VI PEARL OYSTERS

K. VIRABHADRA RAO AND K. SATYANARAYANA RAO

Pearls are formed in a number of species of molluscs *viz.*, the pearl oysters, window-pane oysters, edible oysters, fresh-water mussels, abalones, chanks, topshells, turban shells etc. Pearls formed in some of the pearl oyster species are valued very highly as gems because of their excellent shape, quality and lustre. Pearl oysters enjoy a world-wide distribution occuring in almost all the seas of the tropical belt. Six species of pearl oysters are known from the Indian coasts viz. *Pinctada fucata* (Gould), *P. margaritifera* (Linnaeus), *P. chemnitzii* (Philippi), *P. sugillata* (Reeve), *P. anomioides* (Reeve) and *P. atropurpurea* (Dunker). Of those, *P. fucata* which occurs in extensive beds in the Gulf of Mannar and to a much less extent in the Gulf of Kutch is commercially very important being the source of the 'Oriental pearls' or 'Lingah' pearls of great renown. *P. fucata* occurring in the Persian Gulf and off the coasts of Ceylon also supports excellent fisheries for natural pearls. The Indian pearl fisheries have been famous since ancient times for the most beautiful pearls they yield. The other five species of pearl oysters on the Indian coasts are not of any importance as their pearl yield is low or the pearls produced by them are not of high quality.

GENUS PINCTADA Roding

Pearl oysters originally ascribed to the sub-genus *Margaritifera* under the genus *Pteria* are new referable to the genus *Pinctada* as pointed out by Prashad (1932), Iredale (1939) and Hynd (1955). Members of this genus are characterized by the following features: The hinge is long and straight; the long axis of the shell is at right angles to the hinge; the left valve is a little deeper than the right; there is a byssal notch on each valve at the base of the anterior lobe; the colouration of periostracum varies and is often brownish with radial markings (Rao, 1970).

PINCTADA FUCATA (Gould)

SYNONYMS

Perlamater vulgaris Schumacher 1817
Avicula fucata Gould 1850
Avicula periviridis; A. occa; A. lucunata; A. aerata; A. fucata Reeve 1857
Pteria (Margaritifera) vulgaris Jameson 1901

Margaritifera vulgaris Hornell 1922 a
Pinctada vulgaris Prashad 1932; Prasad and Bhaduri 1933; Satyamurthi 1965
Pteria vulgaris Gravely 1941
Pinctada fucata Hynd 1955 Rao 1970

COMMON NAME

Tamil – *Muthu chippi*
English – *Pearl oyster*

Jameson (1901) stated that *Perlamater vulgaris* of Schumacher (1817) was a recognizable species and that the specific name *fucata* of Gould (1850) should be replaced by the former. But Hynd (1955) considered that the description of Schumacher was too brief to be of value and that in the absence of type specimen and type locality the species should be held to be unidentifiable.

DESCRIPTION

SHELL

The hinge is fairly long, its ratio to the broadest region of the body of the shell is about 0.85 and its ratio to the longest dorso-ventral measurement is about 0.76. In both the valves there are hinge teeth, one each at the anterior and posterior ends of the ligament. The anterior ear is larger than in other species and the byssal notch at the junction of the body of the shell and the ear is slit like. The posterior ear is fairly well developed. The posterior border of the shell shows a small or moderately large sinus. The adductor impression is large and subcentral. There are 12 to 15 small scars caused by the insertion of pallial muscles between the umbo and the anteroventral border. The convexity of the valves is greater than in other species of the genus. The shells of the pearl oysters of Tuticorin pearl banks are reddishbrown or yellowish brown in colour with radiating rays of lighter colour. The non-nacreous border on the inner surface of the valves possesses brownish or reddish patches coinciding with the external rays. The nacreous layer is well developed in both the valves, golden yellow in colour and has a bright, metallic lustre (Fig. 8 A, B, C and D). The younger shells have thin, flat, marginal radiating blunt projections (Rao, 1970).

BODY

The soft body of the pearl oyster has been described by Herdman (1904) and Hornell (1922a) and it conforms to the general pattern of structure of the monomyarian lamellibranchs. It consists of a viscero-pedal mass covered by the right and left mantle lobes which are free anteriorly, ventrally and posteriorly but fused dorsally. The mantle edge has two thin, folds with pigmented, papillate edges. The outer fold is parallel to the inner surface of the shell and the inner fold called the pallial veil or velum projects at right angles from the

mantle edges. In life the pallial veils of the opposite sides are in contact with each other except in the regions of the inhalent aperture about mid-ventrally and the exhalent aperture at the posterior end. The foot is elongated and muscular arising about mid-way between the mouth and the intestinal lobe and has a groove ventrally. The byssus is at the proximal end of the foot and bears byssus fibres with which the pearl oyster attaches itself to the substratum.

The adductor muscle consists of a narrow region formed of white, glistening muscle fibres and a broad region of colourless semi-translucent fibres. The alimentary canal consists of the mouth provided with two pairs of labial palps, the oesophagus, the stomach and a coiled intestine. The digestive gland surrounds the stomach and in healthy oysters a crystalline style is present in the intestine. The rectum passes through the pericardium, curves ventrally and lies around the opsterior aspect of the adductor muscle terminating in the anus.

The gills are paired, sickle-shaped structures lying on either side of the viscero-pedal mass. The vascular system consists of a heart with paired auricles and a ventricle enclosed in a pericardium, and a series of arteries and venous sinuses in the visceral organs. The nervous system has the paired cerebral, pedal and visceral or parieto-splanchnic ganglia from which nerves run to different parts of the body. There are two nephridia one on either side of the posterior half of the viscero-pedal mass. The gonads are paired, asymmeterical and creamy yellow in colour. The gonadal follicles cover the stomach and part of the intestine (Fig. 8 E).

Distribution

Indian Ocean, Red Sea, Persian Gulf and Western Pacific Ocean.

Habitat

In the Gulf of Mannar the pearl oysters occur on rocky or dead coral outcrops forming the pearl banks known as 'paars' which off Tuticorin are about 8–12 miles (13 to 20 km) from the coast at a depth of 7 to 12 fathoms. There is usually a rich fauna comprising of members of various groups like sponges, hydroids, polychaetes, lamellibranchs, amphipods, crabs, echinoderms, fishes etc.

Fig. 8. *Pinctada fucata* (Gould). A. Left valve outer surface. B. Right valve outer surface. C. Left valve inner view. D. Right valve inner view (after Rao, 1970). E. Anotamy. (after Hornell, 1922). a.b.o., anterior border of shell valve; a.e., anterior ear; a.t., anterior hinge tooth; by.n., byssal notch; bys., byssus; dg.g., digestive gland; f., foot; g., gills; h. lig., hinge ligament; l., ligament; l.p., labial palps; m., mouth; m.sc., muscle scar; mt., mantle; n.b., nacreous border; n.n.b., non-nacreous border; p.bo., posterior border of shell valve; p.e., posterior ear; p.n.p., posterior nacreous border; p.si., posterior sinus; p.t., posterior hinge tooth; st., stomach; rct., rectum; um., umbo.

