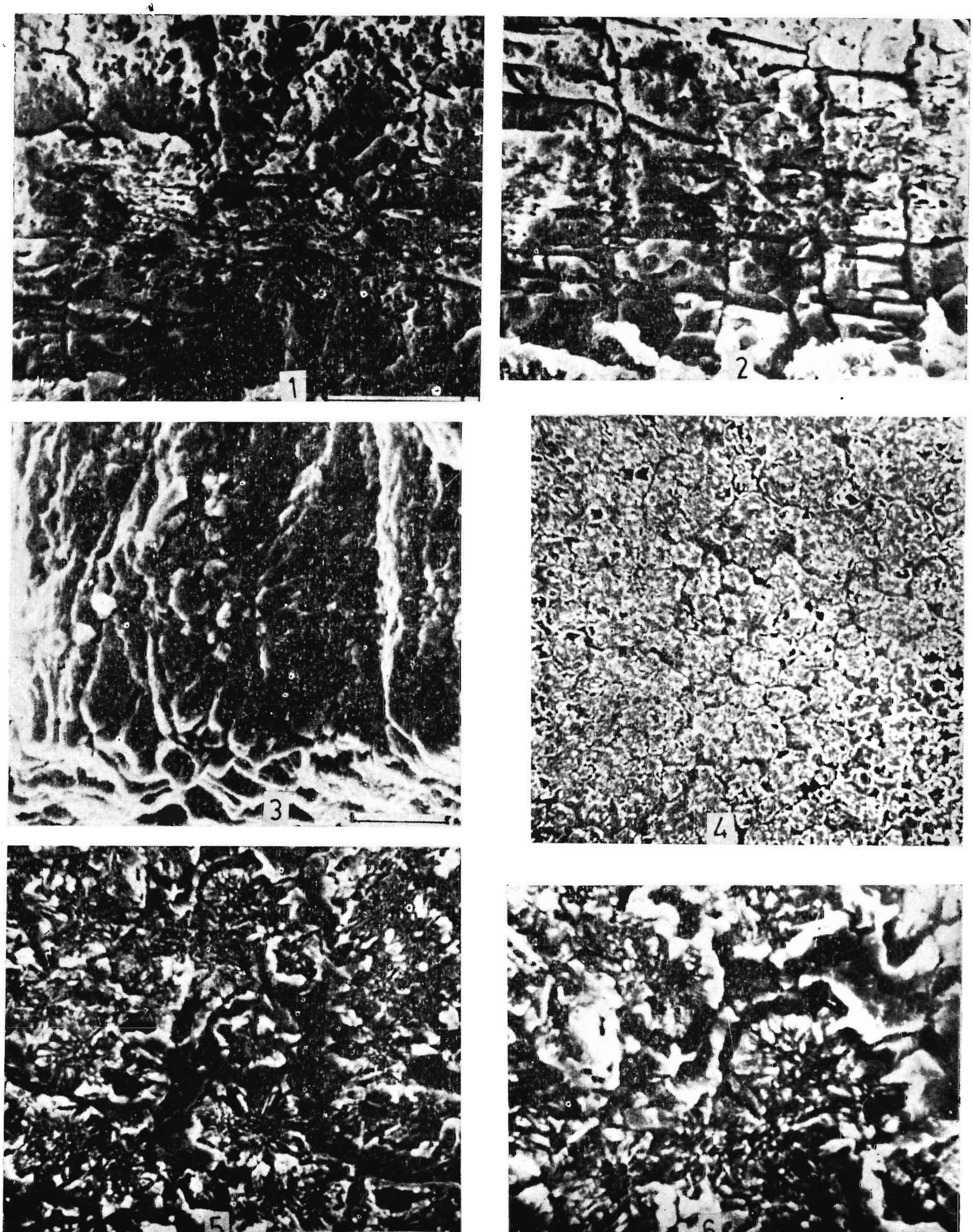
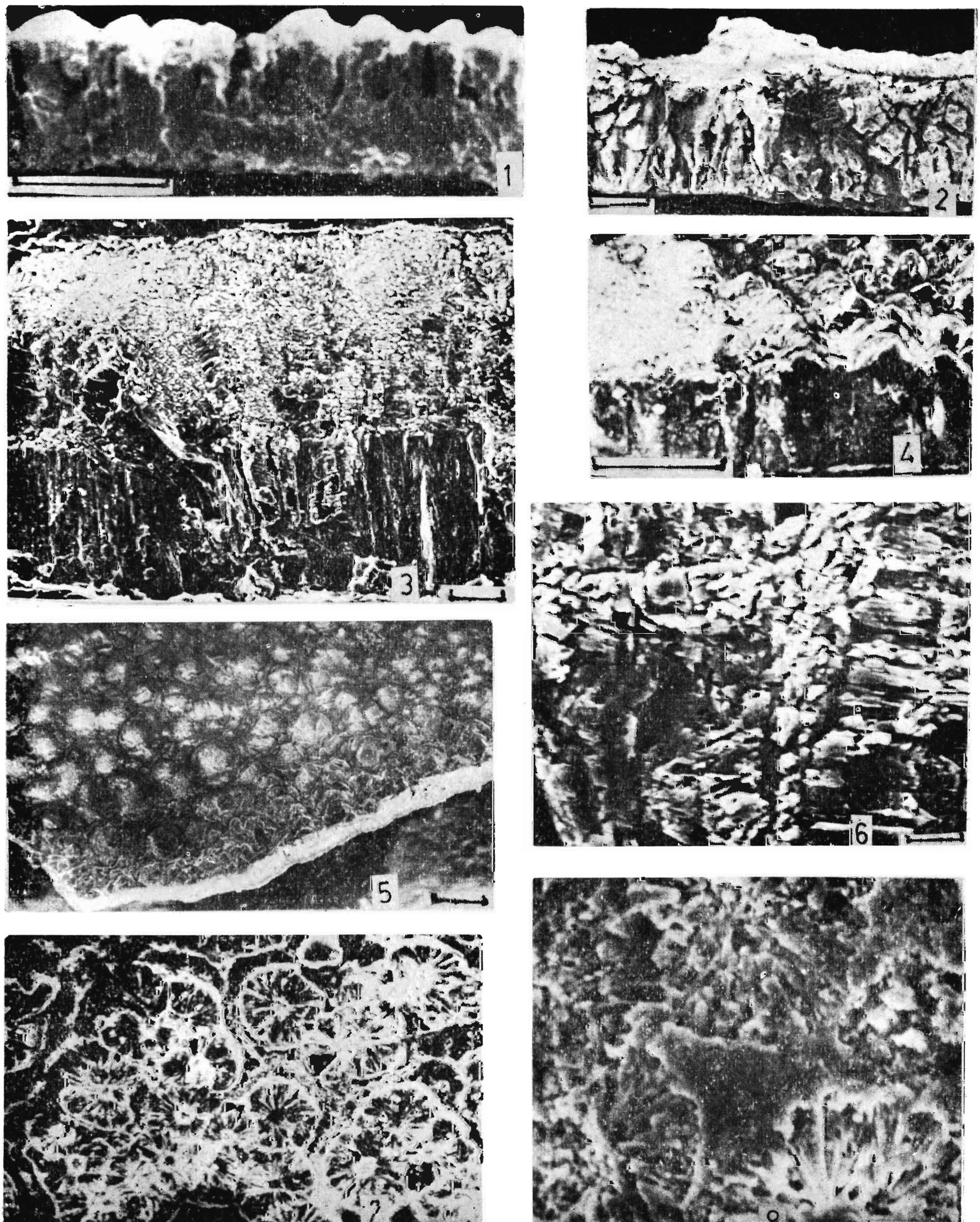




