



REVISION OF THE LATE CRETACEOUS BIVALVES FROM THE TIRUCHIRAPALLI SUB-BASIN: I. OYSTERS (SUBFAMILIES: PYCNODONTEINAE, EXOGYRINAE AND LOPHINAE) FROM THE KALLANKURICHCHI FORMATION (MAASTRICHTIAN) OF THE DISTRICT ARIYALUR, TAMIL NADU

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ABSTRACT

Although Stoliczka published a monograph on the Cretaceous bivalves from the Tiruchirapalli Sub-basin in 1870-71, they have received scant attention from subsequent palaeontologists. The present authors plan to revise the bivalve taxa from this sub-basin in view of the latest development in bivalve taxonomy. As part of the plan, the oysters belonging to three subfamilies Pycnodonteinae, Exogyrinae and Lophinae have been taken here for the purpose of revision. They were collected from the Kallankurichchi Formation (Maastrichtian) of the Ariyalur area, and comprise seven genera and eight species. These species after revision have been recorded here as *Phygraea* (*Phygraea*) *vesicularis* (Lamarck), *Phygraea* (*Phygraea*) sp., *Exogyra* (*Exogyra*) *tamulica* Stoliczka, *Ceratostreon pliciferum* (Dujardin), *Curvostrea rouvillei* (Coquand), *Agerostrea unguolata* (Schlotheim), *Rastellum* (*Arcostrongia*) *pectinatum* (Lamarck) and *Cameleolopha diluviana* (Linné).

Key words: Tiruchirapalli Sub-basin, Oysters, Late Cretaceous, Kallankurichchi Formation, Ariyalur district.

INTRODUCTION

The oysters display considerable variations in their mode of life which, consequently, is reflected in their shell-form, shape and size. Some of them attach themselves after the larval stage to some object and remain cemented throughout their life. While others after their adulthood detach themselves and pass a sedentary life. Due to this life habit, they consist of thicker and heavier shells, since there is no problem of weight as they have not to move their bulk (Stenzel, 1971, N1017). Oysters have immense biostratigraphic value, especially those whose shells are made up of calcite and where the accompanying aragonitic shelled faunas easily succumb to the dissolution activities. The nearshore oysters develop colonial forms, where the shell shape is modified by gregarious habit, crowding and heterogeneous environmental conditions. In contrary, the deepwater forms show relatively stable characters and non-gregarious habit leaving predominantly phenotypic influence on the shape and size of the attachment areas (Cooper,

1992). The identification of these oysters needs a cautious approach as many individuals of the same population may exhibit extreme variability in their morphological characters. So, creation/differentiation of species can only be convincingly established by careful observation of the population structure, otherwise a multiplicity of names would result. More emphasis during investigation should be given to bed-by-bed collection, population analysis and a thorough re-examination of the existing literature.

The Cretaceous sediments of the Tiruchirapalli (Trichinopoly) area occur in the west-central part of the Cauvery Basin, on the southeastern coast of Peninsular India. The first detailed account of the Cretaceous sediments of South India was given by Blanford (1862), who divided the South Indian Cretaceous sediments in three groups; in ascending order, these were the Uttatur, Trichinopoly, and Ariyalur Groups. The Ariyalur Group of sediments is exposed to the east of Ariyalur town (fig.1), which administratively falls in the Ariyalur district; geologically, it forms the northern extension of the

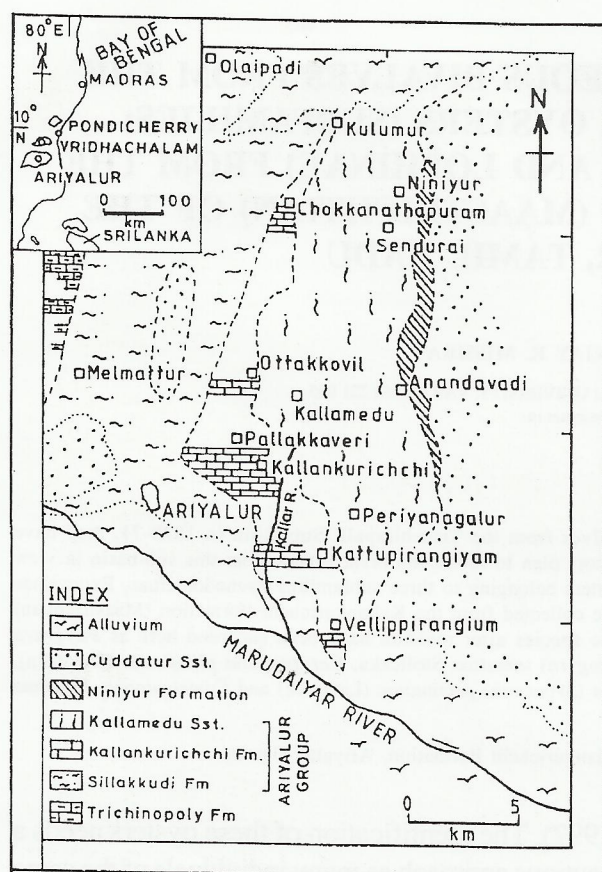


Fig. 1. Geological map of the ariyalur area (after Guha and Nathan, 1990)

Tiruchirapalli Sub-basin. Sastry, Rao and Mamgain (1972) divided the Ariyalur Group into four distinct formations in ascending order (i) Sillakkudi Formation, (ii) Kallankurichchi Formation (iii) Ottakkovil Formation and (iv) Kallamedu Formation; they considered the Sillakkudi Formation to be Campanian in age and the remaining three formations Maastrichtian in age. Tewari, Hart and

Watkinson (1996), however, opined Ottakkovil formation to be a locally developed regressive marine facies and a non-mappable unit, and envisaged that the Ariyalur Group consists of only three formations, lower Sillakkudi, middle Kallankurichchi and upper Kallamedu. Madhavaraju and Ramasamy (1999) favoured retention of all four formations of Sastry, Rao and Mamgain (1972) by some modification in the lithological characters of these formations.

Stoliczka was the first to document the faunal wealth of the Cretaceous sediments of the Tiruchirapalli area through his celebrated memoirs on cephalopods (1866), gastropods (1868), bivalves (1870-71), brachiopods (1872), corals, sponges (1873a) and echinoderms (1873b). Kossmat (1895, 1897, 1898) followed Stoliczka to describe the ammonoids from the Tiruchirapalli area and provided the first biozonation for the Cretaceous sediments of the area. Subsequently, with the exception of ammonites (Sastry, Rao and Mamgain, 1968; Chiplonkar and Ghare, 1979; Chiplonker, 1987), bryozoans (Guha 1980a,b, 1987a,b; Guha and Nathan 1990) and brachiopods (Radulovic and Ramamoorthy 1992), most attention has been given by palaeontologists to the

Ariyalur Group	Kallamedu Formation	Maastrichtian
	Ottakkovil Formation	
	Kallankurichchi Formation	
	Sillakkudi Formation	Campanian

Fig. 2. Lithostratigraphic classification of the Ariyalur Group (after Madhavaraju and Ramasamy, 1999)

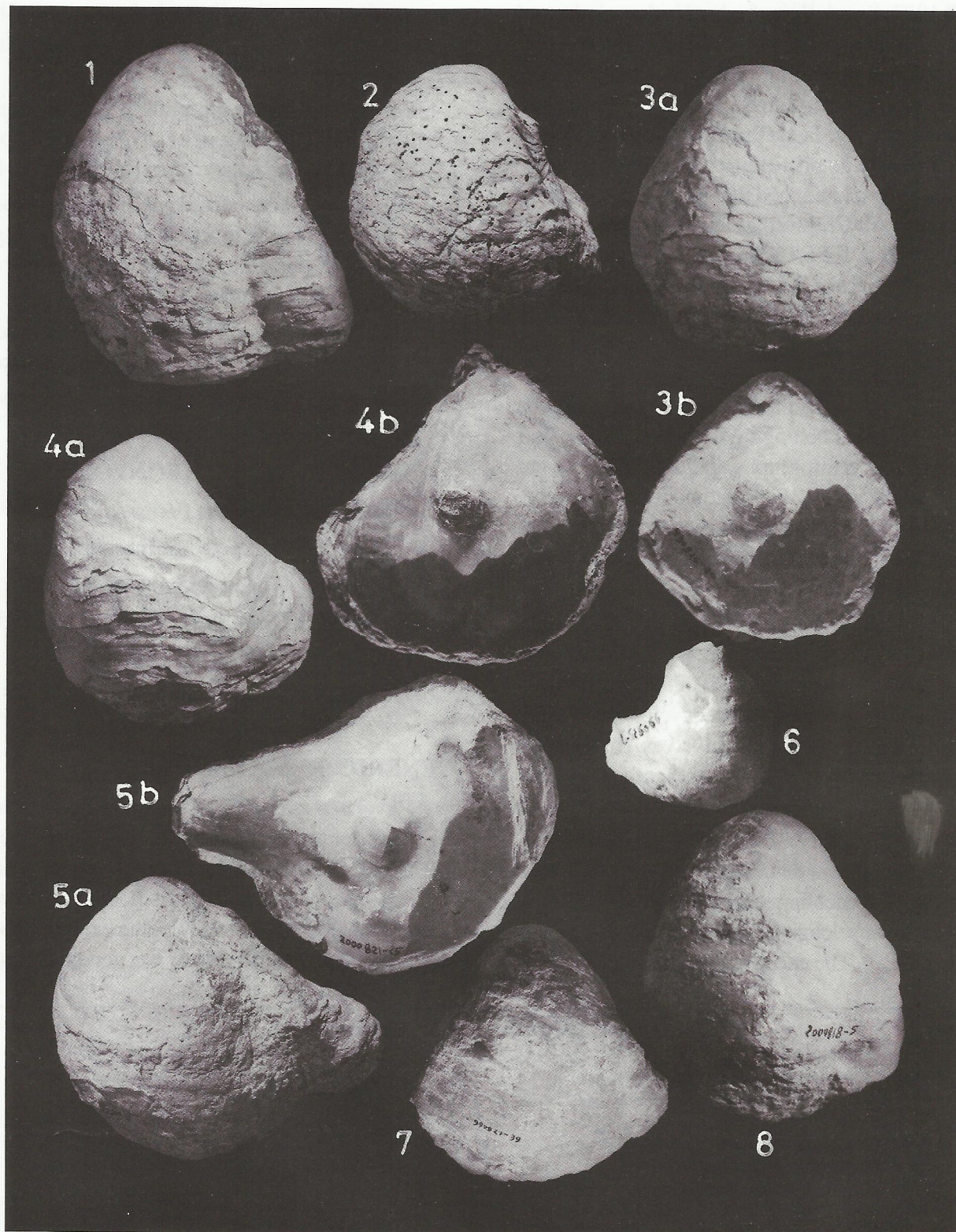
EXPLANATION OF PLATE I

1-8. *Phygraea (Phygraea) vesicularis* (Lamarck)

- No. 990928-57 from Kattupirangiyam, external view of LV (x 0.7).
- No. 2000818-8 from Kallankurichchi, external view of LV (x 0.7).
- No. 990926-20 from Kallankurichchi, a-external view of LV (x 0.9), b-internal view of LV (x 0.9).
- No. 2000818-1 from Kallankurichchi- external view of LV

(x 0.6), b-internal view of LV (x 0.6).