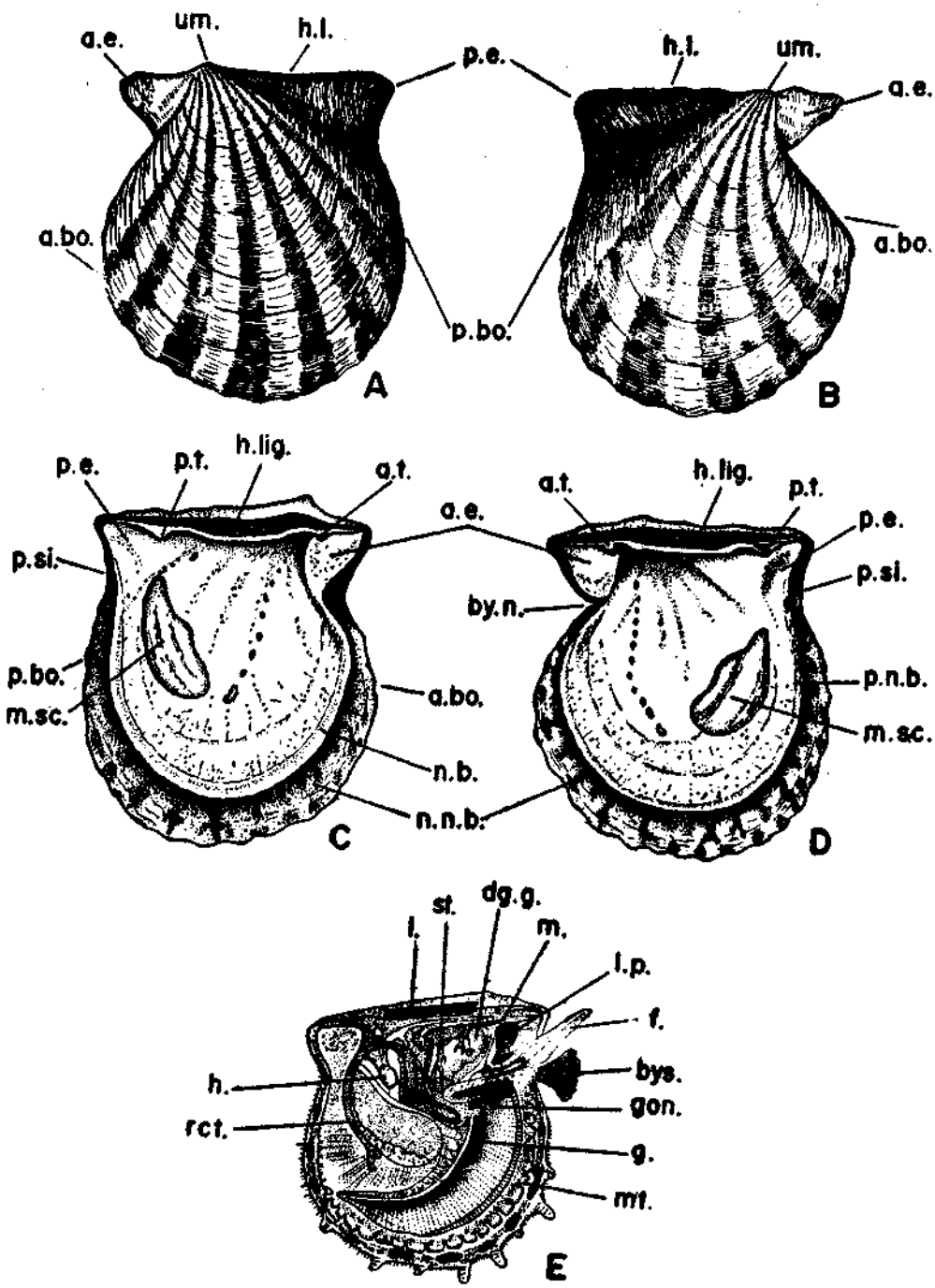

a.e.
um.
h.l.
p.e.
h.l.
um.
a.e.
a.bo.
p.bo.
a.bo.
A
B
p.e.
p.t.
h.lig.
a.t.
a.e.
a.t.
h.lig.
p.t.
p.e.
p.si.
p.si.
by.n.
p.bo.
m.sc.
a.bo.
p.n.b.
m.sc.
n.b.
n.n.b.
C
D
st.
dg.g.
l.
m.
l.p.
f.
h.
bys.
gon.
rct.
g.
mt.
E

Fig. 8

associated with the pearl banks hamphering healthy growth and survival of pearl oysters. It is not uncommon to find fair abundance of marine algae also on the pearl banks. In the Gulf of Kutch the pearl oysters are found as stray individuals on the reefs some feet below the low water mark. *P. fucata* occurs sporadically on loose sandy or muddy substratum attached to the submerged objects in littoral waters in Palk Bay.

Habits

The pearl oyster attaches itself to the substratum firmly with the bundle of byssus threads, each thread having a discoid structure at the distal end for fixation. However, the shell-fish can move with the help of the foot over short distances after detaching the byssus threads from the substratum. The foot is also used by the oyster to free parts of its body like palps, gills and mantle from foreign materials like mud etc. which settle on them. The oyster generally lies on its right valve with the posterior edge elevated at an angle of 20° (Herdman, 1904).

Food and feeding habits

Like other free-living bivalves, the pearl oyster is a filter feeder. The feeding habits of *P. fucata* have been studied by Herdman (1903). Minute food organisms present in the water enter inside the pearl oyster long with water current passing through the narrow slit formed by the inwardly directed edges of the pallial lobes and they are carried towards the branchiae which act as fine strainers arresting every particle in the water current. The food particles collected thus are carried by the cilia to the crest of the branchial lamellae and from there they are directed by the labial palps into the mouth. The labial palps have the ability to reject unwanted materials like mud particles etc.

Reproduction

No information is available on the seasonal gonadal changes of *P. fucata*. Hornell (1922a) has mentioned that some ripe oysters can be seen at any period in the year. In Australian waters Tranter (1959) has recorded that gonad differentiation takes place in *P. fucata* between September and November, spawning between December and May and the gonads are in the resting phase between June and August. The peak spawning periods January–February and April–May were observed in Australian waters. Tranter has reported in *P. fucata* protandry and sex-change.

P. fucata of the Indian coast in the Gulf of Manner has two spawning seasons in the year in April – May and September – October (Hornell, 1916). Herdman (1906) has stated that in Ceylon waters *P. vulgaris* (= *P. fucata*) spawns between May and July and again in the period November – January. According to Malpas (1929) the species spawns in Ceylon in July – August and

December – January. Chacko (1970) has reported breeding of the species in all the months of the year.

