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THE BLACK-LIP PEARL OYSTER RESOURCE AND PEARL CULTURE POTENTIAL

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INTRODUCTION

The survey of the Andaman and Nicobar Islands had, as one of its objectives, an investigation on the potential of the region for pearl culture. The Indo-Australian Archipelago is an important region in the world distribution of pearl oysters. The Mergui Archipelago, which is on the eastern bounds of the Andaman Sea is the area of Burmese pearl culture with the most valued species *Pinctada maxima* (Jameson). Although pearl oysters have been recorded from the Andamans (Prashad and Bhaduri, 1933 ; Rao, 1970) there is no information on their distribution and abundance as an exploitable resource. On the mainland of India the major pearl oyster resource is *Pinctada fucata* (Gould) and technology for pearl culture in this species has been developed earlier (Alagarswami, 1974 ; Alagarswami and Qasim, 1973). Ideal sites for pearl culture, as found in Japan (Alagarswami, 1970) or Australia (Hancock, 1973), are rare along the mainland coast. The marine ecosystem of the Andaman and Nicobar Islands with numerous bays has been considered potential grounds for pearl culture. The survey carried out during January-April 1978 provided some information on the pearl oyster resources and their ecological conditions and helped in a preliminary appraisal of the islands' pearl culture potential.

Dr. K. Alagaraja and Shri M. Srinath helped in deriving the equations for the relationships of shell dimensions and weights presented in the paper.

MATERIAL AND METHODS

The survey was carried out by examining the intertidal beds trekking on foot and by skin-diving and SCUBA-diving, generally up to a depth of 10 m. No diving was undertaken in deeper waters due to lack of knowledge of the environment, swift currents, sudden increase in depth profile close to reefs and shark infestation of the areas. Being a rapid preliminary survey, beset with problems of transport between and within islands, very few areas, mostly on the eastern front of the islands, could be covered. Pearl oysters collected were preserved in 5% formalin. On completion of survey, the materials were transported to the Tuticorin Research Centre of the Institute. Measurements, total weight and shell weight of the preserved material were taken and the gonads were examined for sex of the animal and stage of maturity.

OBSERVATIONS

Species resource

The main species of pearl oyster collected at several centres during the survey was the black-lip *Pinctada margaritifera* (Linnaeus) (Pl. I). This species is rare along the mainland coast of India. The background colour of *P. margaritifera* shells in the collections is dark green, bronze, brown or black. The shells show variation in form and outline as reported by Prashad and Bhaduri (1933) (Pl. II A, B, C). *P. fucata* (Gould) which is the commercial pearl oyster of India, known for the production of orient pearls, was represented only by two specimens in the collection, coming from Camorta in the Nicobar group. The 'flat' oysters, represented by *P. sugillata* (Reeve) (Pl. II, E) and *P. anomioides* (Reeve), were dominant in Hut Bay in Little Andaman, and one or two specimens came from Smith Is., Neill Is., Havelock Is. and Camorta. The wing shell *Pteria penguin* (Röding) was collected from Mayabunder, Havelock Is. and Camorta. *Pinctada maxima* (Jameson) was not available in the areas and depth zones surveyed.

Ecology of pearl oyster beds

Pinctada margaritifera generally occupies the intertidal reef flat and was observed up to a depth of about 10 m. The reef flat is coralline and is interspersed with