- No. 2000821-25 from Kallankurichchi, a- external view of LV (x 0.7), b- internal view of LV (x 0.8).
- No. 990925-7 from Kallankurichchi, external view of RV (same size).
- No.990927-39 from Kallankurichchi, external view of LV (x 0.6).
- No.2000818-5 from Kallankurichchi, external view of LV (same size).



microfauna (Rao & Pia, 1936; Rao 1957; Banerji, 1972, 1987; Sastri, Raju, Sinha, Venkatachala, and Banerji 1966; Sastry, Rao and Mamgain 1972; Jain 1975; Chiplonkar, 1985; Rasheed, 1987; Guha, 1987). Although Stoliczka (1870-71) described the bivalve fauna from the Tiruchirapalli area and exhibited its prolificity of occurrence, it remained almost unnoticed throughout the next hundred years till Chiplonkar and Tapaswi, (1975a, 1975b, 1975c, 1976, 1979) and Chiplonkar (1987) recorded several bivalve faunas from the Cretaceous sediments of the Tiruchirapalli Sub-basin. From the Ariyalur area in particular, Stoliczka (1870-71) recorded 18 species of bivalves belonging to 11 genera, Chiplonkar and Tapaswi, (1979) listed 67 species belonging to 29 genera (most of them without photographs and descriptions) and Fürsich and Pandey (1999) figured five bivalve species while discussing the significance of shell concentrations in the palaeoenvironmental reconstruction of the Ariyalur area.

The present article is part of the major study to revise taxonomically the already known bivalve taxa from the Upper Cretaceous of the Tiruchirapalli Sub-basin in the light of recent developments in the systematic palaeontology of bivalves. An attentive approach has been made by the authors to take due care of the inter/intraspecific variation, while redocumenting the oysters from the Ariyalur area.

All the oysters described here were collected from the Maastrichtian sediments in the vicinity of Ariyalur town belonging to the Kallankurichchi Formation (fig.2). The exogyrid bivalves are confined

to Bed 2 of the Kallankurichchi section, while the remainders are distributed throughout the Kallankurichchi and Kattupirangiyam sections (fig. 3).

For the descriptive morphology, the different terms proposed by Stenzel (1971) and Cooper (1995) for the oysters have been followed (fig.4).

Repository : All the fossil specimens described here are housed in the Invertebrate Palaeontology Laboratory, Department of Geology, Banaras Hindu University, Varanasi 221 005.

In measurements (given in mm) of the specimens the following abbreviations have been used:

L-length, H- Height, I-Inflation, LV- left valve, RV-right valve, BV- both valves.

SYSTEMATIC PALAEONTOLOGY

Suborder **Ostreina** Férussac, 1822

Superfamily **Ostracea** Rafinesque, 1815

Family **Gryphaeidae** Vyalov, 1936

Subfamily **Pycnodonteinae** Stenzel, 1959

Genus **Phygraea** Vyalov, 1936

(*Type species: Gryphaea pseudovesicularis* Gumbel, 1861;OD.)

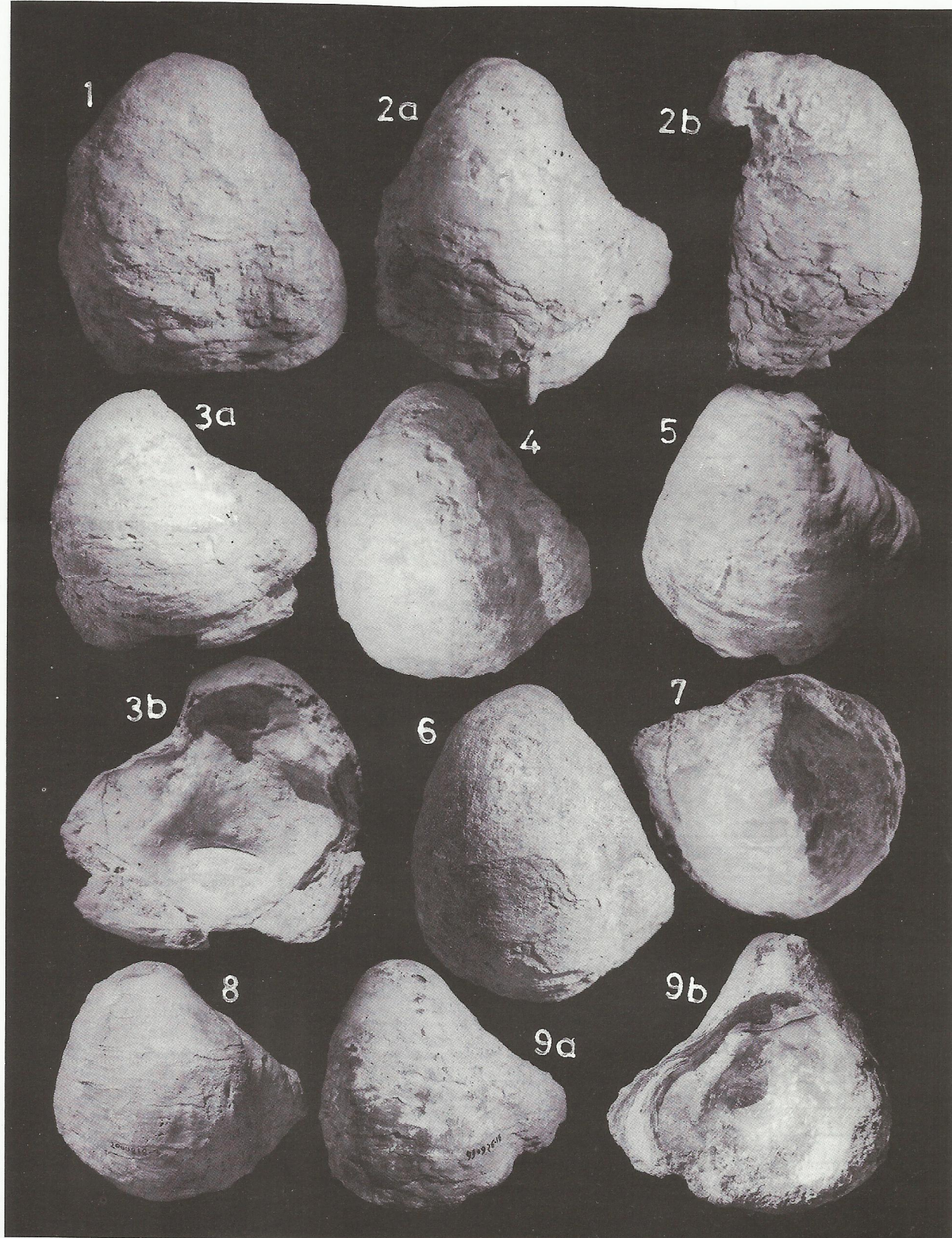
GENERIC REMARKS

Phygraea was earlier treated as a subgenus of *Pycnodonte* (Stenzel, 1971: N1107). Cooper (1992) asserted the need for phyletic taxonomy and re-evaluation of the earlier classification. Accordingly Cooper (1992, fig.1) hypothesized relationships amongst the different oyster genera belong-

EXPLANATION OF PLATE II

- 1-9. *Phygraea (Phygraea) vesicularis* (Lamarck)
1. No. 990926-23 from Kallankurichchi, external view of LV (x 0.8).
2. No. 2000818-2 from Kallankurichchi, a- external view of LV (x 0.7). b- anterior view LV (x 0.7).
3. No. 2000819-21 from Kattupirangiyam, a- external view of LV (x 0.7). b-internal view of LV (x 0.8).
4. No. 2000819-20 from Kattupirangiyam, external view of LV (x 0.6).

5. No. 990925-12 from Kallankurichchi, external view of LV (x 0.8).
6. No. 990926-17 from Kallankurichchi, external view of LV (x 0.8).
7. No. 990928-62 from Kattupirangiyam, internal view of LV (x 0.9).
8. No. 2000818-3 from Kallankurichchi, external view of LV (x 0.7).
9. No. 990926-18 from Kallankurichchi, a- external view of LV (x 0.6), b- internal view of LV (0.7)



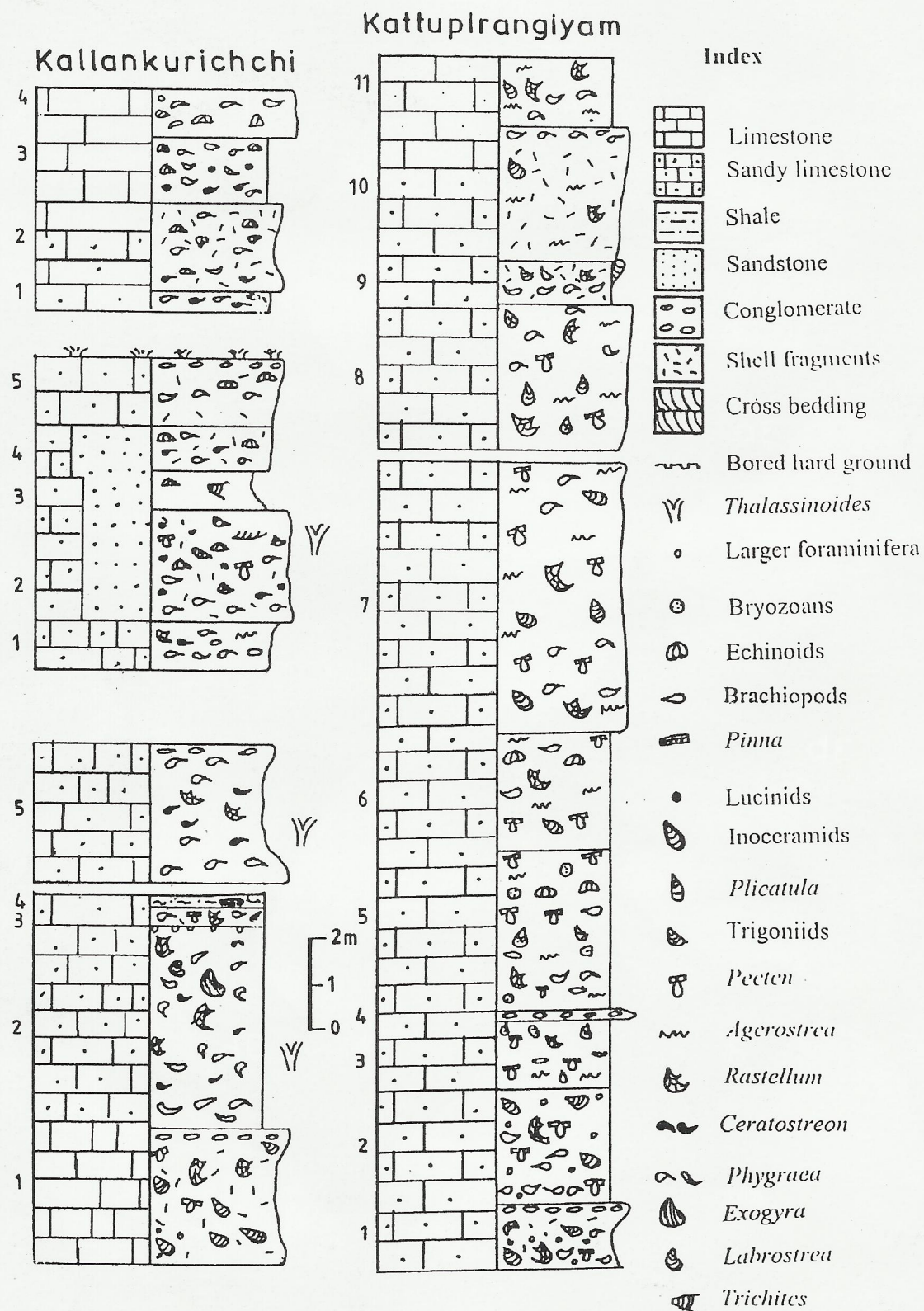


Fig. 3. Sections through the Kallankurichchi Formation along Kallankurichchi and Kattupirangiyam of Ariyalur.