Early Development

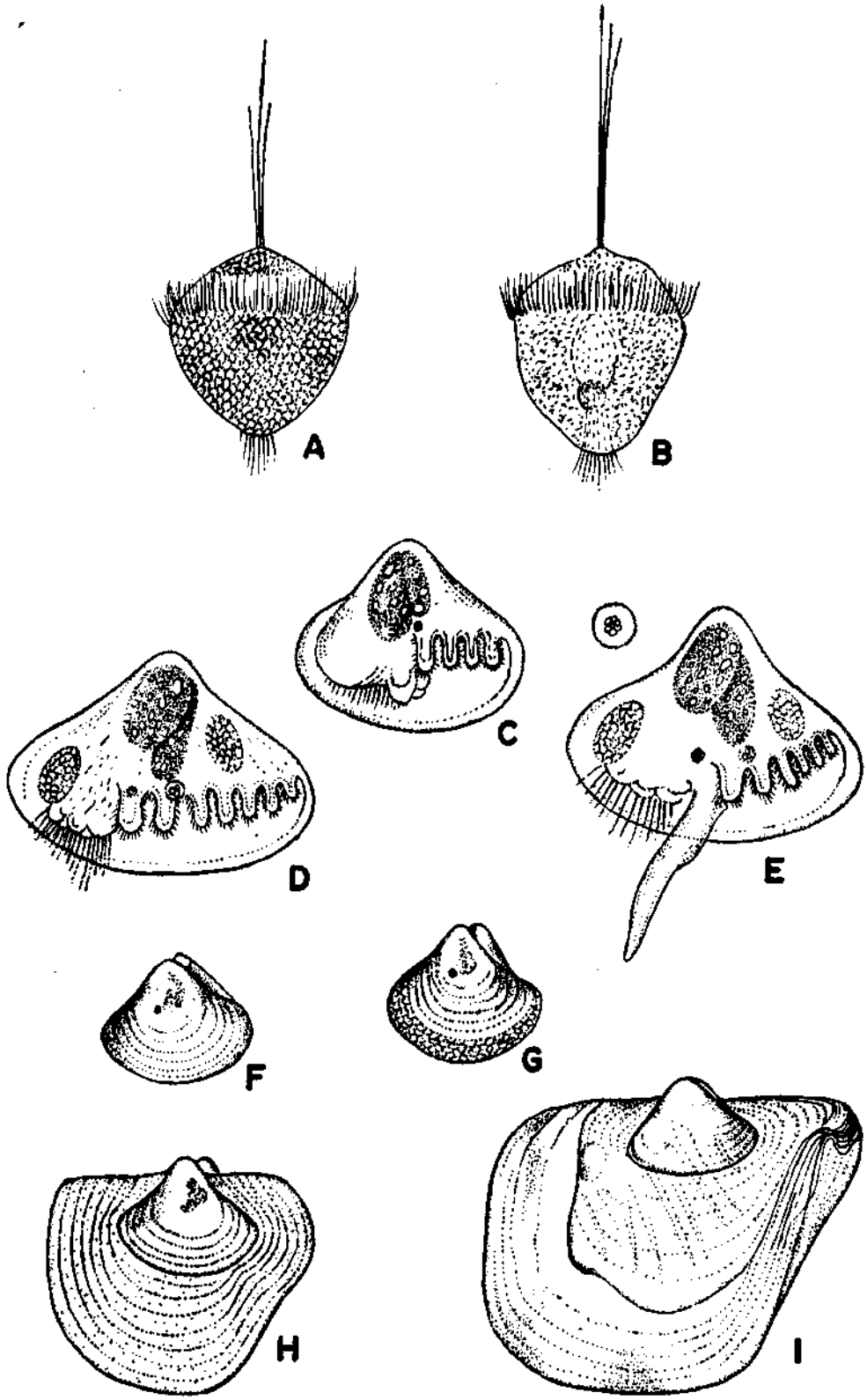
Herdman and Hornell as reported by Herdman (1903) have studied the early development of the pearl oyster. Fertilization is external. The egg when discharged is pyriform or flask-shaped but becomes spherical on fertilization. Segmentation is complete but unequal. The trochophore larva is formed about 20 hours after fertilization, having a pre-equatorial tuft and a patch of circlet of cilia at the opposite pole. The body becomes elongate and the equatorial band moves forwards and becomes a preoral circlet. By the end of the second day the veliger larva is formed with a shell and a velum. A little later the shell grows larger, the umbones are visible, rudiments of branchial filaments and otocysts appear and the anterior and the posterior adductor muscles are prominent. In older larvae the umbones of the shell are larger, the digestive gland is bilobed and there is an increase in the number of branchial filaments. Later the velum is reduced, the foot is prominent and is actively protruded and moved. The byssal gland is formed about the middle of the posterior edge and octocysts lie near the base of the foot. The larva then settles down as spat. In the earliest stage of spat which measures 0·1 mm in diameter the shell shows growth at the margin. At a size of 0·175 mm prismatic shell substance is deposited marginally. There is asymmetrical growth and the umbones are more anterior in position. A byssal sinus and a delicate byssus are devoloped for attachment. Further growth depends on the availability of suitable substratum and other favourable environmental conditions (Fig. 9 A-I).

Spatfall

Hornell (1905, 1916) considered that in the Gulf of Mannar the pearl oyster beds of the Indian coasts are periodically replenished by larvae which are transported by currents from the Ceylon coasts and in the like manner the beds on the Ceylon coasts are repopulated by larvae drifted from the Indian coasts. Hornell (1916) also opined that in addition to the above source the larvae coming from one coast populate adjacent beds along the same coast. Hornell's observations were supported by preliminary experiments with drift bottles which were released in the monsoon period and recovered along the coasts at certain points.

Growth

Observations made on pearl oysters in the pearl oyster farm near Krusadai Island by Devanesan and Chidambaram (1956) and at Tuticorin by Chacko (1954, 1956, 1957) show that the oysters grow to a height of about 36 mm in 6 months, 35-45 mm at the end of one year, 50-55 mm at the end of the second year, 55-60 mm at the end of the third year, 60-65 mm at the end of the fourth year and 65-70 mm


A
B
C
D
E
F
G
H
I

at the end of the fifth year (Table XII). The pearl oysters have been estimated to have a longevity of 5–5½ years on natural beds but have been observed to live

TABLE XII

Growth of *Pinctada fucata* (after Chacko, 1970)

Age of Pearl Oysters (in month)	Length (Height) (mm)	Weight (gm)
< 6	< 36	< 5
6 – 12	35 – 45	5 – 10
12 – 18	45 – 50	10 – 20
18 – 24	50 – 55	20 – 30
24 – 36	55 – 60	30 – 45
36 – 48	60 – 65	45 – 60
48 – 60	65 – 70	60 – 70
60 – 72	70 – 75	70 – 80
> 72	> 75	> 80

upto seven years when reared in a farm. Gokhale *et. al.* (1954) and Narayanan and Michael (1968) have studied the growth and relation between age and linear measurements in the pearl oyster species occurring in the Gulf of Kutch, where its growth rate has been found to be slightly higher (Table XIII).

TABLE XIII

Weighed mean of length (height), breadth (width) and hinge length of *P. fucata* reared in a pearl oyster park in Gulf of Kutch (after Narayanan and Michael, 1968).

Age in Years	Length (Height) in mm	Breadth (Width) in mm	Hinge length in mm
1	44·05	42·14	38·42
2	61·68	58·93	55·45
3	76·20	67·66	62·00
4	81·62	74·32	66·09
5	85·15	77·35	69·37
6	86·65	80·50	72·44
7	86·67	76·70	69·84

Fig. 9. Early developmental stages of *Pinctada fucata*. A and B. Trochophore stages. C, D and E. Different phases of veliger stage. In E enlarged view of otocyst containing granules is shown separately. F, G, H and I. Pearl Oyster spat in progressive stages of growth (after Herdman and Hornell, 1903 and Hornell, 1916)

Narayanan and Michael (*loc. cit.*) observed that the growth rate of the pearl oysters as denoted by increase in length (height), breadth (width) and hinge length is not proportionate to age as growth is retarded after the sixth year. The increase in thickness and hinge width is more or less uniform during growth. It was stated that the thickness and hinge width of the pearl oysters are more dependable than height for determining age.