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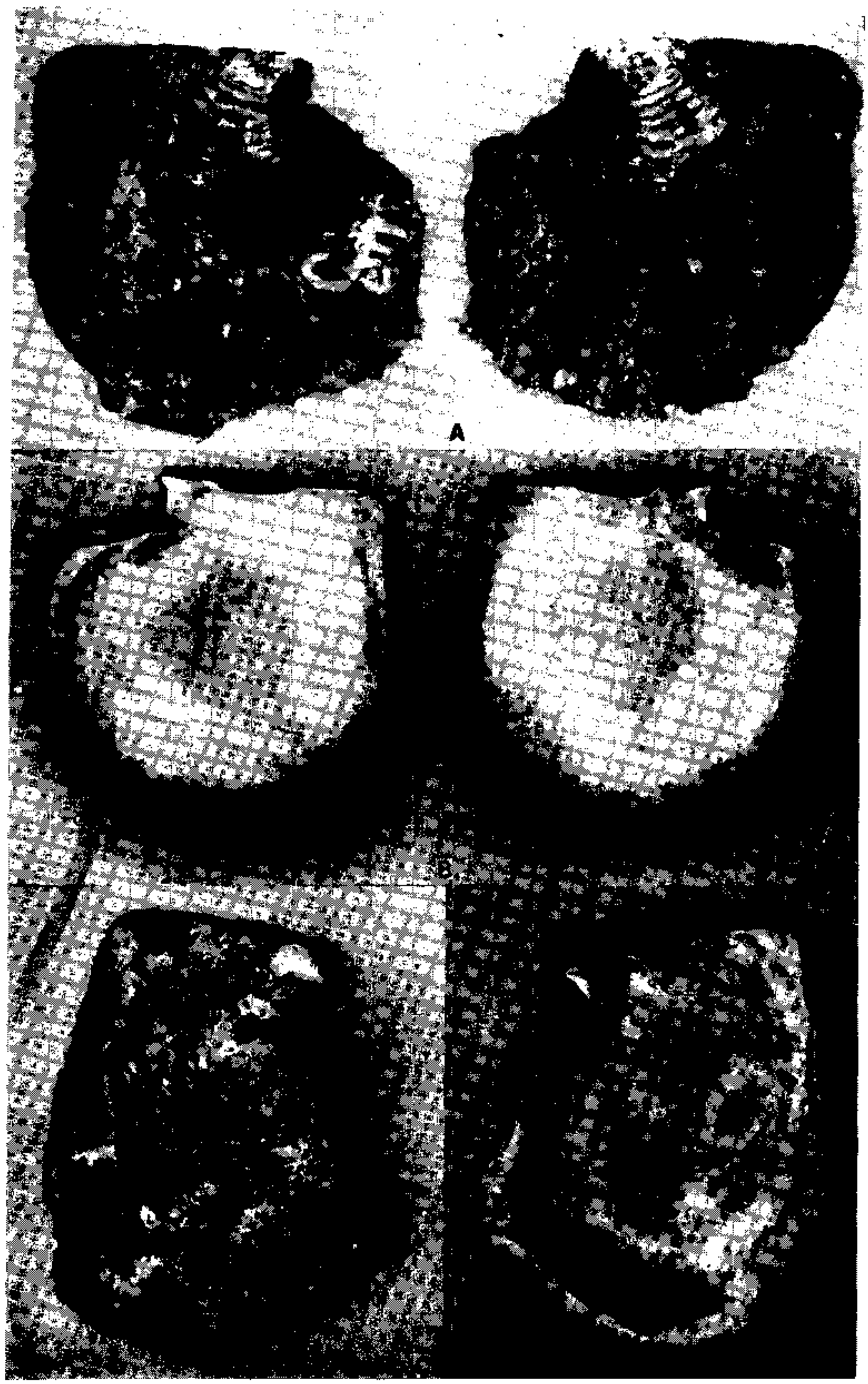


PLATE I. A to D. *Pinctada margaritifera* : A—External characteristics of shell. DVM 70 mm, Hut Bay ; B—Internal features of shell, DVM 90 mm, Neill Island ; C and D—External and internal features of a distorted shell taken from a crevice of boulder, DVM 103 mm, Ross Island off Port Blair.