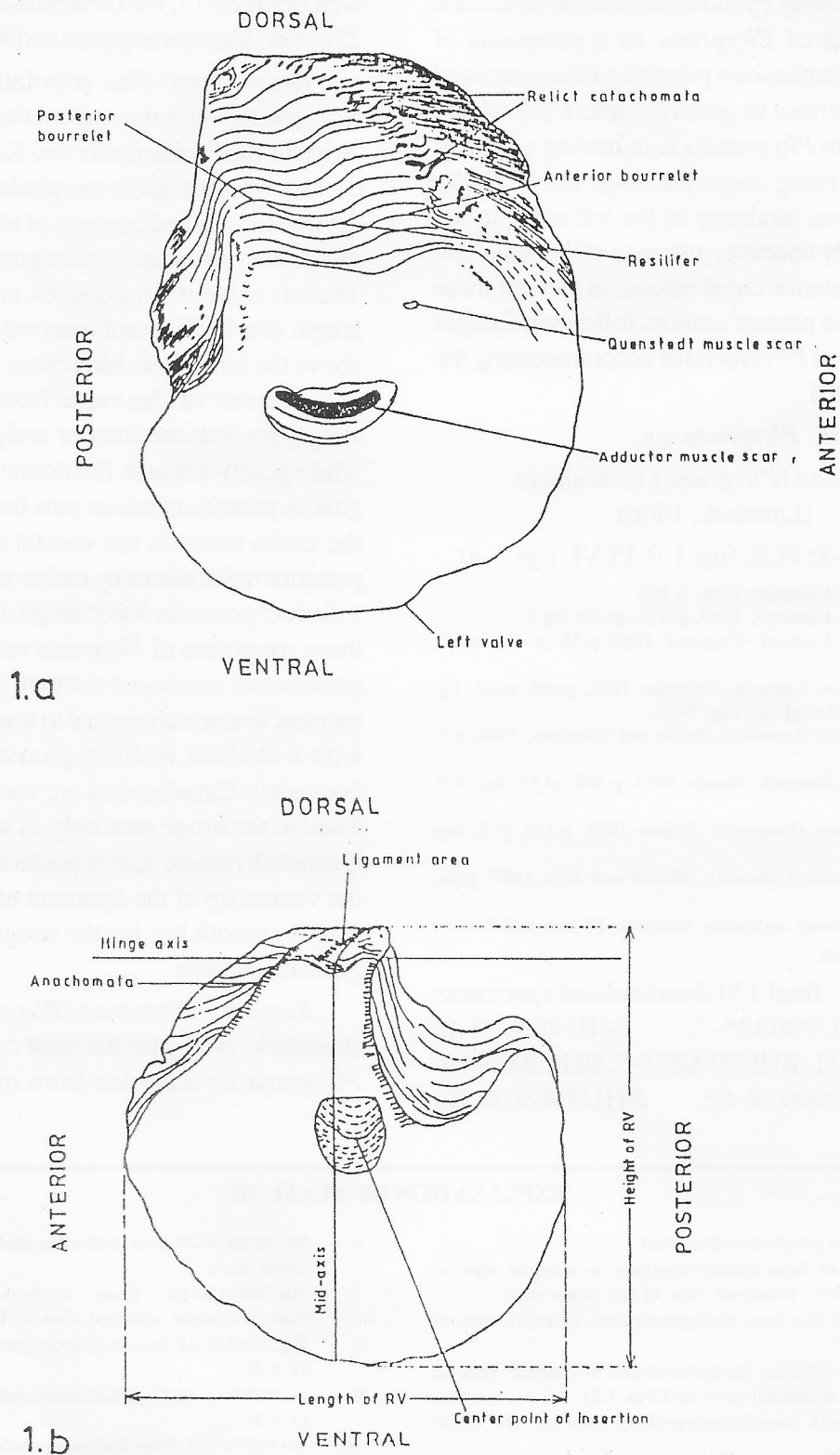


Fig. 4. Internal morphological features used in the description: 1a-L.V., 1b. -R.V.

ing to the subfamily Pycnodontinae. He concluded that treatment of *Phygraea* as a subgenus of *Pycnodonte* emphasizes primitive characters and elevated *Phygraea* to generic rank. *Pycnodonte* s.s differs from *Phygraea* s.s. in having a smaller umbo (barely rising above the hinge line), smaller attachment area, tendency of the left valve to become shallowly concave, presence of auricles, and absence of posterior radial sulcus. In view of these differences, the present authors following Cooper (1992) preferred *Phygraea* for accommodating the Ariyalur material.

Subgenus *Phygraea* s.s.

***Phygraea (Phygraea) vesicularis*
(Lamarck, 1806)**

(Pl.I, figs 1-8; Pl.II, figs 1-9, Pl.VI, figs 5-6)

Ostrea vesicularis Lamarck, 1806, p.160.

Ostrea vesicularis Lamarck, 1809, p.375, pl.22, fig.3.

Ostrea vesicularis Lamarck, Coquand, 1869, p.35, pl.13, figs 2-4,7,10.

Gryphaea vesicularis Lamarck, Stoliczka, 1871, p.465, pl.42, fig. 24, pl., 43, figs 1,1a; pl. 45, figs 7-12.

Phygraea vesicularis (Lamarck), Boule and Thevanin, 1906, p.7, pl.2, fig.3.

Ostrea vesicularis Lamarck, Woods, 1913, p.360, pl.55, figs 4-9, text-figs 143-182.

Phygraea vesicularis (Lamarck), Tashiro 1978, p.119, pl.2, figs 1-3, text fig. 2.

Phygraea vesicularis (Lamarck), Dhondt and Jagt, 1987, p.84, figs 3-6.

Pycnodonte (Phygraea) vesicularis Lamarck, Fürsich and Pandey, 1998, p.124, fig. 4b.

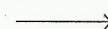
Material : Total 120 disarticulated specimens (No. BHU990925-7, BHU990925-8, BHU990925-11, BHU2000818-5, BHU2000819-23, BHU990928-62, BHU990926-20,

BHU990926-17, BHU990926-23, BHU2000821-25), from Kattupirangiyam and Kallankurichchi.

Description: The population of *Phygraea (Phygraea) vesicularis* from the Maastrichtian of Ariyalur (Kallankurichchi and Kattupirangiyam areas) shows remarkable morphological variations in the individuals and consists of highly inequilateral shells, with subovate to subtrigonal outlines (Fig.5). The left valve is very convex and height exceeds length (fig.6). The umbones are prominent, rising above the hinge line. Maximum shell inflation lies in the center of the valve from where it slopes steeply towards the anterior and posterior margins, while gently towards the dorsal and ventral margins. A prominent sulcus runs from the posterior of the umbo towards the ventral margin (called as posterior radial sulcus by earlier workers) separating a distinct posterior lobe/flange. Internally some of these specimens of *Phygraea vesicularis* show the presence of an almost circular, subcentral adductor muscle scar, subtrigonal to trigonal ligament area with a shallow resilifer groove and almost flat bourrelets. Catachomata are vermiculate and confined to the hinge area only. A small, subrounded Quenstedt muscle scar is positioned 4-7mm below the ventral tip of the ligament area. The shell surface is smooth but for the irregularly distributed growth squamae.

Remarks: *Phygraea (Phygraea) vesicularis* (Lamarck) is a by far the most common species of *Phygraea* s.s recorded from most of the Upper

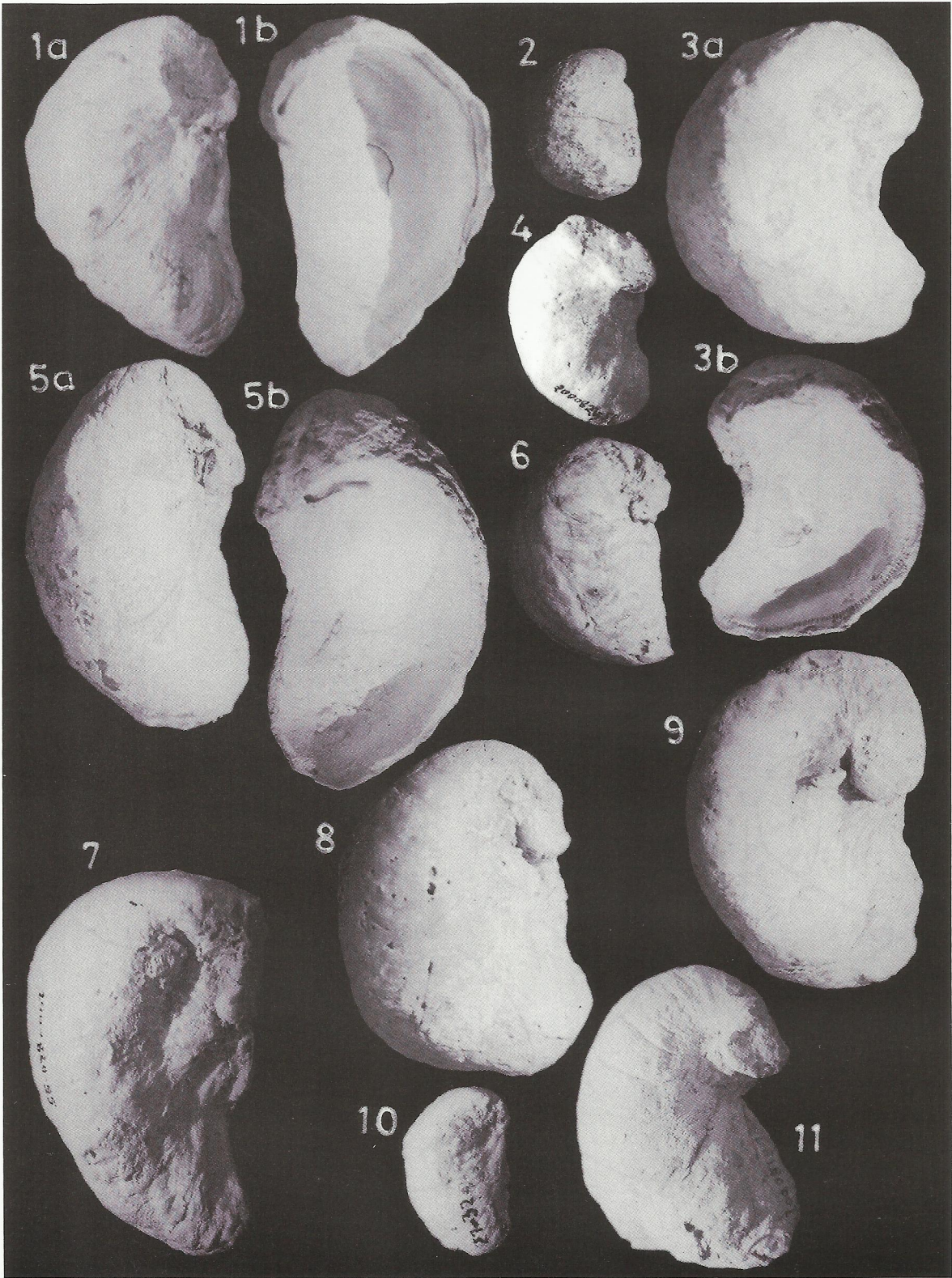
EXPLANATION OF PLATE III



1-11. *Ceratostreon pliciferum* (Dujardin)

1. No.990928-45 from Kattupirangiyam, a- external view of LV (same size), b-internal view of LV (same size).
2. No.2000825-58a from Kallankurichchi, external view of LV (x 1.4).
3. No.2000821-38 from Kallankurichchi, a- external view of LV (x 1.3), b-internal view of LV(x 1.2).
4. No.2000825-58 from Kallankurichchi, external view of LV (x 0.9).
5. No.990927-38 from Kallankurichchi, a- external view of LV (x 1.4). b- internal view of the LV(x1.5)

6. No.2000818-29 from Kallankurichchi, external view of LV (same size).
7. No.2000820-55 from Kallankurichchi Formation, Kallankurichchi, external view of LV (x 1.4).
8. No.2000822-42 from Kallankurichchi, external view of LV (x 1.3).
9. No.2000818-31 from Kallankurichchi, external view of LV (x 1.4).
10. No.990927-32 from Kallankurichchi, external view of LV (x 1.4).
11. No.2000818-30 from Kallankurichchi, external view of LV (x 1.4).