Parasites

The parasites of *Pinctada fucata* have been studied by Shipley and Hornell (1904) and Hornell (1922a). Roughly spherical cestode larvae are abundant in the tissues of the pearl oysters. Shipley and Hornell (*loc. cit.*) considered these to be the younger stage larvae of the species *Tetrarhynchus unionifactor* found encysted in the intestinal walls of the pearl oysters. Hornell (1922a) has stated that the early larvae recorded earlier may belong to the cestode genus *Tylocephalum* and not to this species. Dead cestode larvae commonly form the nucleus of cyst pearls of Indian and Ceylon pearl oysters Three species of trematodes *Mutta margaritiferae, Musalia herdmani, Aspidogaster margaritifeae* and three species of nematodes *Ascaris meleagrinae, Cheiracanthus uncinatus* and *Oxyuris* sp. have been recorded in *P. fucata* (Shipley and Hornell, *loc. cit.*). Detailed studies should be made of the parasitic species infesting *P. fucata* and their life-histories. The studies are of importance as it is (Hornell *loc. cit.*) believed that the cestode larvae are most important in the production of the larger and finer pearls.

Pests

Sponges, hydroids, polychaetes like *Eunice tubifex*, polynoids and serpulids, nemertines, polyzoans, mussels belonging to the genus *Modiolus* (*M. barbatus*), and crinoid *Antedon* sp., some ophiuroids and ascidians often occur on the surface of the pearl oysters, sometimes in large numbers and constitute serious pests. The presence of the epi-fauna weakens the shell and also prevents the healthy growth of the oysters. Sponges of *Cliona* spp. bore into the shells of the pearl oysters and causeheavy damage. Algae belonging to various genera such as *Padina, Gracilaria, Sargassum* and *Hypnaea* are also usually common on the pearl oyster beds and are not conducive for the healthy growth and survival of the oysters as they are engulfed by the algal masses.

Predators

Some invertebrate animals and fishes feed on the pearl oysters causing large mortalities. Among the invertebrates the starfish *Protoreaster lincki* (Blainville), the octopus *Polypus* sp. and *Murex ramosus* are the well-known predators. Of the fishes the important ones are *Balistes* sp., *Lethrinus* spp., *Serranus* spp., *Tetradon* and different species of sharks and rays. *Rhinoptera javanica* and *Ginglymostoma* are the main predators on adult pearl oysters. Rays

are responsible for large-scale mortality of them. The pearl oyster beds subjected to attacks by rays show large furrows made by these elasmobranchs and heaps of broken shells of oysters devoured by them (Hornell, 1916). Hornell (*loc. cit.*) considered that one of the primary factors resulting in alternating cycles of years with poor and rich pearl oyster populations over the banks is the abudance or scarcity of predators.

PEARL FISHERIES

The pearl oyster resources in the Gulf of Mannar along the Indian coast have been harvested from time immemorial. In the Gulf of Mannar the pearl banks are located between Kanyakumari and Rameswaram at varying depths. They are grouped under three divisions viz. the northern or Kilakarai division which extends from Adam's Bridge to Vaippar, the central or Tuticorin division extending from Vaippar to Manapad and the southern or Kanyakumari division from Manapad to Kanyakumari. The Central division is the most productive one.

Thirty eight pearl fisheries only were conducted in the Gulf of Mannar in the period between 1663 and 1961 (Chacko, 1970). A characteristic feature of these fisheries is their irregular nature, a fishery sometimes being conducted after an interval of a number of decades. This is due to the pearl banks being poor in pearl oysters for a number of years. The gross revenue from pearl fisheries conducted in various years shows marked differences (Table XIV).

TABLE XIV

Revenue from the Pearl Fisheries in the Gulf of Mannar in the period 1900–1961 (after Chacko, 1970).

Year of Fishery	Gross Revenue (Rupees)
1900	19,461
1908	10,218
1914	16,542
1926 February–March	2,25,498
1926 November–December	31,387
1927 February–April	2,54,497
1927–28 November–January	1,95,039
1928 March–April	2,02,575
1955 March–May	1,46,138
1956 February–March	44,795
1957 March–May	1,68,807
1958 March–May	4,74,096
1959 February–May	8,65,130
1660 March–May	2,53,339
1961 March–April	3,18,234

The fluctations in the abundance of pearl oysters on the pearl beds in different years has been attributed to various factors like the presence of predators and pests, differences in hydrological characteristics, occasional silting, availability of breeding pearl oysters in sufficient numbers and successful spatfalls. The pearl banks off Tuticorin are only sparsely populated at present.

The pearl fisheries along the Indian coasts of the Gulf of Mannar are conducted by the Department of Fisheries of the Government of Tamil Nadu. A fishery is announced after a preliminary inspection when sufficiently dense populations of pearl oysters of fishable size are found on the pearl banks. Elaborate arrangements are made for conducting a fishery and a pearl camp is organised by the Govenment with the help and co-operation of divers, owners of boats, their crew and pearl merchants. On each day during the season which lasts for about two to four months, the pearl fishing boats with the divers leave the camp early in the morning hours for the pearl fishing grounds. If the wind is not favourable for the boats to sail they are towed to the fishing grounds by the inspection launches. On reaching the fishing grounds, the divers descend into the waters, being helped by sinking stones. Mahadevan (1971) has described the mode of diving practised by the divers of Tuticorin. Each diver quickly collects as many oysters as possible and comes up with the catch. The divers do skin-diving and hence cannot remain under water for more than 1½ minutes for each dive. The diving operations are continued till about mid-day when they leave the grounds and return to the camp. Each diver gets a third of the catch of the oysters as his wages, but out of this he surrenders a part to the boat owner and the crew. The remaining two thirds of the catch is the Governmental share, which is auctioned late in the evening in lots of thousand oysters each. The merchants who buy the oysters remove them to the special enclosures where they are allowed to rot for sometime so that the tissues become softened, then washed and the pearls are carefully recovered. The divers and the boatmen sell their share of oysters by retail. The fisheries are operated from Tuticorin to harvest oysters from the richly productive central zone of the pearl banks.

A pearl fishery with rather a poor yield was conducted off Tondi in the Palk Bay in 1914, but the area has since then showed only stray oysters on scattered submerged objects on loose muddy sand.