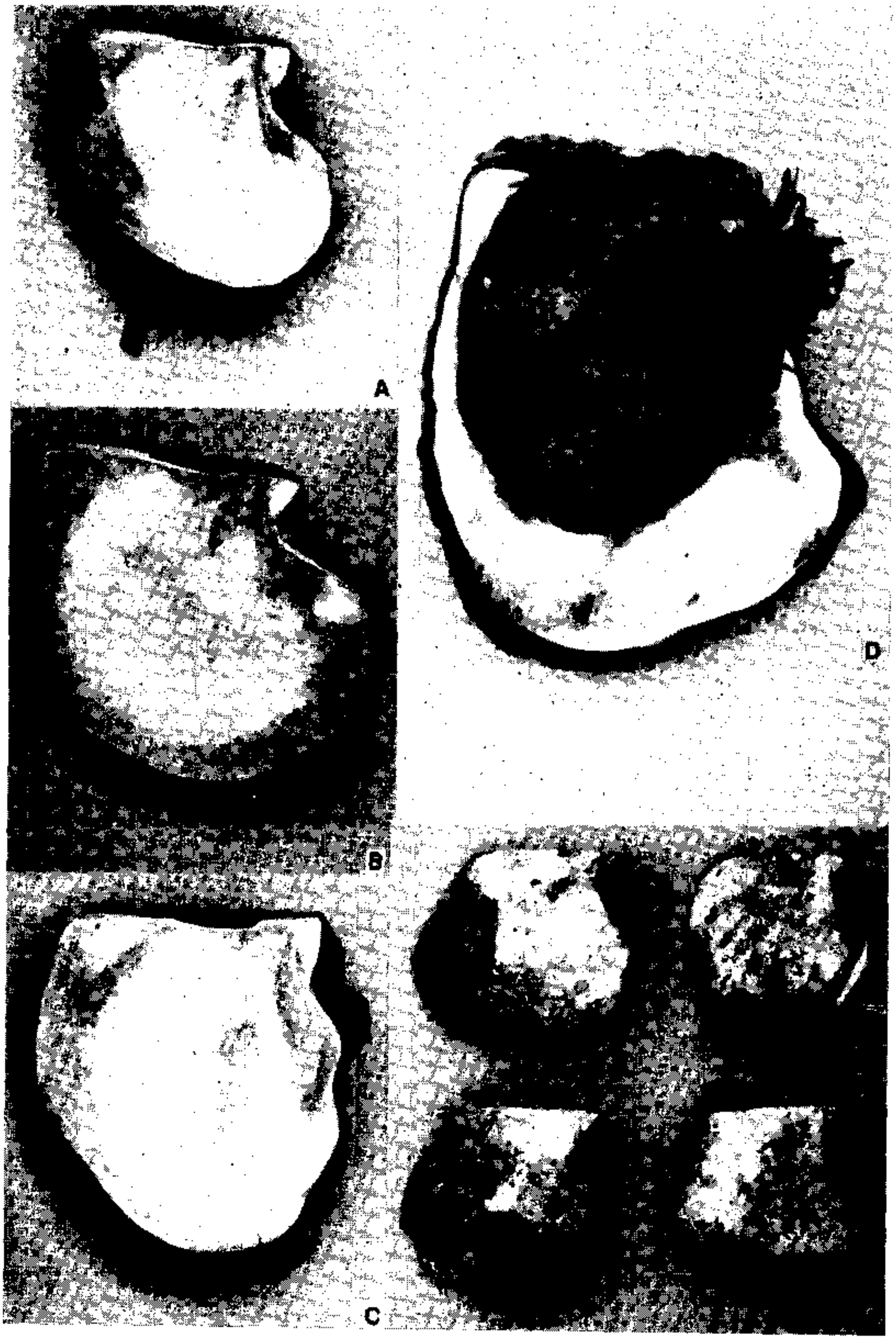


PLATE II. A to D. *Pinctada margaritifera* : A to C—Variations in nacreous border of shells DVM respectively of 45 mm, 70 mm and 69 mm ; D—Rich byssal threads and soft parts of animal ; E—*Pinctada sugillata* from Hut Bay, Little Andaman.

hard sandy bottom, covered with algal growth. Pearl oysters are found attached with strong byssal threads (Pl. II D) to live or dead corals, block corals and large boulders. While they are commonly found on the exposed sides of corals, rocks etc., are occasionally seen in crevices and such shells have slightly distorted shape (Pl. I, C, D). They are also found on the pillars of piers and jetties as in Mayabunder, Havelock Is. and Camorta.