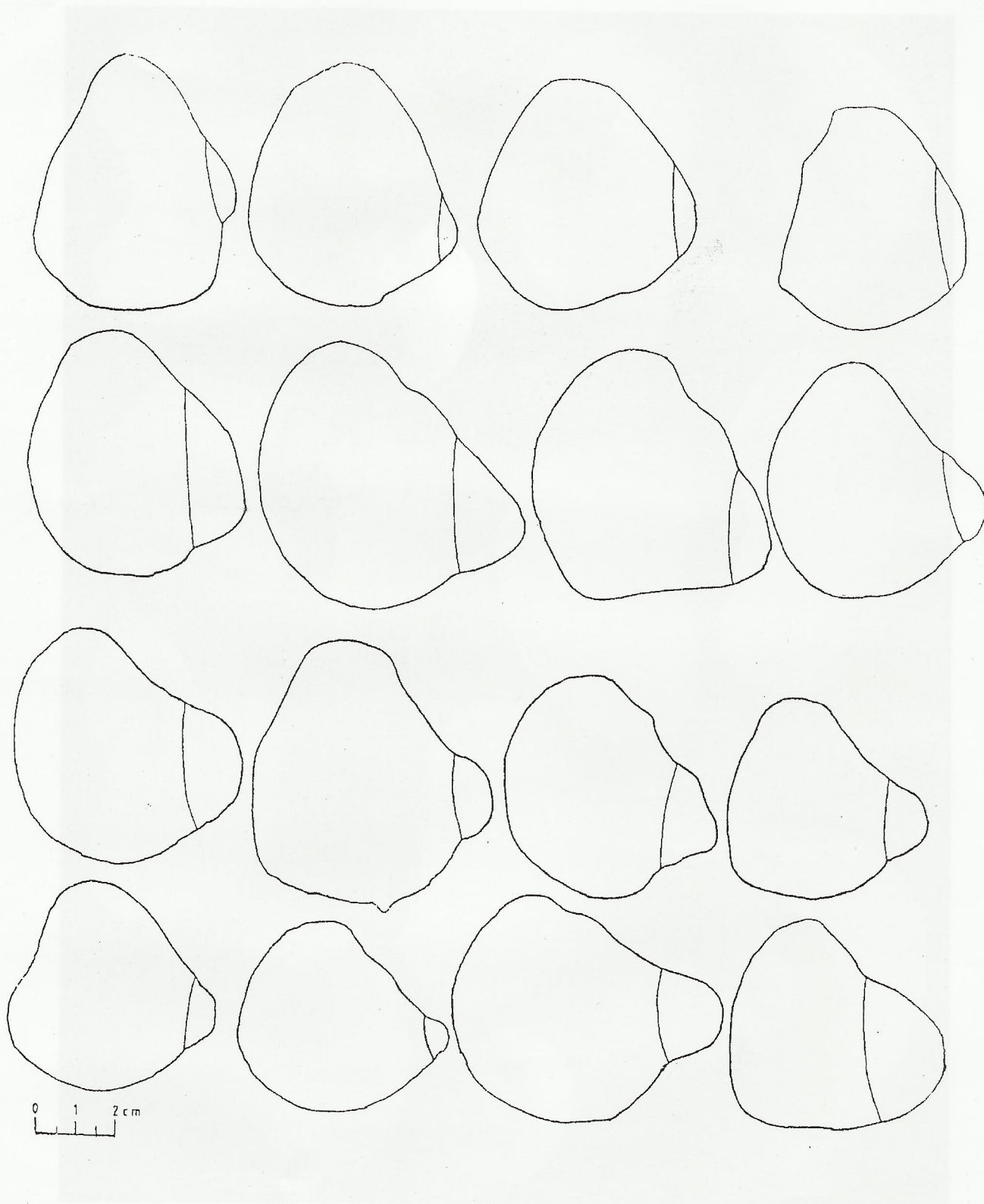


Fig. 5. Left valve profiles of *Phygraea (Phygraea) vesicularis* (Lamarck) exhibiting range of variations.

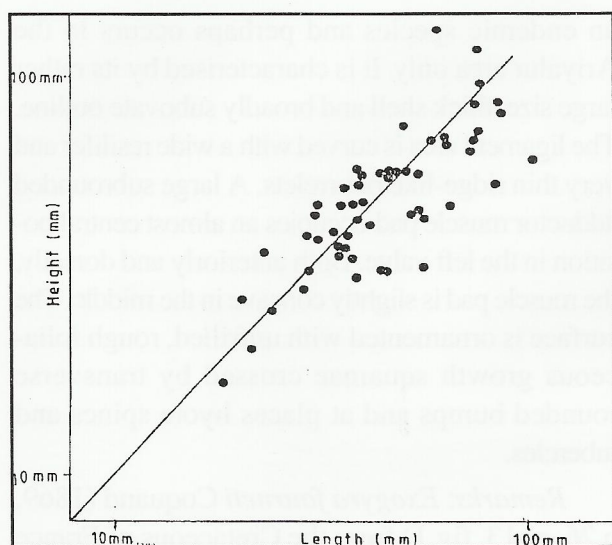


Fig. 6. Height/Length ratio of *Phygraea (Phygraea) vesicularis* (Lamarck)

Cretaceous horizons of the different parts of the world, e.g. Mozambique (Rennie, 1943, Förster, 1975), Angola (Rennie, 1945), Madagascar (Tashiro, 1978), France (Lamarck, 1806, Coquand, 1869), England (Woods, 1913, Cleavelly and Morris, 1987), Belgium (Dhondt and Jagt, 1987), Poland (Pugaczewska, 1977), etc. Also, *Phygraea (Phygraea) vesicularis* exhibits a wide range of variation in its general morphological features, which has led to the creation of numerous "species" by many authors; most of these, however, are merely distinctive morphotypes within a contemporaneous polytypic population. Hence, the subspecies category is used for temporal and geographic changes in a population structure, not for sympatric morphotypes (Cooper, 1992, p.23).

Gryphaea vesiculosa Sowerby, recorded by Stoliczka (1870-71, p.466, pl.39, figs 1-2) from the older Uttatur Group of the Tiruchirapalli area may be a morphological variant of the present species, Picard (1928, 1930) considered it a junior synonym of *Phygraea vesicularis*.

Measurements:

No.	L.	H.	I.
BHU990925-7	33	31	13 (LV)
BHU990925-8	42	61	17 (LV)

BHU990925-11	51	65	27(LV)
BHU2000818-5	53	64	31(LV)
BHU2000819-23	61	73	32(LV)
BHU990928-62	62	56	22(LV)
BHU990926-20	65	68	38(LV)
BHU990926-17	67	80	45(LV)
BHU990926-23	69	80	41(LV)
BHU990925-12	74	70	35(LV)
BHU2000818-3	77	70	42(LV)
BHU2000818-8	81	86	49(LV)
BHU2000819-21	82	72	36(LV)
BHU2000821-27	87	87	52(LV)
BHU2000818-2	87	95	51(LV)
BHU990926-18	88	89	50(LV)
BHU2000819-20	88	100	57(LV)
BHU990928-57	88	108	52(LV)
BHU2000818-1	92	96	52(LV)
BHU990927-39	93	93	48(LV)
BHU2000821-25	100	83	36(LV)

Phygraea (Phygraea) sp.

(Pl. VI, figs 4a, b)

Material: A partly incomplete left valve, BHU990927-42a, from Kallankurichchi.

Description: This lone specimen from the Kallankurichchi quarry is slightly broken along the margins. However, the available part of the shell is quite inequilateral, posteriorly produced (rather arcuate), suborbicular in outline. Umbo prominent, curved and opisthogyrous. The attachment area is small. Internal shell cavity deep. Ligament area small and trigonal with broad resilifer; bourrelets narrow, flat and almost of same size. Anterodorsally the commissural shelf is ornamented with 7 nonvermiculate, lath-like catachomata present inside an elongated duct. Adductor muscle impression is subrounded, moderate in size and subcentral in position. Quenstedt muscle scar very near to the ligamental area. Shell surface ornamented with widely spaced, irregularly distributed growth lamellae.

Remarks: This specimen from the Tiruchirapalli shows some semblance to the genus *Labrostrea* Vylow, in its shape, small hinge, concave ligament area and non-vermiculate anterior catachomata, but it lacks sharply defined circumferential commissural shelf and a well-defined deep shell cavity, the feature diagnostic of the genus *Labrostrea*. Although

the shell structure is vesicular, which is found both in *Phygraea* and *Labrostrea*, but due to prominent umbo (rising well above the hinge line) and well inflated left valve, this specimen is much closer to *Phygraea* than *Labrostrea*. The present specimen differs from the earlier described *Phygraea* (*Phygraea*) *vesicularis* in its posteriorly produced (rather arcuate) outline and absence of the posterior radial sulcus. In all probability, this is a new species of *Phygraea*. Since it is represented here by single incomplete specimen, it has been described here as *Phygraea* (*Phygraea*) sp.

Measurements :

No.	L.	H.	I.
BHU990927-42a	54	56	32 (LV)

Superfamily Gryphaeidea Vyalov, 1936
(*nom. transl.* Sobetski 1982 ex Gryphaeidae Vyalov, 1936)

Family Exogyridae Vyalov, 1936

Subfamily Exogyrinae Vyalov, 1936

Genus Exogyra Say, 1820

Subgenus Exogyra Say, 1820

(*Type species: Exogyra costata* Say, 1820

Exogyra (*Exogyra*) *tamulica* Stoliczka, 1870-71

(Pl.V, fig.2; Pl.VI, fig.1)

Exogyra tamulica Stoliczka, 1870-71, p.462, pl., 51, figs 2-3, pl.52, fig.1.

Material: A partly incomplete left valve (No. BHU2000821-28) from Kallankurichchi.