In the Gulf of Kutch the pearl fishery is conducted by the Gujarat Government once in two or three years. The pearl banks known locally as 'khaddas' are located along the southern coast of Jamnagar District (Hornell, 1909 a; Easwaran *et al*, 1969). The divers are paid 25 paise for each oyster they bring. The income from the Gulf of Kutch fishery is small as compared to that of the Gulf of Mannar. The value of pearls fished in the years 1960-61 and 1961-62 has been estimated to be Rs. 6,005. In the year 1966-67 30,000 pearl oysters were fished in the Gulf (Easwaran *et al*, *loc. cit.*)

Pearls and pearl formation

The name pearl has originated according to Zeigler (as quoted by Bolman, 1941) from the Latin root 'pirula' meaning pear, due to natural pearls being often pear-shaped. Any concretion secreted by a mollusc may be called a pearl, though by pearl only the lustrous nacreous gems secreted by the pearl oysters are meant. Pearls are recognised as different types according to their composition. Periostracal pearls consisting of periostracal layers around a central nucleus, are brown in colour and do not have have any lustre (Hornell, 1922a). In porcellianous pearls the concentric layers are porcellanous e.g., those secreted by edible oysters, the sacred chank *Xancus pyrum* and the conch *Strombus gigas*. Hypostracal pearls are minute and found in the place of insertion of pallial and adductor muscles. True gem pearls are composed of concentric layers of iridescent nacre consisting of fine aragonite crystals, embedded in an organic matrix called conchiolin. Nacreous pearls are usually formed in the region between the pallial line and the border of nacreous layer of the shell of the pearl oyster. Several theories have been put forth at various times to explain the mode of formation of pearls. Careful studies have shown that the outer epithelial cells of the mantle of the pearl oyster secrete nacreous matter around foreign particles when they cause irritation to the soft body of the oyster. The foreign matter may be a sand grain, organic or inorganic debris or microscopic structures like cestode larvae. The mantle forms a pouch like epithelial sac around the intruding particle and there is secretion of nacre in concentric layers resulting in course of time in a pearl.

In Bombay markets four varieties of Indian pearls are recognised as reported by Ranganathan (1964) viz., 1. *Jeevan* — in which the pearl is perfectly spherical in shape, has bright lustre and the colour is rosy, pink or pinkish-white 2. *Gholwa* — the pearl is nearly spherical, lustrous with colouration of varying shades, 3. *Ghat* — small, irregular pearls and 4. *Masi* — very small sized ones.

Pearl culture

The Japanese have succeeded in evolving a method of culturing perfectly spherical pearls. There is controversy as to who exactly among the Japanese workers first produced the spherical culture pearl. It appears that credit for the achievement should go to Mise and Nishikawa (Cahn, 1949). Mikimoto improved upon the method and established an industry for manufacture of culture pearls in amazingly large quantities and earned the title of 'Pearl King'.

In the Japanese method a small piece of pearl oyster mantle is grafted carefully along with a spherical shell bead as the nucleus into a pearl oyster in between the lobes of the gonad. The operation is completed within a couple of minutes but it requires dexterity. The beads forming the nuclei are manufactured

from the hard shell of lamellibranchs like *Pleurobema* and *Megalonais* which Japan imports in large quantities from U.S.A. The operated oysters are reared in farms in calm shallow bays and looked after with great care. In the farm the oysters are kept in cages hanging from rafts at a depth of a few feet down from the surface water. The secretion of nacre commences at the end of one or two weeks. Small sized culture pearls are formed in a period of six months and large ones in two to three years. The pearl oysters reared in the farms are cleaned thrice or four times in a year to remove pests like sponges, barnacles, ascidians etc. which settle on them. For successful pearl culture the availability of adequate quantities of pearl oyster spat, careful rearing of them, careful implantation of the nucleus, protection of treated oysters under favourable environmental conditions like optimum ranges of temperature, salinity and light intensity, availability of food organisms, absence of strong currents and absence of pests and predators are essential.

70% of the culture pearls produced in Japan come from the pearl farms in Ago Bay in Mie Prefecture. The total annual production of culture pearls in Japan amounts to 25,000 Kan (1 Kan = 3·75 Kg). A major portion of this (more than 80%) is exported to a number of countries like U.S.A., West Germany, Hong Kong, Switzerland, Australia, India, Spain, France, Canada etc. India imports about 2,400 Kan of pearls annually from Japan (Alagarswami, 1970). Japan which is the foremost producer of culture pearls in the world has also helped other countries like Australia, Philippines and Hong Kong to set up pearl culture industries.

Culture pearls are classified into three kinds nacreous layer pearls, prismatic layer pearls and organic layer pearls (Wada, 1970) based on their composition. The nacreous layer pearls only are valuable as gems. Perfectly spherical and drop-shaped culture pearls are esteemed highly. The pearls exhibit a wide variety in colour and lustre which is due to differences in the pigment contained and superficial and laminar structures of the nacre. In addition to well known pearls of silvery sheen, there are rosy, pink, black, yellow and blue pearls. Environmental conditions like water temperature and light intensity in the farming area have been shown to influence the quality of pearls (Cahn, 1949).

About thirty years ago attempts were made by the Department of Fisheries of the erstwhile Madras State to rear the pearl oysters and induce them to form pearls (Devanesan and Chidambaram 1956, Devanesan and Chacko 1958). The oysters were successfully reared in cages in the vicinity of the Krusadai Island and secretion of nacre around the introduced shell beads was observed but spherical culture pearls were not formed. The techniques of pearl culture are better understood now than ever before. The local species *P. fucata* is very much like the Japanese oyster *P. martensii* and in fact it is doubted whether it is a variety of *P. fucata*. The Indian species has been found to be tolerant to farming conditions

and the prospect of culturing pearls employing this is bright although it may involve some initial trials attended with failure. If culture is taken up at least on a small scale, it would ensure a sustained supply of culture pearls and reduce fishing pressure on the natural beds the yields from which for natural pearls as pointed out are erratic and very irregular.

PEARL OYSTERS OTHER THAN *P. FUCATA* FROM INDIAN WATERS

In addition to *P. fucata* as stated earlier five other species of pearl oysters occur on the Indian coasts. The following is extracted from the senior author's earlier account on the subject (Rao, 1970).

PINCTADA MARGARITIFERA (Linnaeus)

SYNONYMS

Mytilus margaritiferus Linnaeus 1758
Avicula magaritifera Reeve 1857
Pteria (Margaritifera) margaritifera var. *typica* Jameson 1901
Margaritifera margaritifera Hornell 1922a
Pteria margaritifera Gravely 1941
Pinctada margaritifera Prashad 1932, Prashad and Bhaduri 1933, Hynd 1955, Satyamurthy 1956, Rao 1970

COMMON NAME

English - *Black lip.*

DESCRIPTION

The hinge is devoid of teeth and much shorter than the width of shell. Anterior border of the body of shell extends far in advance of the anterior ear lobe. Byssal notch is broad. Anterior ear is well developed, posterior ear and posterior sinus are absent. Posterior end meets the hinge almost at right angles. Shell valves are moderately convex. The general colouration externally is dark grayish brown with a greenish tinge and with radially distributed white spots. These spots represent the basal portions of the successive growth processes. The nacreous layer is iridescent with a silvery sheen for the most part except distally where it is sooty black in colour. The non-nacreous border is very dark, sometimes with faint markings. Due to the dark marginal colouration this species is called 'Black lip'. The width of the nacreous region at the hinge about two-thirds of of the same in the broadest region of the valve (Fig. 10 A-D).