Some of the organisms commonly found on the beds where pearl oysters have been collected are *Tridacna* spp., *Crassostrea* spp., *Trochus niloticus*, holothurians, brittlestars and ascidians. *P. margaritifera* appears to follow closely the distribution of *Tridacna* species in the islands. On the piers, the associated organisms are *Crassostrea* spp. and *Pteria penguin* as found in Mayabunder and Havelock Is.

While the pearl oysters on the reef flat are invariably covered with a thin sand encrustation, those on the pillars are relatively clean. Biofouling is light and the organisms generally noticed on the shells are algae, hydrozoans, ascidians, sponges, tubicolous polychaetes, young corals, bryozoans, oyster spat and small barnacles. Boring by sponge was occasionally noticed and on one shell, *Lithophaga* sp. was present. Going by the very little damage caused to the shells by the fouling and boring organisms, these do not appear to be of any consequence. Evidence of predation was not available, except on a few specimens from Chiriyatapu whose shell margins appeared to have been crushed by fishes.

Pearl oyster population

Among the areas visited from Diglipur base (North Andaman), *P. margaritifera* was collected only from Smith Is. The extreme south-western coast of the island had an approximate population density of 0.25 oyster/m^2. The 16 oysters examined were in the size range (dorsoventral measurement, DVM) 34.0-92.3 mm and weight range 7.0-152.5 g.

In Mayabunder, the northernmost part of the Middle Andaman, *P. margaritifera* was collected on the reef flat from Takla Oyster Point to old jetty and also in the new jetty area. In the latter place the density on the pillars was *ca.* 10 oysters/m^2, between the high water and low water marks. *Pteria penguin* and *Crassostrea* spp. formed an assemblage with the pearl oyster. The density of *P. penguin* was *ca.* 3/m^2. A total of 13 pearl oysters examined was in the size range 43.5-106.0 mm and weight range 13.0-184.0 g.

In Long Is., surveyed from Rangat base, only one pearl oyster and two shells were collected in the reef flat north of Lalaji Bay, which lies on the eastern side of the island. Oysters were very scarce.

The Ritchie's Archipelago was surveyed from a base in Neill Is. On the southern coast of Outram Is. one pearl oyster was collected. On the south-eastern coast of Inglis Is. the density was 0.2 oyster/m^2. Similar was the observation on the south-eastern extremity of Sir William Peel Is. Havelock Is. proved to be a better area for *P. margaritifera*, particularly a virtually *Tridacna* bed lying on the north-eastern coast of the island, south of jetty. All the pillars of the jetty showed the presence of *P. margaritifera*, along with edible oysters and *Pteria penguin*. The rock oyster *Saccostrea cucullata* was the most dominant in this community. The 14 black-lip oysters examined were in the size range 45.4-91.2 mm and weight range 14.0-93.0 g. Three flat oysters were also observed in the collection. On the eastern side of the jetty in Neill Is., the density of black-lip oyster on the reef exposed during the neap tide was 1 oyster/m^2. The 14 specimens examined were in the size range 39.7-92.3 mm and weight range 10.0-125.0 g.

In the survey programme, areas around Port Blair received a wider coverage than all other centres. On the eastern bounds of North Bay, pearl oysters were collected in the area north of the jetty. It was a good *Tridacna* bed, but the pearl oyster population was poor. The Blair reef was a bed of large edible oysters and here was a moderate population of *P. margaritifera* on the exposed reef flat. In the Phoenix Bay, the shoreline was muddy but pearl oysters were found at 7-8 m depth. Between Atalanta Point and South Point, *P. margaritifera* was collected from Aberdeen jetty and Sesostris Bay. The reef on the western side of Ross Island had a pearl oyster population of 1-2/m^2 at 5-8 m depth. A sample of 23 specimens examined from the Port Blair collections was in the size range 38.2-109.5 mm and weight range 11.0-191.0 g.