Description: *Exogyra* (*Exogyra*) *tamulica* is

an endemic species and perhaps occurs in the Ariyalur area only. It is characterised by its rather large size, thick shell and broadly subovate outline. The ligament area is curved with a wide resilifer and very thin ridge-like bourrelets. A large subrounded adductor muscle pad occupies an almost central position in the left valve. Both anteriorly and dorsally, the muscle pad is slightly concave in the middle. The surface is ornamented with unfrilled, rough foliaceous growth squamae crossed by transverse rounded bumps and at places hyote spines and tubercles.

Remarks: *Exogyraourneti* Coquand (1869, p.26, pl.13, fig.1) from the Cretaceous of France is distinguished from *E. tamulica* by its more broadly ovate outline, shell surface without foliaceous growth squamae, and the adductor muscle pad positioned more towards the posterior side. *Exogyra costata*, the type species of *Exogyra* earlier recorded by Say (1820), Stoliczka (1870-71), Stephenson (1914), Wade (1926), at first sight resembles the Ariyalur species in its identical size and similar outline, but can be readily distinguished by its closely spaced conspicuous radial costae and more posteriorly placed adductor scar. The North American species *Exogyra ponderosa ponderosa* Roemer (1849, p.395) is another large thick shelled *Exogyra*, but with a very distinct pattern of radial ribs. Another Maastrichtian species *Exogyra overwegi* (von Buch), described by Malchus (1990, p.138, pl.11, figs1-9, pl. 12, figs 1-5), is distinguished from *Exogyra tamulica* by more prominent, strongly incoiled umbones and coarser radial ribs.

EXPLANATION OF PLATE IV

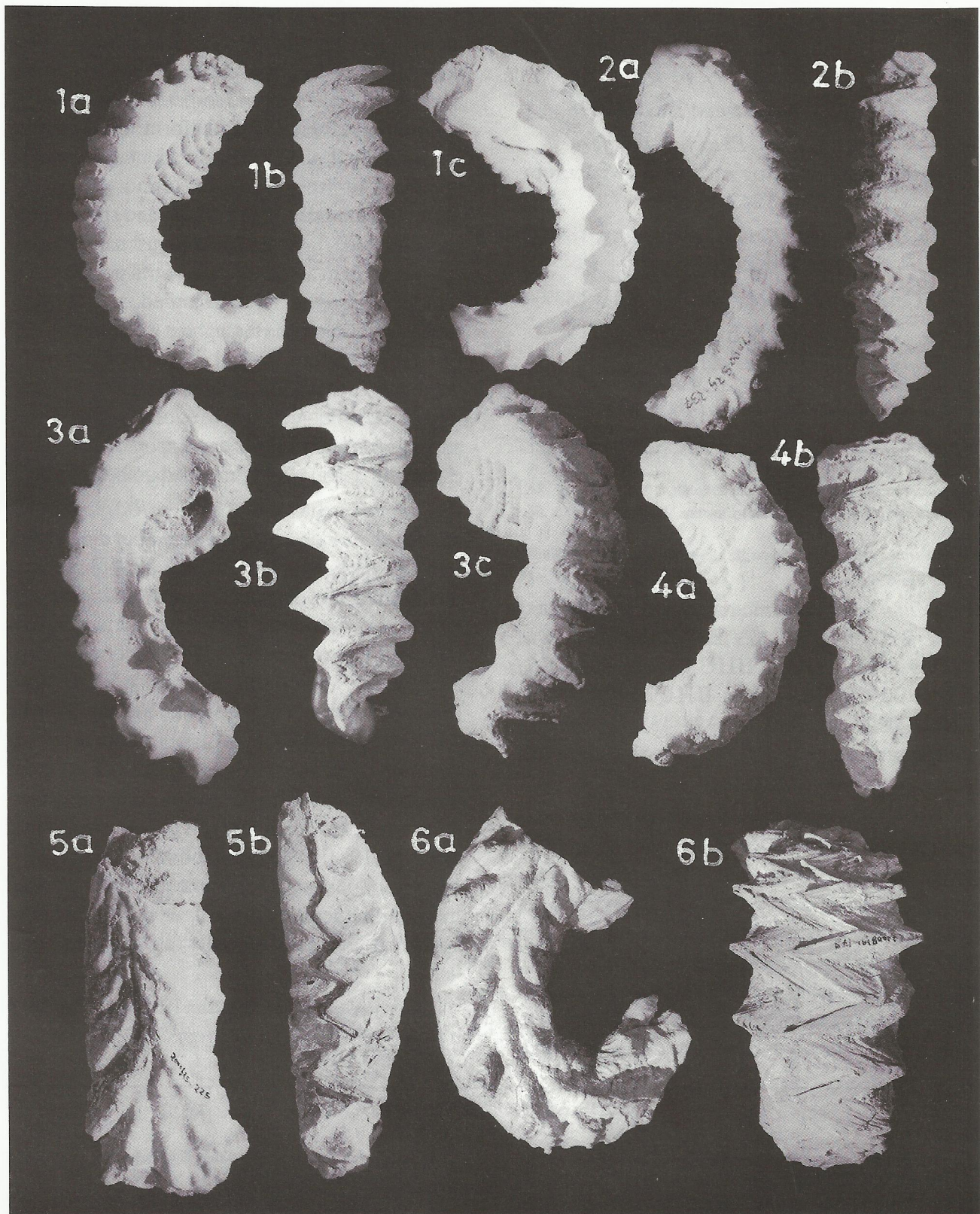


1-4. *Agerostrea unguolata* (Schlotheim)

1. No. 2000819-180 from Kattupirangiyam, a- external view of LV (x 0.9), b-anterior view of LV(x 0.9), c-internal view of LV(x0.9).
2. No.2000825-237 from Kattupirangiyam, a- external view of RV (same size), b-anterior view of both valve (same size).
3. No.2000819-181 from Kattupirangiyam, a- internal view of RV (same size), b- anterior view of RV (same size),

c-external oblique view of RV (same size).

4. No.2000825-203 from Kattupirangiyam, a- external view of RV (x1.1), b- anterior view of both valve (x 1.3).
- 5-6. *Rastellum* (*Arcostrea*) *pectinatum* (Lamarck)
5. No.2000825-225 from Kattupirangiyam, a- external view of LV (0.7), b-anterior view of BV(x 0.7).
6. No.2000819-179 from Kattupirangiyam, a- external view of LV (0.6), b-anterior view of BV(x 0.6).



Measurements :

No.	L	H	I
BHU2000821-28	126.00	165.00	78.00(LV)

Genus *Ceratostreon* Bayle, 1878

Type species : *Exogyra plicifera*
Dujardin, 1837 (= *Exogyra spinosa* Matheron,
1843,

= *Ostrea matheroniana* d'Orbigny, 1848);
SD Douville, 1879).

Ceratostreon pliciferum (Dujardin 1837)
(Pl.III, figs 1-11)

Planospirites ostracina Lamarck, 1801, p.700.

Exogyra plicifera Dujardin, 1837, p.229, fig. No. 73.

Exogyra plicifera Dujardin, Coquand, 1869, p. 80, pl.36, figs 6-18.

Exogyra ostracina Lam., Stoliczka, 1871, p.459, pl.35, figs 6-12, pl.36, figs 1-4.

Ceratostreon pliciferum (Dujardin) Dhondt, 1985, p.59, fig. 2A.

Ceratostreon pliciferum (Dujardin) Malchus, 1990, p.113, pl.5, figs 8-10.

Ceratostreon pliciferum (Dujardin) Fürsich and Pandey, 1998, p.126, figs 5 d,e.

Material: 53 disarticulated and 2 articulated (No. BHU990927-32, BHU2000825-58a, BHU990927-31, BHU 2000818-35, BHU990927-36, BHU2000818-30, BHU990927-38, BHU990928-45), moderately well preserved specimens from Kallankurichchi and Kattupirangiyam.

Description: After *Phygraea* (*Phygraea*) *vesicularis*, *Ceratostreon pliciferum* constitutes the next most abundant oyster in the collection from Ariyalur. It is characterised by small to medium size, inequilateral and moderately inflated specimens. The outline varies from subelliptical to subovate (fig.7). Height is appreciably greater than length (fig.8). The umbones are opisthogyrous, twisted and incoiled. The umbonal cavity is deep. The attachment area

variable in size, but usually broad. The ligamental area is of exogyrid type (Malchus, 1990), with a narrow posterior bourrelet and resilifer but the anterior bourrelet thin and sometimes obscured by overgrown posterodorsal platform. The commissural margin is plicate. The paradontal recess is in the form of linear groove supported by the paradontal buttress. The position and shape of the adductor pad (fig.9) varies from just near the posterior margin to an almost subcentral position. It is rather large, ovate to subrounded, and dorsally concave. Catachomata throughout the margins, lath-like on the anterior, ventral and posterior margins but pustulose along the dorsal margin. The shell surface is ornamented with irregularly distributed adpressed growth squamae and sporadic tubercles, especially on the bluntly rounded umbonal ridge.

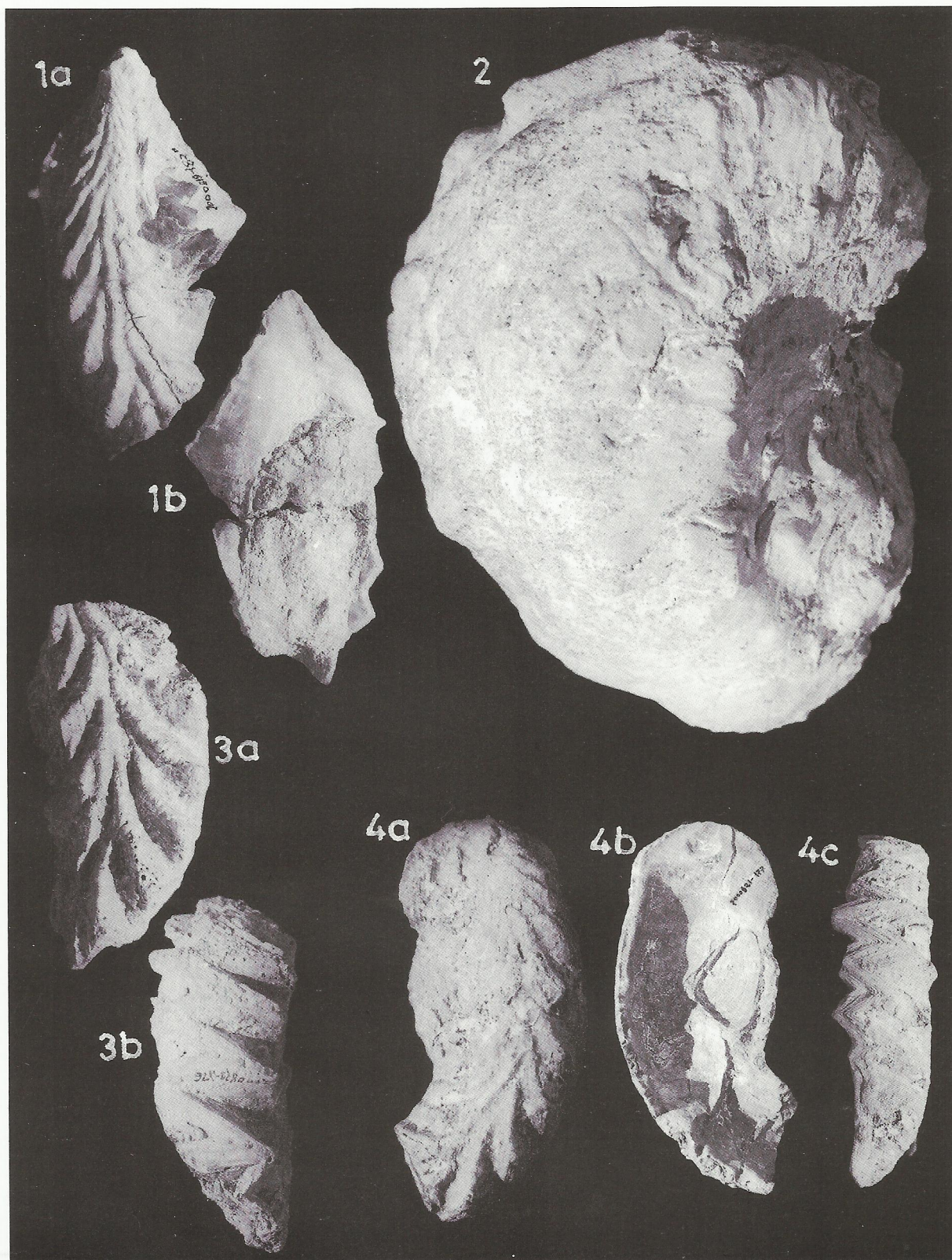
Remarks: Lamarck (1801 p.700) listed this species as *Planospirites ostracina* but did not figure it. Dujardin (1837, p.229, fig. No.73) was first to describe and figure *Exogyra plicifera* and hence, as per the code, the species name *plicifera* has priority. (Dhondt, 1985, Malchus, 1990). *Amphidonte humboldtii* (Fischer de Waldheim), the type species of the genus *Amphidonte* (Stenzel, 1971, N1119, fig J93, 1a-e), is quite similar in outline to the Ariyalur specimens but has a different profile to the left valve, besides different ornamental features. *Utrobiqueostreon greylingae* Cooper (1995, p.19, figs 15-19) from the Barremian – Aptian of Zululand shows some resemblance in the internal characters of the left valve to the present specimens, but has a typically falciform shell outline.