SAHNI, RANA & PRASAD



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EXPLANATION OF PLATES

(All photographs magnified ×500)

PLATE I

1-5. *Muderongia mcwhaei* Cookson & Eisenack, 1958; Slide nos./coordinates are BSIP 8551/140.2×4.4; BSIP 8553/120.0×24.9; BSIP 8551/137.9×10.6; BSIP 8549/107.3×3.2 and BSIP 8092/104.6×16.9 respectively.

1-2, showing pouch like development at the extreme distal end of the antapical horn, with stout lateral horns; 2, complete cyst with displaced operculum (apical horn together with a portion of inner body), zig-zag sutures indicating number of apical and precingular para plates involved in the formation of archaeopyle and operculum; 3, showing well developed notch on the arm of left lateral horn; 4, showing well developed notch at the proximal end of the antapical horn; 5, showing no pouch or notching at the proximal end of the antapical horn.

PLATE II

1-7. *Muderongia mcwhaei* Cookson & Eisenack, 1958 (showing variations in cyst body shape and size of lateral as well as antapical horns). Slide Nos./coordinates are BSIP 8549/137.9. ×8.6; BSIP 8552/100.7×20.2; BSIP 8551/129.8×10.7; BSIP 8549/119.3×15.4; BSIP 8549/124.3×19.1; BSIP 8554/123.2×10.5 and BSIP 8552/113.9×2 respectively.