Jameson (1901) has distinguished several varieties under this species viz., *P. magaritifera* var. *typica* presumbly from Malay Archipelago, var. *zanzibarensis* from the east coast of Africa, var. *persica* from the Persian Gulf, var. *erythraensis*

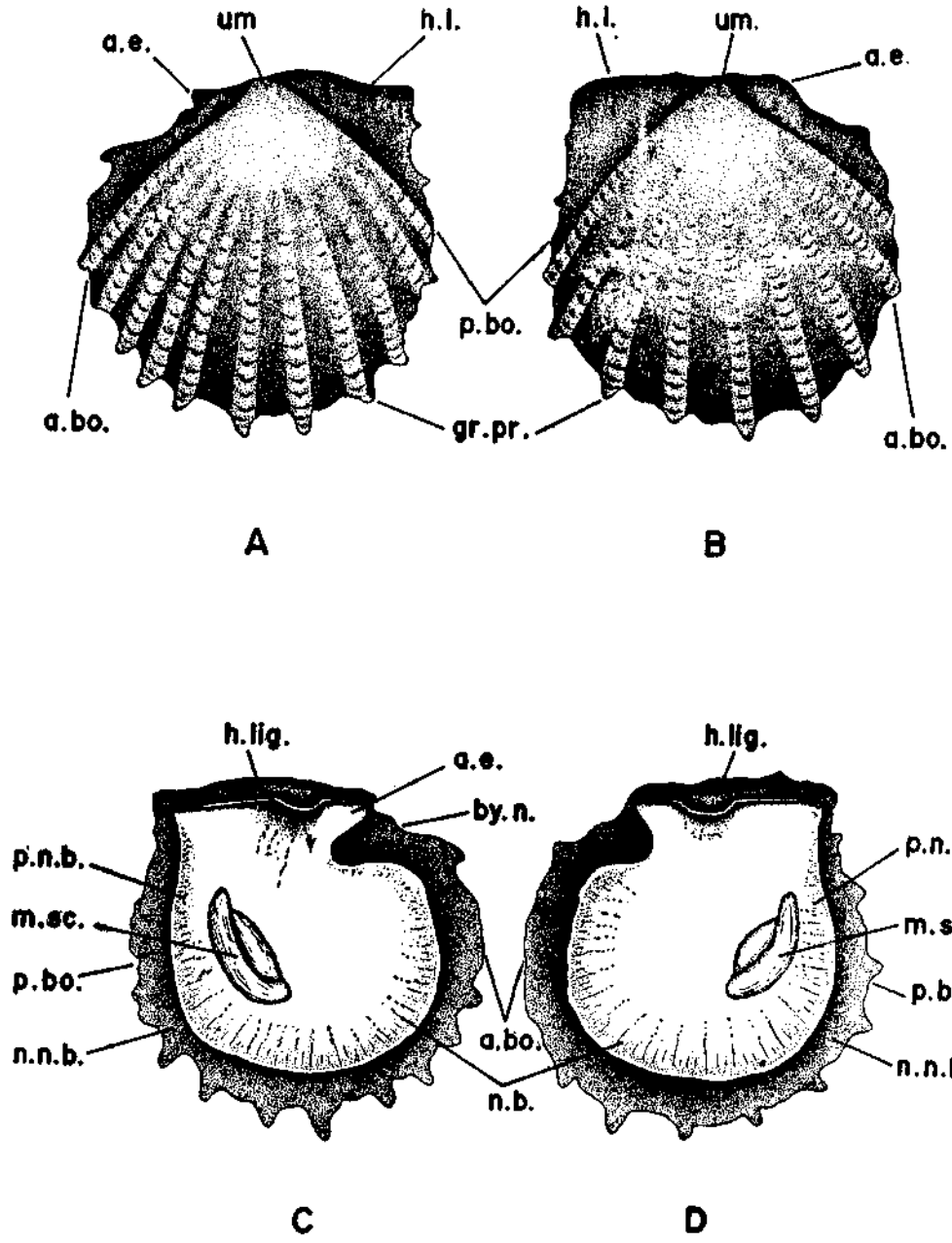


Fig. 10. *Pinctada margaritifera* (Linnaeus). A. Left valve outer surface. B. Right valve outer surface, C. Left valve inner view. D. Right valve inner view (after Rao, 1970) Lettering as in Fig. 8.

from the Red Sea, var. *cumingi* from the Eastern Polynesia and var. *mazatlanica* off Panama (Mazatlan etc.). These varieties are well known in commerce as Zanzibar shell, Panama shell etc. But some of these so called varieties so closely resemble the var. *typica* except in size and colouration that the distinction into varieties has been pointed out to be doubtful (Prashad and Bhaduri *loc. cit.*).

DISTRIBUTION

It is widely distributed throughout the Indo-Pacific region.

This species is sparse on the Indian coasts. It yields good quality pearls and is utilized in Japan and Australia in pearl culture. It supports important mother-of-pearl fisheries in the Persian Gulf, Red Sea, south-western part of the Indian ocean and the Pacific Ocean.

REPRODUCTION

The structure and development of gonads and reproductive cycles of this pearl oyster have been studied by Tranter (1958d) in the Torres Strait area Australia. Both protandry and protogyny were observed. Gametogenesis takes place in September and the gonads thereafter ripen and this is followed by limited spawning between October and December and intensive spawning in early January. The gonads are in the recovering phase in February and exhibit active gametogenesis and ripening in March. There is again restricted spawning in the period April – June, heavy spawning in July and the gonads are either in shrunken or recovering phase in August. This species has two spawning seasons in a year with some breeding activity in the intervening months. The breeding periodicity of this species occurring in the Indian waters is little known.

PINCTADA CHEMNITZII (Philippi)

SYNONYMS

Concha magaritifera laevis Chemnitz 1785
Avicula atlantica var. *B.* Lamarck 1819
Avicula chemnitzii Philippi 1849
Avicula pretexta; *A. tegulata* Reeve 1857
Avicula (Meleagrina) chemnitzii Dunker 1872
Pteria (Margaritifera) pretexta; P. (M) chemnitzii;
P. (M.) tegulata: Jameson 1901
Pteria chemnitzii Gravely 1941
Pinctada chemnitzii Prashad and Bhaduri 1933, Hynd 1955
Pinctada chemnitzii Rao 1970

The first authentic description of this species under the name *Avicula chemnitzii* was by Philippi (1849) from the China Sea. Reeve's *A. tegulata* of

Moreton Bay is identical with this species, but the name *tegulata* of Reeve being preoccupied by *tegulata* of Goldfuss (1836), Iredale (1939) as cited by Hynd (*loc. cit.*) has named it *P. epitheca*. The Philippine shell, *Avicula pretexta* of Reeve (1857) is also synonymous with this species. Prashad and Bhaduri (1933) recorded it for the first time from the Indian coasts.

DESCRIPTION

The shell is very similar to that of *P. fucata* except that the posterior ear is better developed and the convexity of the valves is much less. The anterior ear is well developed and the byssal notch is slit-like The hinge line is almost as long as the longest antero-posterior measurement of the valves. Both the anterior and posterior hinge teeth are present, the former small and rounded and the latter large and well developed like a ridge starting a little in advance of the posterior region of the hinge ligament. Correlated with the greater development of the posterior ear, the posterior sinus is very conspicuous.

The valves are externally reddish-brown with about four or more whitish or cream yellow radial markings from the umbo to the margin of the shell and the growth processes are rather broad. The nacreous lining is bright and lustrous and is developed to a far greater extent in the left valve than in the right valve and in the latter this border meets the hinge line obliquely outwards. The non-nacreous border is brownish without any conspicuous blotches of the kind met with in *P. fucata* (Fig. 11 A-D).

The pearl oysters are known to grow to about 10 cm in dorso-ventral axis.