Ceratostreon reticulatum (Reuss), described by Cooper (1995, p.24, figs 21-23) from the

EXPLANATION OF PLATE V

- 1, 3-4. *Rastellum* (*Arcostrea*) *pectinatum* (Lamarck)
1. No.2000819-182a from Kattupirangiyam, a- external view of LV (0.8), b-internal view of LV (x 0.7).
3. No.2000821-176 from Kallankurichchi, a- external view of RV (0.8), b- anterior view of RV (x 0.8).

2. *Exogyra* (*Exogyra*) *tamulica* Stoliczka No.2000821-28 from Kallankurichchi, external view of LV (0.8).
4. No.2000821-177 from Kallankurichchi, a- external view of RV (0.6), b-internal view of RV (x 0.6), c-anterior view of RV (x 0.5).



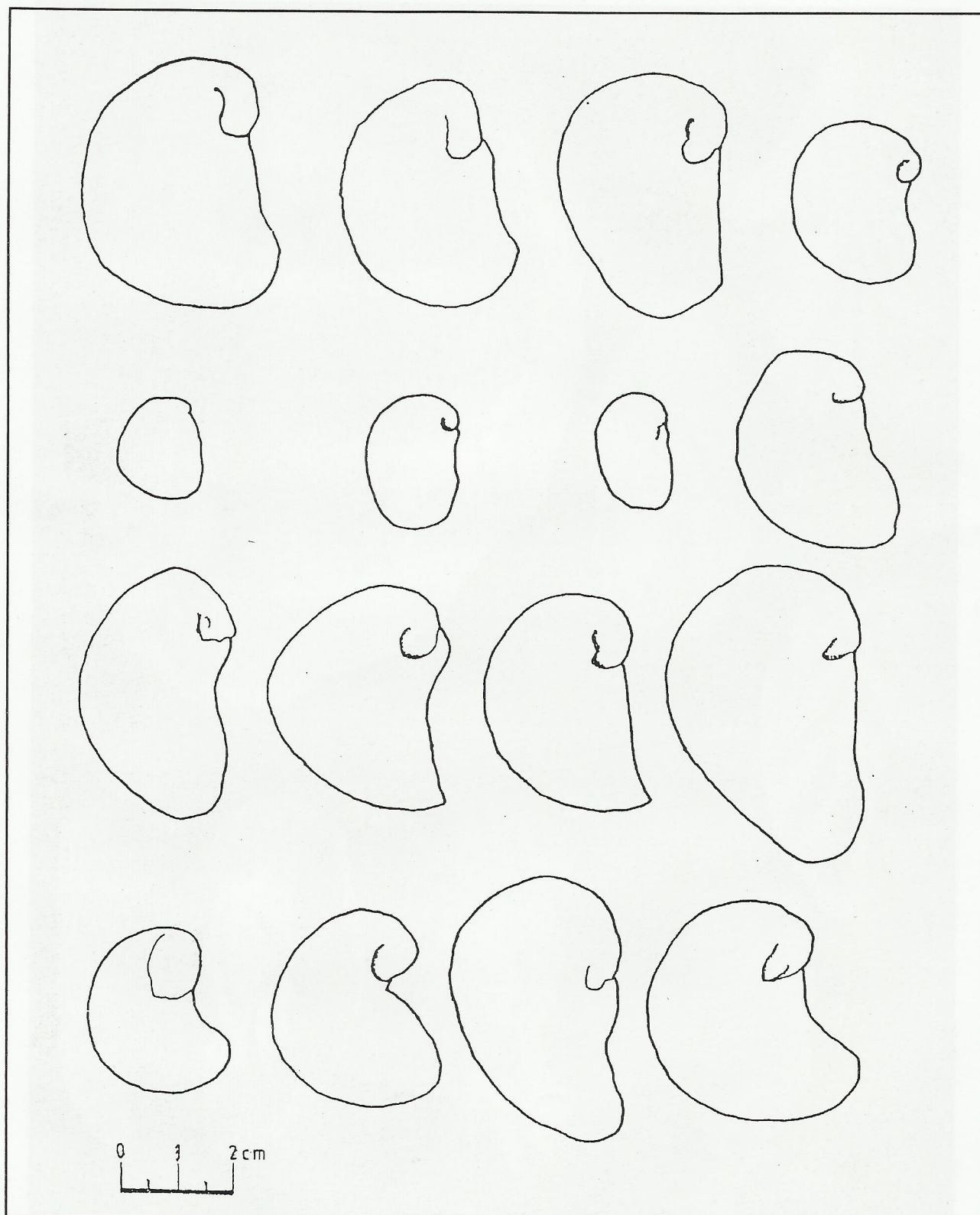


Fig. 7. Variation in outline of *Ceratostreon pliciferum* (Dujardin).

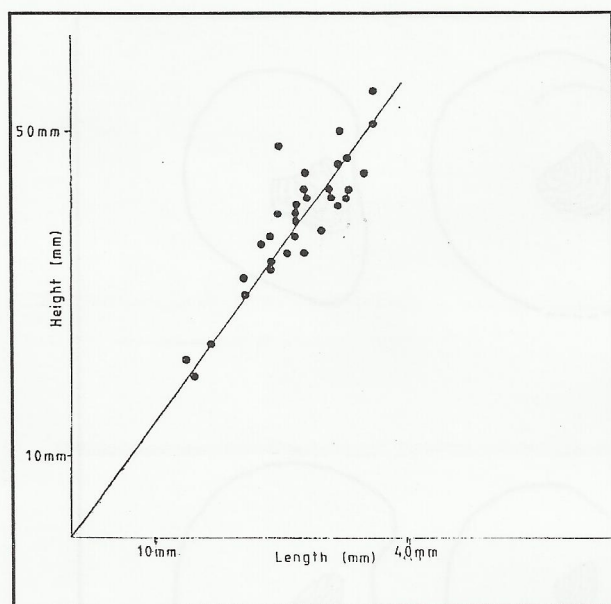


Fig. 8. Height/Length ratio of *Ceratostreon pliciferum* (Dujardin).

Lower Coniacian of Zululand and also by Malchus, Dhondt and Trögger (1994, p.121, pl.3, figs 4, 6,10) from the Upper Cretaceous of Belgium, is another similar species, but is much broader (length is greater than height) and with a crescentic adductor muscle pad in the left valve. *Ceratostreon hilli* (Cragin) recorded by Stanton (1947, p.33, pl.24, fig.7, pl.25, figs 1-14) from the Aptian of Texas, has some similarities in outline and general appearance but consists of different ornamental pattern.

Ceratostreon flabellatum (Goldfuss), one of the most common species of *Ceratostreon* in the Albian to Cenomanian recorded by Goldfuss (1833, p.38, pl.877, fig.6.), Coquand (1869, p.126, pl.49, figs 1-2, pl.52, figs1-9), Freneix and Viaud (1986, p.40, pl.3, figs 13-15), Malchus (1990, p.111, pl.4, figs 4-11, pl.5, figs1-7), resembles the Ariyalur species in shape but has prominent ribs on the surface.

Measurements:

No.	L.	H.	I.
BHU990927-32	14	22	8 (LV)
BHU2000825-58a	15	20	10(LV)
BHU990927-31	17	24	11(LV)

BHU2000818-35	21	32	16(LV)
BHU990927-36	24	33	17((BV)
BHU2000818-30	25	40	18(LV)
BHU990927-38	25	48	17(LV)
BHU2000818-29	27	41	15(LV)
BHU2000822-52	28	35	17(LV)
BHU2000825-58	28	42	13(LV)
BHU2000822-50	28	43	18(LV)
BHU2000821-38	28	45	21(LV)
BHU990927-29	31	42	17(LV)
BHU2000818-31	31	43	16(LV)
BHU990927-26	32	41	17(LV)
BHU2000822-45	32	41	20(LV)
BHU990928-53	32	46	15(LV)
BHU2000820-55	32	50	15(LV)
BHU2000822-43	33	43	18(LV)
BHU2000822-42	33	47	20(LV)
BHU990928-45	36	60	17(LV)

Genus *Curvostrea* Vyalov, 1936

(Type species: *Ostrea rouvillei*, Coquand, 1862, *Ostrea rediviva* Coquand, 1869)

Curvostrea rouvillei (Coquand, 1862) (Pl. VII, figs1-3)

Ostrea rouvillei Coquand, 1862, p.224, pl.18, figs 1,7.

Ostrea rouvillei Coquand, 1869, p.89, pl.21, figs 3-6, pl. 24, figs 7-11.

Ostrea rediviva Coquand 1869, p.154, pl. 42, figs 8-11, pl.54, figs 18-30.

Gryphaea arrialoorensis Stoliczka, 1870-71, p.464, pl.45, figs13-14; pl. 50, fig.9.

Curvostrea rouvillei (Coquand), Malchus, 1990, p. 154, pl. 14, figs 1-7,16.

Material: 2 partly incomplete left valves (No. BHU2000818-16, BHU2000818-18) and 1 disarticulated left and right valve of the same specimen (BHU990926-25) from Kallankurichchi.