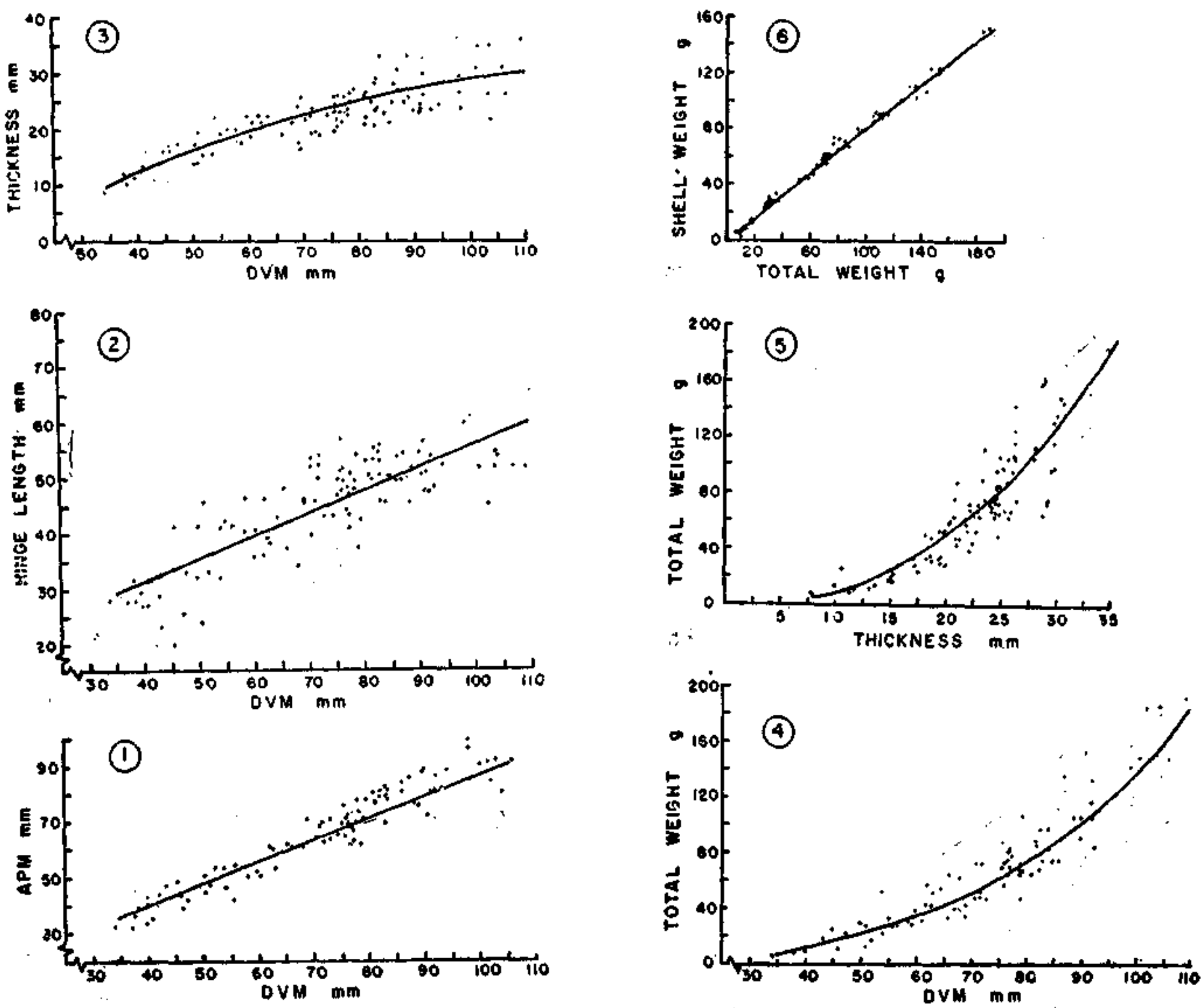
Pearl oysters were collected from the reef flat at Chiriyatapu and along the north-eastern shore of Rutland Is., the two areas being separated by the Macpherson strait. The oysters collected from this area were above 110 mm DVM.