DISTRIBUTION

On the Indian coasts it occurs in Tranquebar, Madras Harbour, Tuticorin pearl beds in Gulf of Mannar, in Palk Bay and off Balassore coast (Orissa). Outside India it has been recorded in Ceylon, Aden, Mergui Archipelago, Penang, Indonesian group of Islands, Australia, Hong Kong, Philippines, China Sea and Japan.

PINCTADA SUGILLATA (Reeve)

SYNONYMS

Avicula fimbriata; A. sugillata; A. irradians; A. chamoides Reeve 1857
Pteria (*Margaritifera*) *sugillata* Jameson 1901
Meleagrina sugillata Hedley 1910
Pinctada albina sugillata Hynd 1955
Pinctada sugillata Hedley 1916, Prashad 1932, Rao 1970

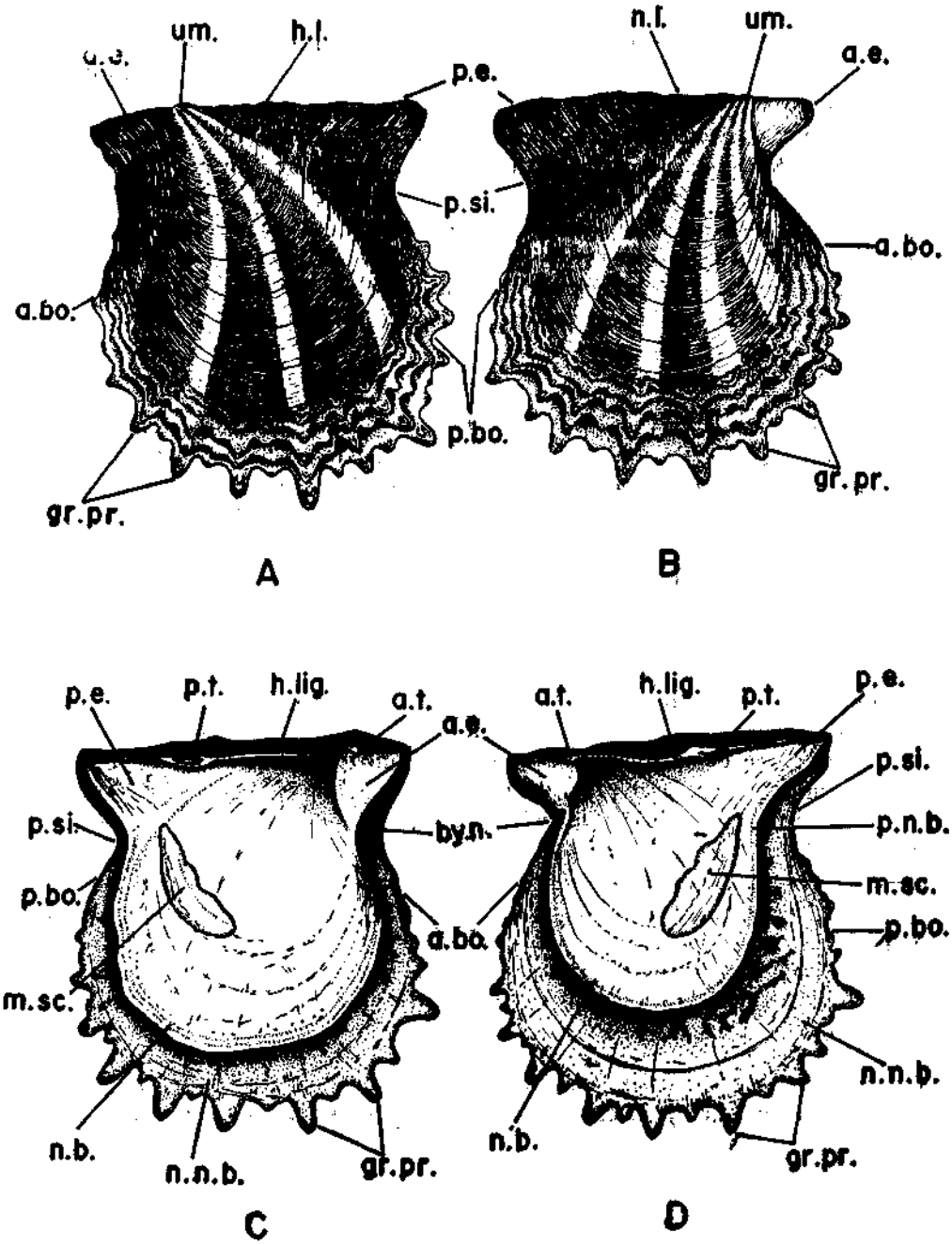


Fig. 11. *Pinctada chemnitzii* (Philippi). A. Left valve outer surface. B. Right valve outer surface. C. Left valve inner view. D. Right valve inner view (after Rao, 1970). Lettering as in Fig. 8.

Jameson (1901) considered *Avicula fimbriata*, *A. sugillata* and *A. irradians* of Reeve (1857) to be synonymous. The species *fimbriata* has page priority but is preoccupied by *A. fimbriata* of Dunker (1852) which is recognized as a valid and distinctly separate species by Jameson (1901) and Hynd (1955). *A. chamoides* of Reeve (1857) has been stated to be only a young specimen of *A. sugillata* (Hynd, *loc. cit.*). Prashad (1932) considered *Meleagrina albina* of Lamarck (1819) to be synonymous with *Pinctada vulgaris* of Schumacher, but Hynd recognized it as a valid species synonymous with *P.* (*M.*) *carcharium* a name given by Jameson (*loc. cit.*) to the Shark Bay shell. Hynd considers two varieties under *Pinctada albina* viz., *sugillata* (Reeve) and *carcharium* (Jameson).

DESCRIPTION

The hinge is very much shorter than the widest antero-posterior axis of shell, they being in the ratio of 1:1·3. The antero-posterior measurement is almost equal to the dorso-ventral measurement. The anterior ear in both valves is small and the byssal notch is a moderately wide slit. The anterior ears are slightly bent towards the right so that the hinge line when viewed from the top, is seen to be deflected anteriorly to the right side. This character recorded by Hynd (1955) in Australian shell is prominent in the Indian shell. The posterior border of the shell shows a small, not well-defined sinus which is correlated with the very poor development of the posterior ear. The convexity of the valves is not marked, particularly that of the right valve which is only moderately convex. The hinge teeth are present but inconspicuous in the adult specimens examined, the anterior one being roundish and small and the posterior one seen as a streak. The colouration of the valves for the most part from the hinge and extending over the body of the shell is dark gray with a tinge of brown. The lower and posterior regions of the valves are light yellow and gray. There are about six yellowish radial markings starting from the umbo and extending towards the margin. The nacreous region on the inner surface of both the valves is well developed. Posteriorly the nacreous border as it meets the hinge line presents a wavy course. Hynd has stated that the nacreous region is bounded by a narrow black band on the non-nacreous border, but this was noticed only in one of the two specimens examined (Fig. 12 A-D).

A well-shaped shell from the pearl oyster beds of Tuticorin measured 5·5 cm in hinge length, 7·1 cm in widest antero-posterior axis and 7·2 cm in the dorso-ventral axis.

DISTRIBUTION

This species occurs in Australia, Indonesian group of Islands, India and Celebes. The species has been recorded in India at Tuticorin and Madras harbour.