Description: Although the present specimens from Ariyalur are partly incomplete, they exhibit most of the diagnostic characters. The left valve is of moderate size, subovate in shape, posteriorly produced (rather arcuate), highly inequilateral and well inflated. Height is slightly greater than length. Umbo, prominent and opisthogyrous. The internal shell cavity is deep. Ligament area small and trigonal with broad, shallow resilifer and narrow, flat and subequal bourrelets. The anterior catachomata are in the form of parallel grooves, the posterior ones eroded. The adductor muscle impression is subcircular, moderate in size and subcentral in po-

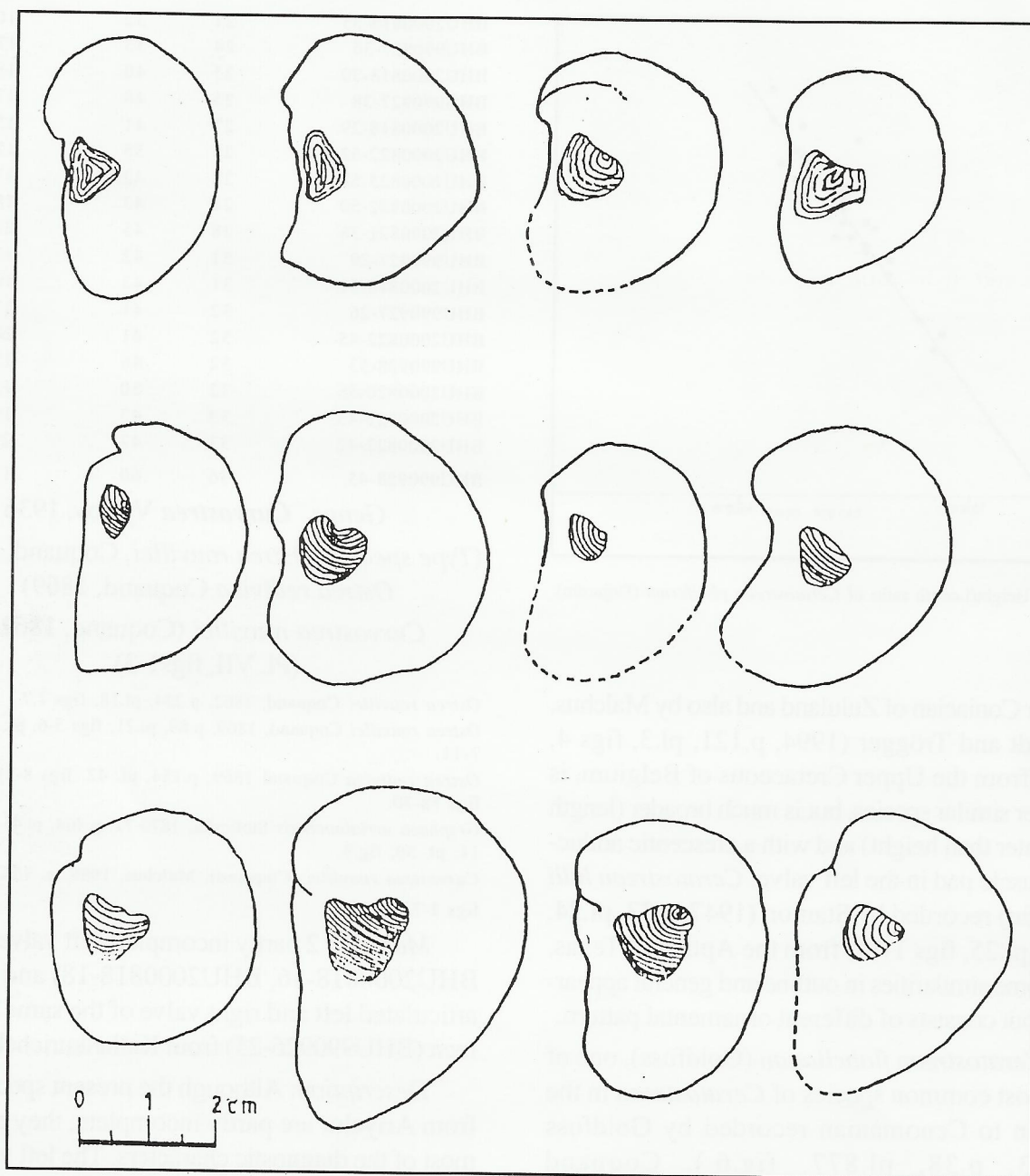
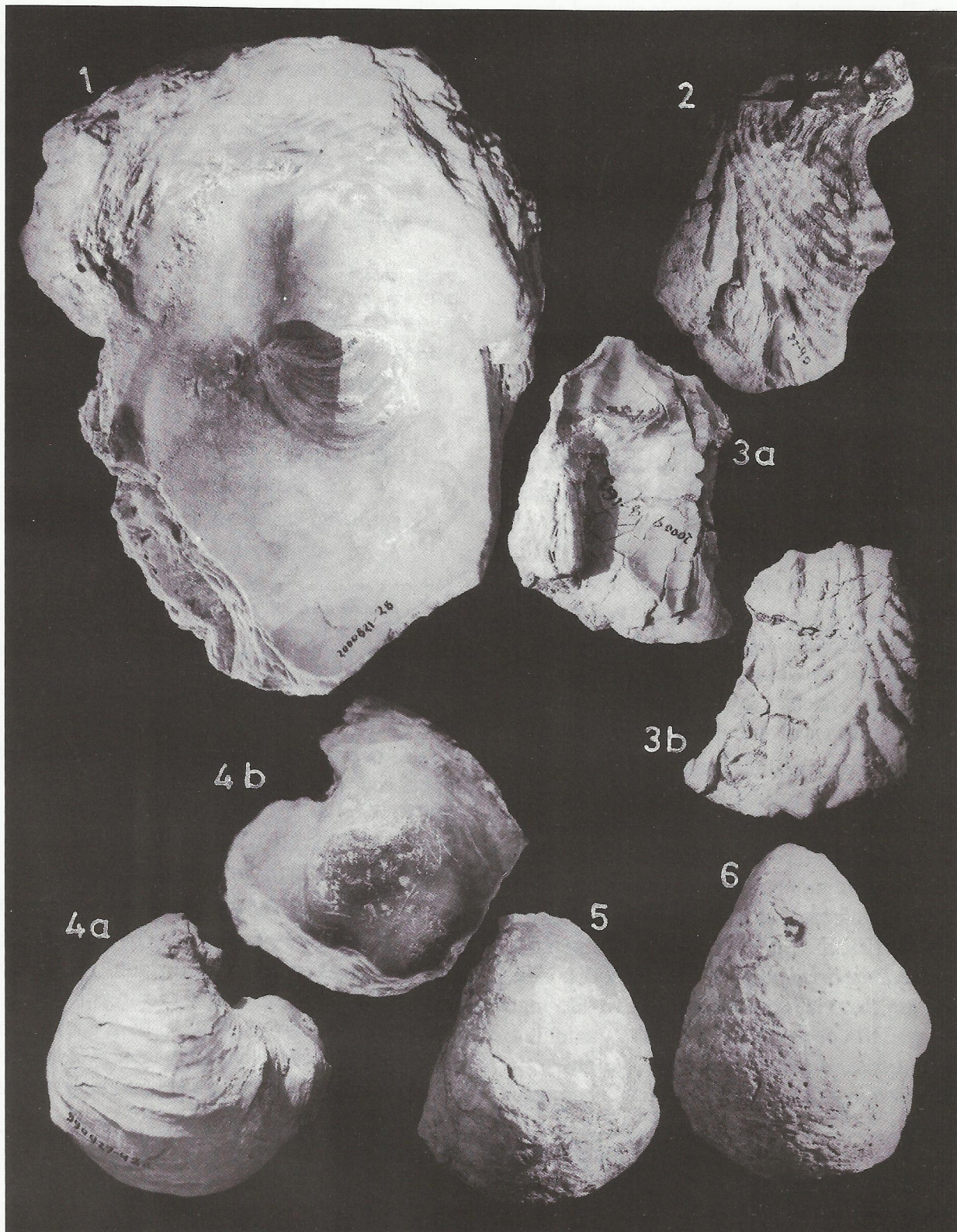


Fig. 9. Variation in the position of adductor muscle in *Ceratostreon pliciferum* (Dujardin) population.

EXPLANATION OF PLATE VI

1. *Exogyra* (*Exogyra*) *tamulica* Stoliczka
1. No.2000821-28 from Kallankurichchi, internal view of LV (0.8).
- 2-3. *Cameleolopha diluviana*. (Linné)
2. No.990927-40 from Kallankurichchi, external view of LV (0.8).
3. Sp.no.2000818-163 from Kallankurichchi, a-internal view of RV (x1.2), b-external view of RV (1.2).
4. *Phygraea* (*Phygraea*) sp. No.990927-42a from Kallankurichchi, a-external view of LV (same size), b- internal view of LV (x 1.1).
- 5- 6. *Phygraea* (*Phygraea*) *vesicularis* (Lamarck).
5. No.2000819-23 from Kattupirangiyam, external view of LV (x 0.8).
6. No.990925 -11 from Kallankurichchi, external view of LV (same size).



sition. The quenstedt muscle scar is situated about 4 mm below the ventral margin of ligamental area. The shell surface ornamented with widely spaced, irregularly distributed growth squamae. The right valve is smaller, subrounded, feebly inflated and irregularly concave. The umbo is very small, rather insignificant, paradontal process small; ligament area reflected, triangular with obtuse apex; resilifer subtrigonal, moderately deep; adjoining bourrelets flat, broad and subequal in size. The chomata on the posterior commissural shelf are pustulose, while those on the anterior side are obscured but appears to be arborescent.

Remarks: The genus *Curvostrea* Vyalov had earlier been considered (Stenzel, 1971) a *nomina dubia* since the type species *Ostrea rediviva* Coquand did not show most of the internal characters. Malchus (1990) studied the genus *Curvostrea* Vyalov in considerable detail and further elaborated the characters which were not known earlier. It has been established that the type species *O. rediviva* is a subjective junior synonym of *Curvostrea rouvillei* (Coquand) (Freneix and Viaud, 1986; Malchus, 1990) that lacks both vermiform chomata and vesicular shell structure.

In all these available characters these specimens from the Maastrichtian of Ariyalur area appear to belong to *Gryphaea arrialoorensis* Stoliczka (1870-71, p.464, pl.45, figs 13-14; pl. 50, fig.9) from the same horizon and locality. This species of Stoliczka has been recorded by Tashiro (1978, p. 121, pl. 2, figs 4-5) from Madagascar as *Pycnodonte arrialoorensis* (Stoliczka), but the Malagash material is a *Phygraea* and a different species. Malchus (1990, p.154) considered *arrialoorensis* a junior subjective synonym of *Curvostrea rouvillei* (Coquand). Another compa-

rable form is *Labrostrea umsineniensis* described by Cooper (1992, p.43, figs 4H-M, 15-18) from the Middle Coniacian of Zululand. However, the diagnostic features of the Zululand species, the small size, conspicuous posterior auricle with arborescent catachomata on innerside, differentiate it from the Ariyalur specimens.

Measurements:

No.	L.	H.	I.
BHU990926-25	48	59	14(RV)
BHU990926-25	62	76	32(LV)
BHU2000818-16	57	62	21(LV)
BHU2000818-18	59	57	27(LV)

Subfamily Lophinae Vyalov, 1936

Genus Agerostrea Vyalov, 1936

(Type species : *Ostracites ungulatus* von Schlotheim, 1813)

Agerostrea ungulata (Schlotheim, 1813).

(Pl.IV, figs. 1-4)

Ostracites ungulatus Schlotheim, 1813, p.112.

Ostrea tegulacca, Forbes, 1845, pl.18, fig. 6.