1, Prominent doule notching on the arm of lateral horns and very well developed pouch like structure on the right side of the proximal end of antapical horn; 2, 4-5, showing small lateral horns with spine like out growths over them, prominent notching on the right side of the proximal end of the antapical horn in figs 2 & 5; 3 & 6, showing long arms of lateral horns.

8-9. *Muderongia tetracantha* (Gocht) Alberti, 1961; Slide Nos./coordinates are BSIP 8093/130.6×10.3 and 8092/111.7×22.2 respectively.

PLATE III

1, 3-9. *Muderongia mcwhaei* Cookson & Eisenack, 1958 (showing variations in shape and size of cyst body, lateral horns and antapical horns); Slide Nos./coordinates are BSIP 8550/111.8×23.7; BSIP 8549/126.8×7.9; BSIP 8549/138.4×21.3; BSIP 8550/113.9×3.6; BSIP 8551/120.8×15.6; BSIP 8553/132.3×3.5; BSIP 8554 109.6×14.0 and BSIP 8092/102.6×5.9 respectively;

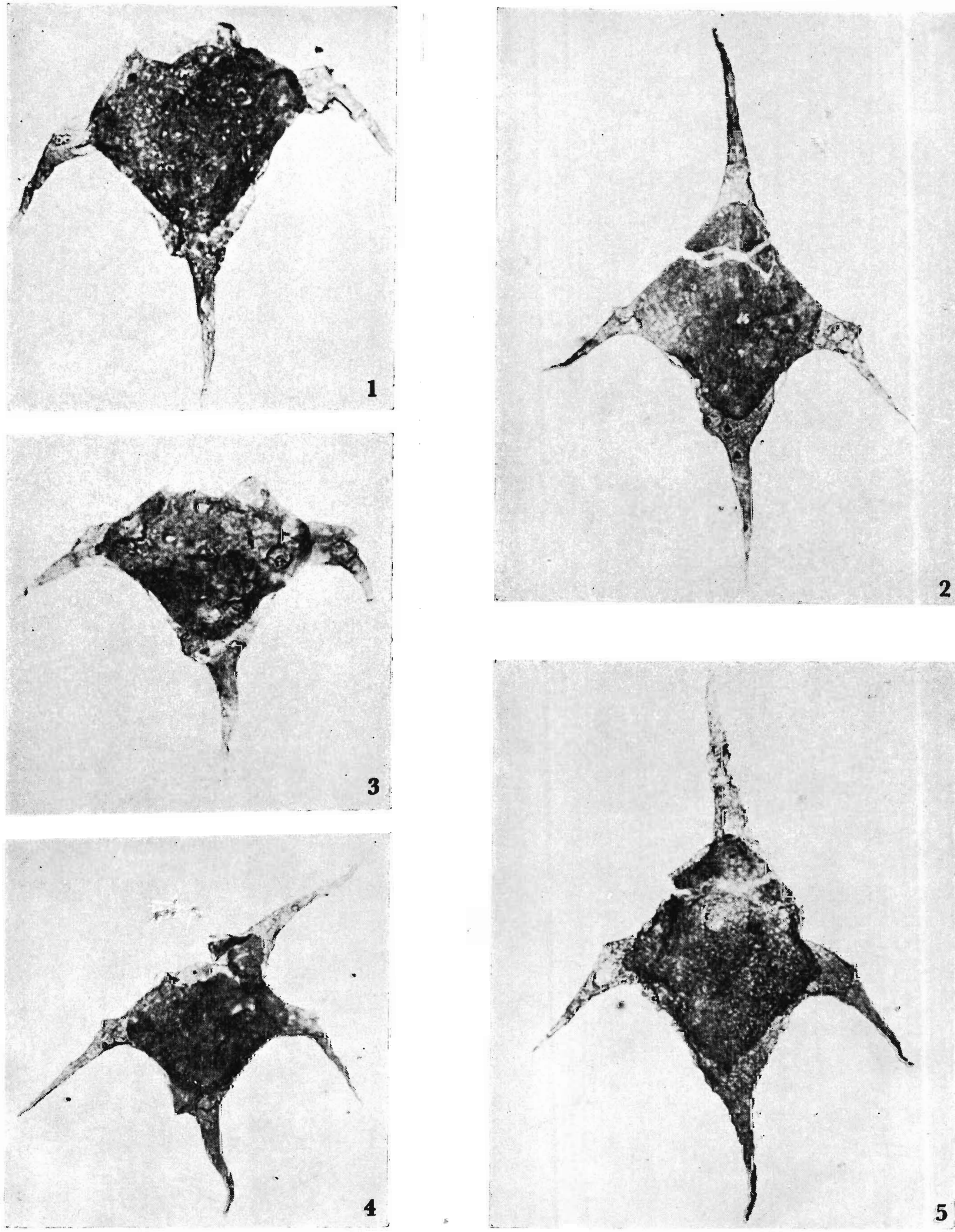
1, lateral horns longer than the over all breadth of the cyst body, arm of the horn is nearly half of its overall length.