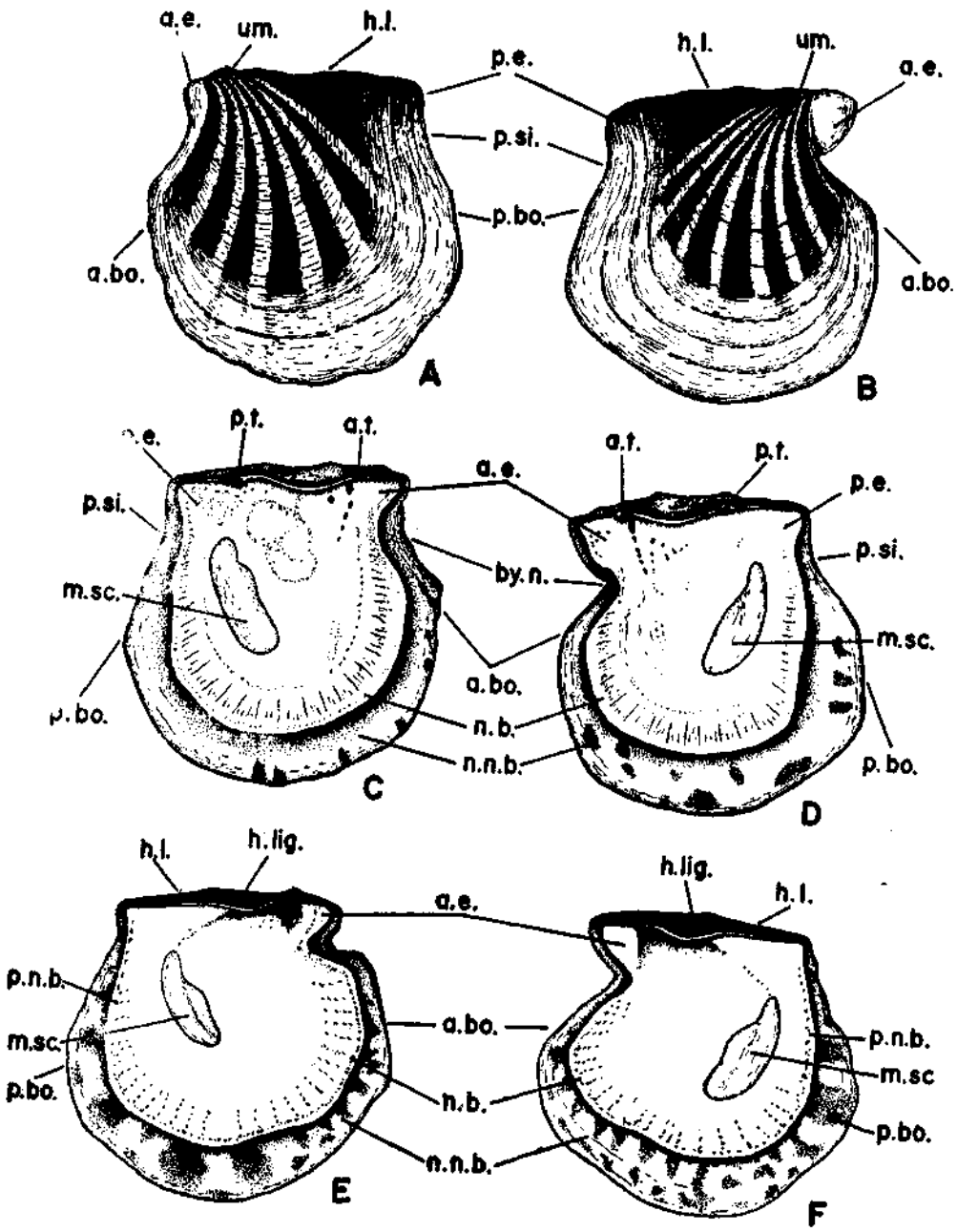


Fig. 12. *Pinctada sugillata* (Reeve). A. Left valve outer surface. B. Right valve outer surface. C. Left valve inner view. D. Right valve inner view. *Pinctada anomioides* (Reeve). E and F. Left and right valves inner view (after Rao, 1970). Lettering as in Fig. 8.

REPRODUCTION

Tranter (1958 a, b, c) has studied the structure of the primary gonad and adult gonad and reproductive cycles in Australia. The primary gonad consists of a paired system of confluent tubules (follicles) opening to the exterior by laterally situated urino-genital openings. The primary gonad does not have morphologically differentiated gonoducts. The adult gonad is of cream colour in the male and yellow in female and covers the stomach, associated digestive diverticula and gut loop, Sexual maturity is attained within six months. There is a major spawning period in the autumn. Spawning is frequently partial and there is phagocytosis of unspawned germ cells.

PINCTADA ANOMIOIDES (Reeve)

SYNONYMS

Avicula anomioides Reeve 1857
Avicula (*Meleagrina*) *anomioides* Dunker 1872
Pteria (*Margaritifera*) *anomioides* Jameson 1901
Pinctada anomioides Prashad 1932, Prashad and Bhaduri 1933, Rao 1970

DESCRIPTION

The hinge line is shorter than the width of the broadest region in the antero-posterior axis, they being in the ratio of 1:1·2–1·5. The hinge line and the dorso-ventral axis are in the ratio of 1:1·4. Hinge teeth are absent or faintly visible. The antero-posterior axis of the body of the shell extends to some distance in front of the vertical line to the external border of the anterior ear. The anterior ear is very moderately developed and presents a deep byssal notch at its base. The posterior ear and the posterior sinus are absent. Externally the valves are yellowish with a light tinge of gray. Faint radial markings are present. The valves are translucent. The nacreous region is well developed and its posterior border meets the hinge at right angles (Fig. 12 E-F).

DISTRIBUTION

In India it is recorded from Bombay, Madras, Mandapam (Palk Bay), Tuticorin and Andaman Islands. Outside India it has been recorded off Aden, Ceylon, Mergui Archipelago and the Indonesian group and the nearby Islands.

PINCTADA ATROPURPUREA (Dunker)

SYNONYMS

Avicula (*Meleagrina*) *atropurpurea* Dunker 1852, Dunker 1872
Pteria (*Margaritifera*) *atropurpurea* Jameson 1901
Pinctada atropurpurea Prashad and Bhaduri 1933, Rao 1970

DESCRIPTION

The shell is roundish with a narrow hinge. The valves are thin, translucent, copper coloured and moderately convex. The byssal notch is deep. The nacreous layer is thin and extends to a greater portion of each valve. The posterior nacreous border meets the hinge line at an acute angle. A trace of an anterior hinge tooth may be present in some shells. Prashad and Bhaduri (1933) state that this species is closely allied to *P. anomioides* but distinguishable from the latter by its copper red colouration, thinner and more translucent valves and the posterior nacreous border meeting the hinge line at an acute angle.

DISTRIBUTION

On the Indian coasts it is known from the Madras harbour and Andaman Islands. Outside India it has been recorded from Ceylon, Mergui Archipelago and the Philippine Islands.

A specimen obtained from the Madras harbour measured 3·7 cm in hinge line, 4·2 cm in the broadest region of the shell in the antero-posterior axis, 4·5 cm in the dorso-ventral axis and 1·9 cm in thickness.