Ostrea ungulata Coquand, 1869, p.58, pl. 31, figs 4-15.

Ostrea (Alectryonia) ungulata, Schlotheim, Stoliczka, 1870-71, p.470, pl.47, figs 3-4.

Agerostrea ungulata, (Schlotheim), Fürsich and Pandey, 1999, fig. 5f.

Material : 6 articulated and 5 disarticulated specimens (No. BHU2000819-180, BHU2000819-181, BHU2000825-203, BHU2000825-237, BHU2000825-238, BHU2000825-240) from the Kattupirangiyam.

Description: The present specimens from the Ariyalur area are characterised by medium size, inequilateral, moderately inflated shells with crescentic outline. Shell tapers gently from umbo to the posteroventral end. Anterior flank convex, posterior one concave, both nearly vertical along commissural plane which is folded into high and nar-

EXPLANATION OF PLATE VII

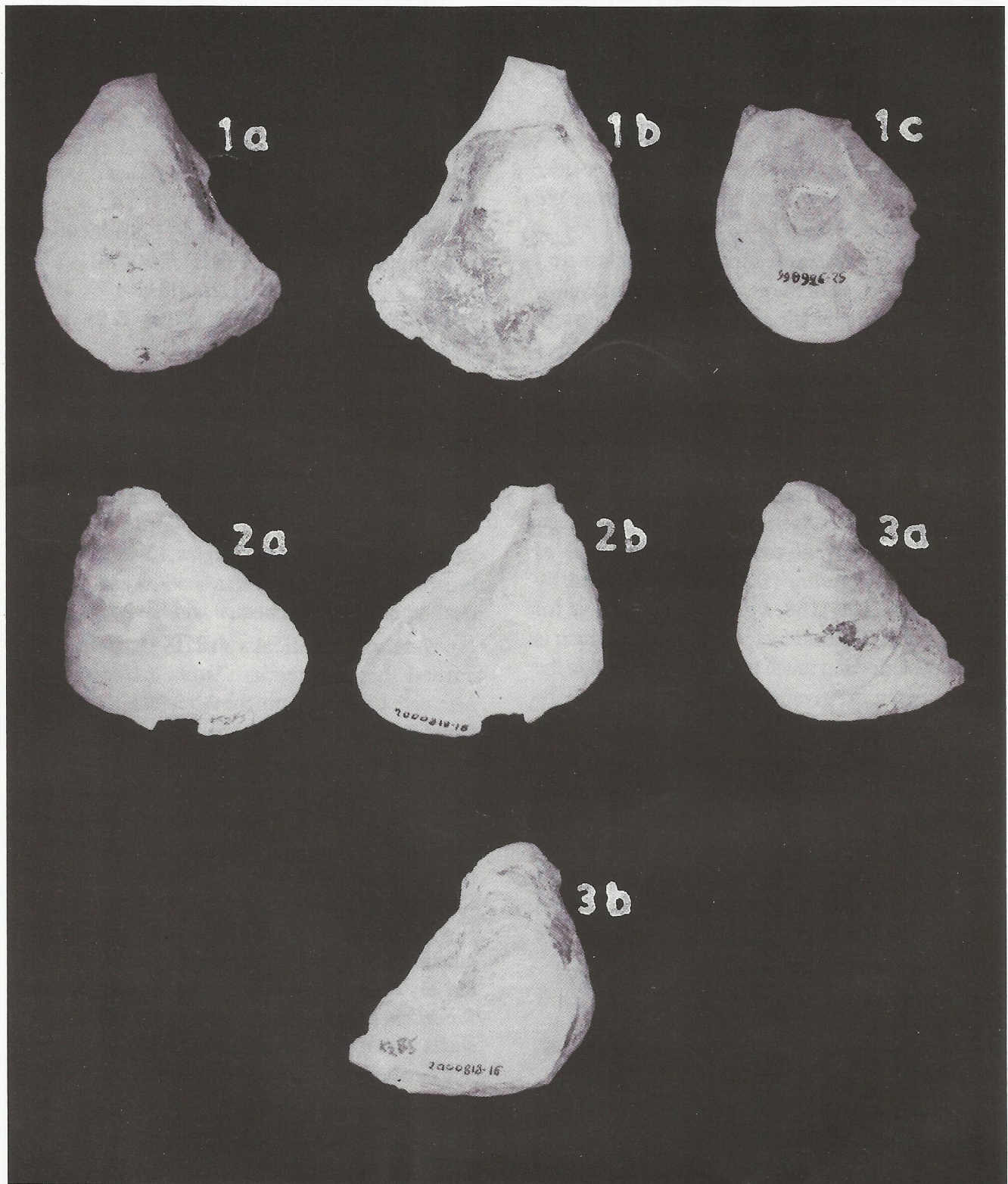


1-3 *Curvostrea rouvillei* (Coquand)

1. No.990926-25 from Kallankurichchi, a-external view of LV (x 0.7), b-internal view of LV (x 0.7), c- internal view of RV (x 0.7).

2. No.2000818-18 from Kallankurichchi, a-external view of LV (x 0.7), b- internal view of LV (x 0.7).

3. No.2000818-16 from Kallankurichchi, a-external view of LV (x 0.7), b- internal view of LV (x 0.8).



row plicae ending in highly acute and sharp points. In the initial stage of growth, along the posterior margin, costae are gradually thickening into plicae, while along the anterior margin these are of homogeneous thickness with gradually widening interspaces. Margin of insertion of adductor muscle near the hinge, just adjacent to posterior side; more or less bean shaped with slightly concave posterior and convex anterior margins.

Remarks : *Agerostrea ungulata* (Schlotheim) is the type species of the genus *Agerostrea* Vyalov, whose most diagnostic features are the falcately curved outline and flat and smooth central field of the valves. Earlier this species has been described by Stoliczka (1870-71, p.470) from the Ariyalur sediments of the Pondicherry area as *Ostrea (Alectryonia) ungulata* Schlotheim and, due to flat and smooth median space, his species certainly belonged to the genus *Agerostrea*. The Ariyalur specimens are identical to the type material of *Agerostrea ungulata* (Schlotheim) figured by Stenzel (1971, N1158, figs J133, 1a-e), save for the position of the adductor muscle scar which is more posterior and much nearer to the hinge in the specimens from Ariyalur.

The present specimens are quite similar in outline, ribbing pattern and position of adductor muscle scar to *Rastellum (Arctostrea) carinatum* (Lamarck) described as *Ostrea (Alectryonia) carinata* Lamarck by Stoliczka (1870-71, p.468, pl. 48, fig. 5, pl. 49, figs 1-2) from older Trichinopoly and Uttatur Groups, but this species lacks the mesial smooth area, a diagnostic feature of *Agerostrea ungulata*.

Measurements:

No.	L.	H.	I.
BHU2000825-240	19	61	20(BV)
BHU2000825-238	21	62	21(BV)
BHU2000825-203	30	57	13(BV)
BHU2000825-237	35	81	15(BV)
BHU2000819-181	38	77	20(RV)
BHU2000819-180	46	74	17(LV)

Genus *Rastellum* Faujas-Saint-Fond, 1799

Subgenus *Arctostrea* Pervinquiere, 1910a

(Type species: *Lopha (Arctostrea) carinata* Lamarck, 1806)

Rastellum (Arctostrea) pectinatum (Lamarck, 1810)

(Pl.IV, figs. 5-6; Pl.V, figs.1, 3-4)

Ostrea pectinata Lamarck, Coquand, 1869, p.76, pl. 29, figs. 1-7.

Ostrea (Alectryonia) pectinata Lamarck, Stoliczka, 1870-71, p.469, pl. 48, figs. 1-2.

Material: 2 articulated and 17 disarticulated specimens (No. BHU2000821-176, BHU2000821-177, BHU2000819-179, BHU2000819-182a, BHU2000825-225) from Kattupirangiyam and Kallankurichchi.

Desscription : The additional specimens collected from the Ariyalur area show variation in outlines from almost straight to coma shape. The commissure is quite serrated and the commissural shelf broad. The adductor muscle scar is large, subtriangular, with obtusely rounded anterior and gently rounded posterior margins. Ligamental area broadly subtriangular with a shallow and trigonal resilifer and broad, subequal and flat bourrelets.

Remarks: Stoliczka (1870-71, p.469) recorded this species as *Ostrea (Alectryonia) pectinata* Lamarck from the Ariyalur Group of different parts of the Tiruchirapalli Sub-basin. It is assigned to *Rastellum (Arctostrea)* due to its variable outline, from almost straight to curved, parallel and steep flanks, and slender hyote spines with sharply pointed and narrow tips. *Rastellum (Arctostrea) carinatum* (Lamarck) described by Stoliczka (1870-71, p.468, pl. 48, fig. 5, pl. 49, figs 1-2) from the older Trichinopoly Group and Uttatur Group of the Tiruchirapalli area, is the only closely comparable species which differs from *Rastellum (Arctostrea) pectinatum* in its narrower shells with more numerous ribs, subparallel flanks and smaller adductor muscle scars.

Measurements:

No.	L.	H.	I.
BHU2000825-225	40	104	31(BV)
BHU2000821-176	43	87	24(RV)
BHU2000819-182a	54	104	24(LV)
BHU2000821-177	56	125	32(RV)
BHU2000819-179	74	120	53(BV)

Genus Cameleolopha Vyalov, 1936(Type species: *Ostrea cameleo* Coquand, 1869)*Cameleolopha diluviana* (Linné 1767)

(Pl. VI, Figs. 2-3)

Ostrea (Alectryonia) diluviana Linné, Stoliczka, 1870-71, p.466, pl. 46, figs 1-2, pl.47, figs 1-2 (non Linné).

Material : 1 articulated and 2 disarticulated, imperfectly preserved specimens (No. BHU990927-33, BHU990927-40, BHU2000818-163) from Kallankurichchi.

Description: Three specimens from the Kallankurichchi formation of the Ariyalur area are incomplete so that the exact outline cannot be ascertained but these consist of narrow, sharp crested, dichotomous plicae with the intercalation of 1-2 unbranched costae / plicae. The plicae branch in the middle of the shell height and some of them again dichotomise near the ventral margin. The ligament area is broad with wide and shallow triangular resilifer and flat and narrow bourrelets.

Remarks: *Lopha (Actinostreon)* Bayle, 1878 and *Cameleolopha* Vyalov, 1936 are distinguished from each other by ornamental pattern, with about 25 dichotomous, narrow but not angular-crested plicae in *Actinostreon* and about 12-20, angular narrow-crested, dichotomous plicae in *Cameleolopha*. The specimens recorded by Stoliczka (1870-71, p.466, pl., 46, figs 1-2, pl.47, figs 1-2) as *Ostrea (Alectryonia) diluviana* Linné from the older Trichinopoly and Uttatur Groups comprise very sharp crested plicae which are a bit widely spaced than their thickness.

Ostrea (Alectryonia) arcotensis Stoliczka (1870-71, p.471, pl.43, figs 3-7) from the Ariyalur Group of the Ariyalur area belongs to *Lopha (Actinostreon)* due to its small to medium size and bluntly rounded, narrow, dichotomous plicae. In outline and size, it resembles *Cameleolopha diluviana* which, however, differs in having sharply crested plicae on the shell surface.

Measurements:

No.	L.	H.	I.
BHU990927-33	32	55	19(RV)
BHU2000818-163	40	52	13(RV)
BHU990927-40	53	91	33(BV)

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