The Hut Bay, on the east coast of Little Andaman, had a population of *P. margaritifera*, along with *P. sugillata* and *P. anomioides* which were predominant, on the western side of the jetty (South Point). The oysters were collected from the reef at a depth of 2 m. By far the highest density of pearl oyster population was noticed here. The long breakwater makes the area a sheltered place. The 10 specimens of *P. margaritifera* sampled had a size range of 50.2-104.2 mm and weight range of 42.0-149.0 g. The 65 flat oysters had a size range of 21.0-56.2 mm and weight range of 1.5-23.0 g.

The last pearl oyster collection of the survey came from Camorta in the Nicobar group. *P. margaritifera*

Notes on biology of P. margaritifera

Size composition : A total of 106 numbers of *P. margaritifera* sampled from different centres had an overall DVM range of 34.0-109.5 mm. The modal size group was at 70-80 mm. The weight range was 7.0-191.0 g and the modal weight group was at 60-80 g.



Figs. 1-6. *Pinctada margaritifera* : Dimensional relationships among shell characters and weights. (1) Anteroposterior measurement (APM) and dorsoventral measurement (DVM) ; (2) Hinge length and DVM ; (3) Shell thickness (exterior width of animal) and DVM ; (4) Total weight (formalin preserved oysters) and DVM ; (5) Total weight and shell thickness ; (6) Shell weight (both valves) and total weight. Regression equations of relationships are given in the text.

was found at the top 1-5 m column of the pillars of the jetty and as many as 15 oysters could be collected from each pillar. Two specimens of *P. fucata* and two of flat oysters were collected from this area. The 17 black-lip oysters sampled had a size range of 42.3-103.4 mm and weight range of 41.0-115.0 g. The two *P. fucata* measured 49.5 mm and 59.7 mm DVM.

Dimensional relationships : The availability of oysters of a wide size range made it possible to work out the relationships of shell dimensions and weights.

Fig. 1 represents the relationship of antero-posterior measurement (APM), which is the greatest distance between the anterior and posterior margins of the animal, to the dorso-ventral measurement (DVM) which is the distance between the hinge line and ventral margin. This relationship is expressed by the equation

$$Y = 9.6393 + 0.7685\,X \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

with $r = 0.9257$, where Y = APM and X = DVM in mm.

Fig. 2 describes the relationship between hinge length and DVM and the equation is

$$Y = 14.8224 + 0.4041\,X \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

with $r = 0.7921$, where Y = hinge length and X = DVM in mm.

Fig. 3 shows the relationship of thickness, the distance between the two valves measured externally, to DVM. This relationship was found best described by the asymptotic regression of the form $Y = a + b.c^x$, where Y = thickness (mm), X = DVM (mm), a = asymptotic value of Y, and b and c are constants. The fitted model is

$$Y = 41.331 - (50.8862)\ (0.9864)^x \quad \ldots\ldots\ldots \quad (3)$$

with $r = 0.8698$. The dimension of thickness tends to approach an asymptotic value after reaching a certain size.

Fig. 4 depicts the DVM-total weight relationship and the equation is

$$Y = 0.0006\,X^{2.6753} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where Y = total weight (g) and X = DVM (mm). The logarithmic transformation of this equation is

$$\log_e Y = -\ 7.3626 + 2.6753 \log_e X \quad \ldots\ldots\ldots \quad (5)$$

which has $r = 0.9610$.

Fig. 5 gives the relationship of total weight on thickness and the equation is

$$Y = 0.0306\,X^{2.4589} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

The logarithmic transformation of this equation is

$$\log_e Y = -3.4858 + 2.4589 \log_e X \quad \ldots\ldots\ldots \quad (7)$$

with $r = 0.9427$. The lower r value, as compared to equation (5), is attributable to the wider spread of the weights after a certain value of thickness which is due to the asymptotic nature of growth of thickness as explained in equation (3).

Fig. 6 illustrates the total weight-shell weight relationship which is of the form $Y = a + b\,X$, and the equation is

$$Y = -0.3841 + 0.8216\,X \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

where Y=shell weight and X = total weight (animal formalin preserved) with a very high correlation co-efficient $r = 0.9995$.