3, 4, 7, showing small lateral horns; 3, having spiny outgrowths on lateral as well as antapical horns;

7, spiny outgrowths present all over the margin of the cyst body including apical horn;

5, short and broad lateral horns.

2. *Muderongia tetracantha* (Gocht) Alberti, 1961; Slide No. /cooridnate is BSIP 8550/114.0×24.5.



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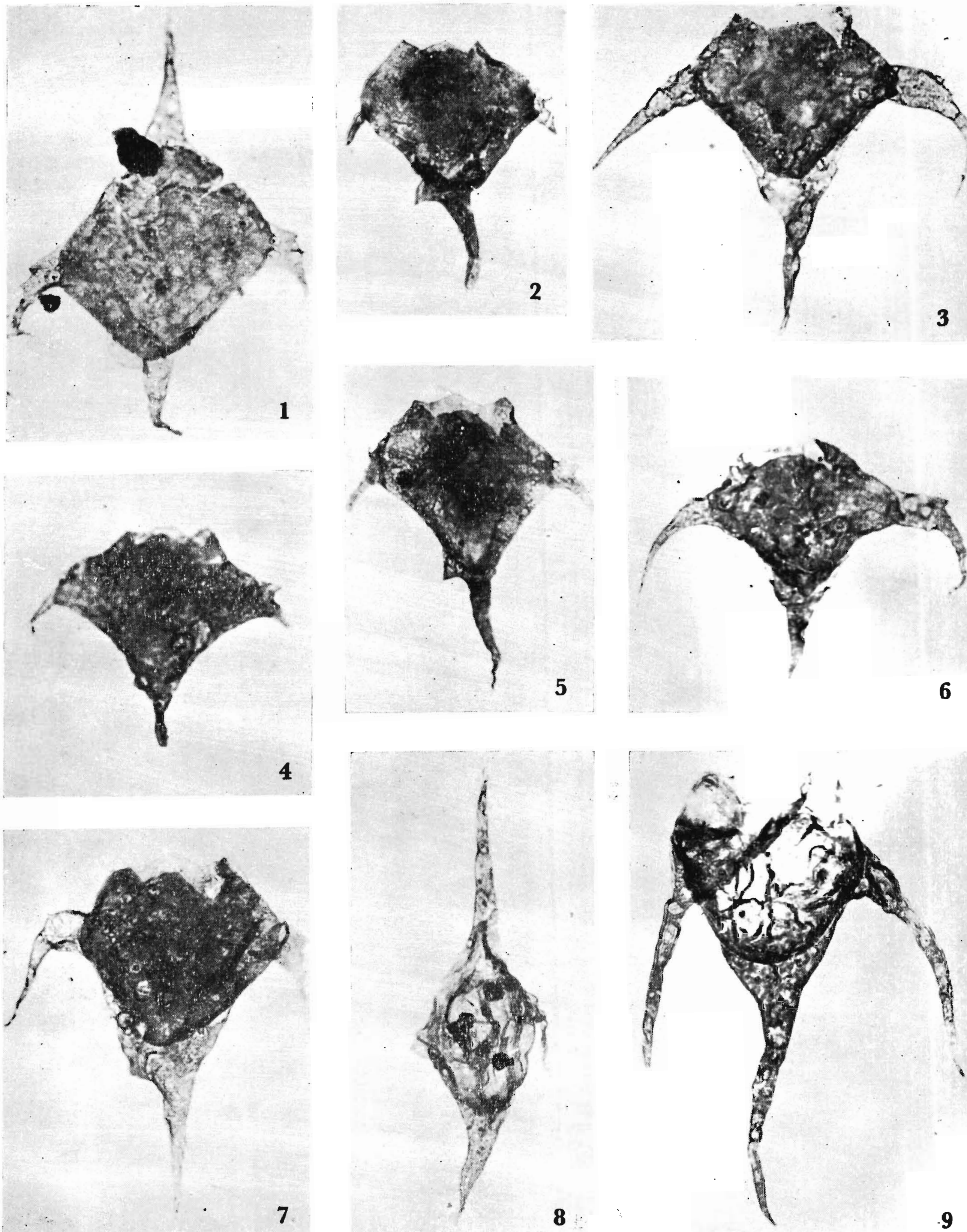
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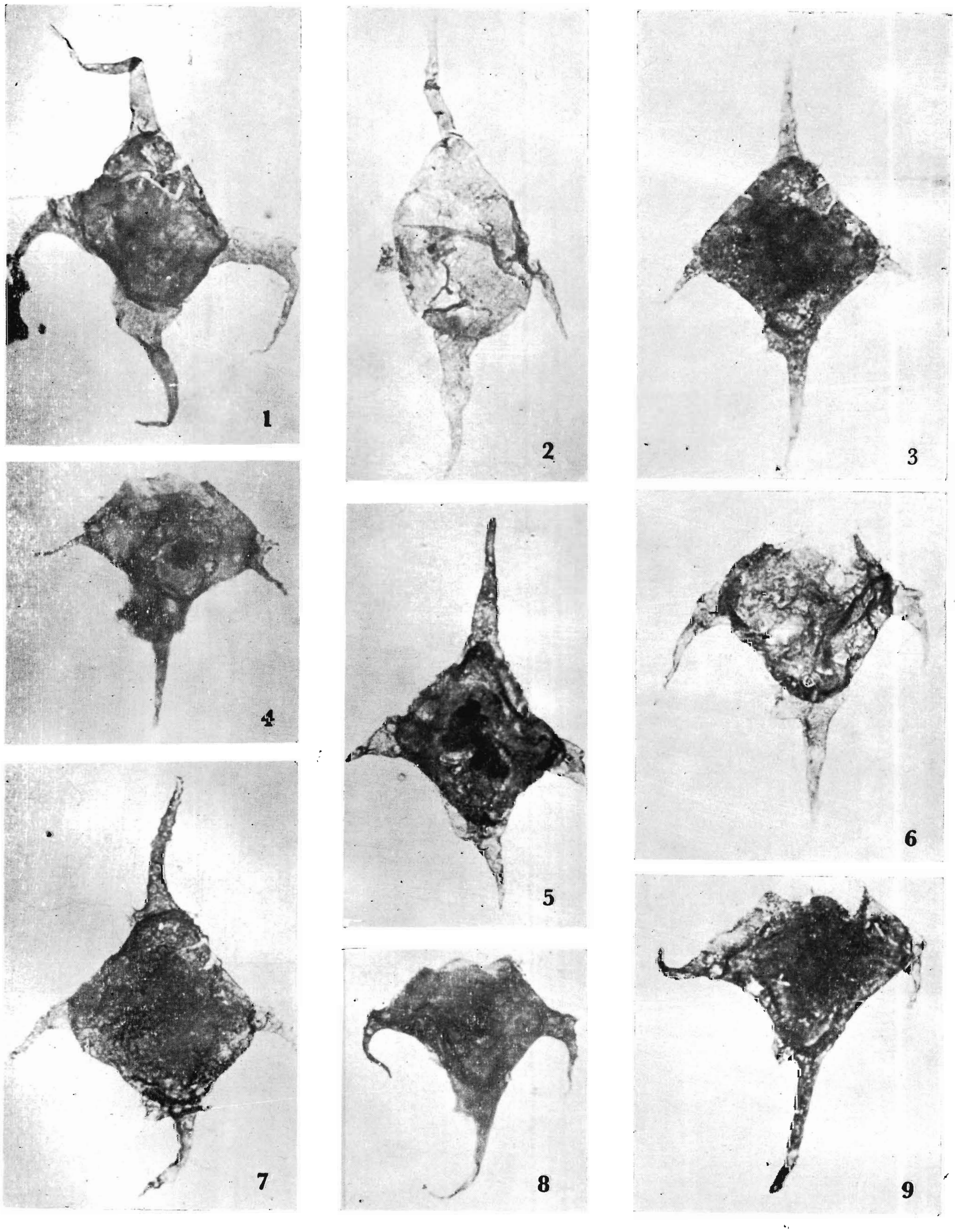
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