Food organisms : The stomach of preserved specimens was cut open and the inclusions were identified. The items included bivalve eggs (few), appendages of copepods and phytoplankters such as *Tetraselmis* (abundant), *Navicula, Nitzschia, Oscillatoria, Fragilaria, Chaetoceros, Euglena, Amphora* and *Diploneis.*

Sex composition and stages of maturity : Of the 85 pearl oysters examined for sex composition, 16 were indeterminate. Among others, 56.5% were males and 43.5% females. They were in the following reproductive phases :

Stage of gonad		*Males %*	*Females %*
Developing	..	46.2	43.3
Mature/ripe	..	51.2	50.0
Spent	..	2.6	6.7

From these data, it may be presumed that peak spawning might take place around June with the onset of the south-west monsoon.

The biological data presented here are sketchy and have severe limitations, but appear to be the only information available for the black-lip oyster in the area so far.

Discussion

The present survey has brought out *Pinctada margaritifera* as a resource of some importance in the Andaman and Nicobar Islands. This species is widely distributed in the Indo-Pacific region. Several varieties of this species such as *persica, erythraensis, zanzibarensis, cumingi* and *mazatlantica* are known from different parts of the world. Prashad (1932) referred all the Siboga collections of *P. magaritifera* to Jameson's var. *typica.* Prashad and Bhaduri (1933) noted that some of the black-lip shells from Andaman and Nicobar Islands resembled var. *zanzibarensis* but opined that these shells, as also others from a number of localities in the Indian Ocean present in the collections of the Indian Museum, must be referred to Jameson's (1901) var. *typica.*

The preliminary investigation has failed to throw any light on the occurrence of the gold-lip or silver-lip pearl oyster *Pinctada maxima* in the Andaman and Nicobar Islands. The Indo-Australian Archipelago is an important region for pearl culture, next to Japan, and the countries and species of pearl culture are represented in Fig. 7. It can be seen that *P. maxima* is a common factor of pearl culture in this belt. The pearl culture farms of Burma are located in Owen Is. and Sir Malcolm Is. in Mergui Archipelago which is on the eastern boundary of Andaman Sea. These centres are roughly opposite to Little Andaman of India. The farms of Thailand are located at Phuket, approximately opposite to Nancowry Is. of the Nicobar group. The juxtaposition of *P. maxima* production centres of Burma and Thailand to the Andaman and Nicobar Islands, across the Andaman Sea, would indicate the possibility of occurrence of this species in the latter region. Hynd (1955) mentions that, in Australia, this species has been taken from low tide level down to about 40 fm (73 m) but the bulk of the commercial catch comes from waters of 5-30 fm (9-55 m). The present survey was restricted up to 10 m depth and area coverage was also limited. Therefore, presence of this species, if available, has gone undetected.

The wing shell *Pteria penguin*, also called black-winged pearl oyster, has been collected from Mayabunder, Havelock Is. and Camorta. Wada (1973) states that this species is used for producing brilliant, pinkish half-pearls in the Fiji Islands and Borneo. Saraya (1982) mentions that this species is cultured in Thailand for pearls. Young and Serna (1982) indicate *Pteria* sp. among the commercially important bivalves and, according to Blanco (1972), *Pinctada maxima*, *P. margaritifera* and *Pteria macroptera* are the main species used in pearl culture in the Philippines. It is suggested that *P. penguin* may form a candidate species for pearl culture in the Andaman and Nicobar Islands.

Pinctada fucata, although recorded, is rare in the islands. This species does not contribute to pearl culture in the Indo-Australian Archipelago. However, Unar *et al.* (1982) mention that *P. vulgaris* (= *P. fucata*) occurs in Banten Bay of Indonesia. Any possibility of using this species for pearl production in the Andamans would be through transplantation from the mainland. But development of the local species would be of a higher priority. The ' flat ' oysters, *P. sugillata* and *P. anomioides* abundant in Hut Bay are not good as pearl-producing molluscs and, hence, are not of any significance to pearl culture.

Seen from the survey results, the density of population of *P. margaritifera* is very low on the intertidal reef flats. This may be adduced, on the one hand, to poor survival and predation and, on the other, to the exploitation of the pearl oyster for human consumption by the Nicobarese. The fact that the pillars of the jetty at

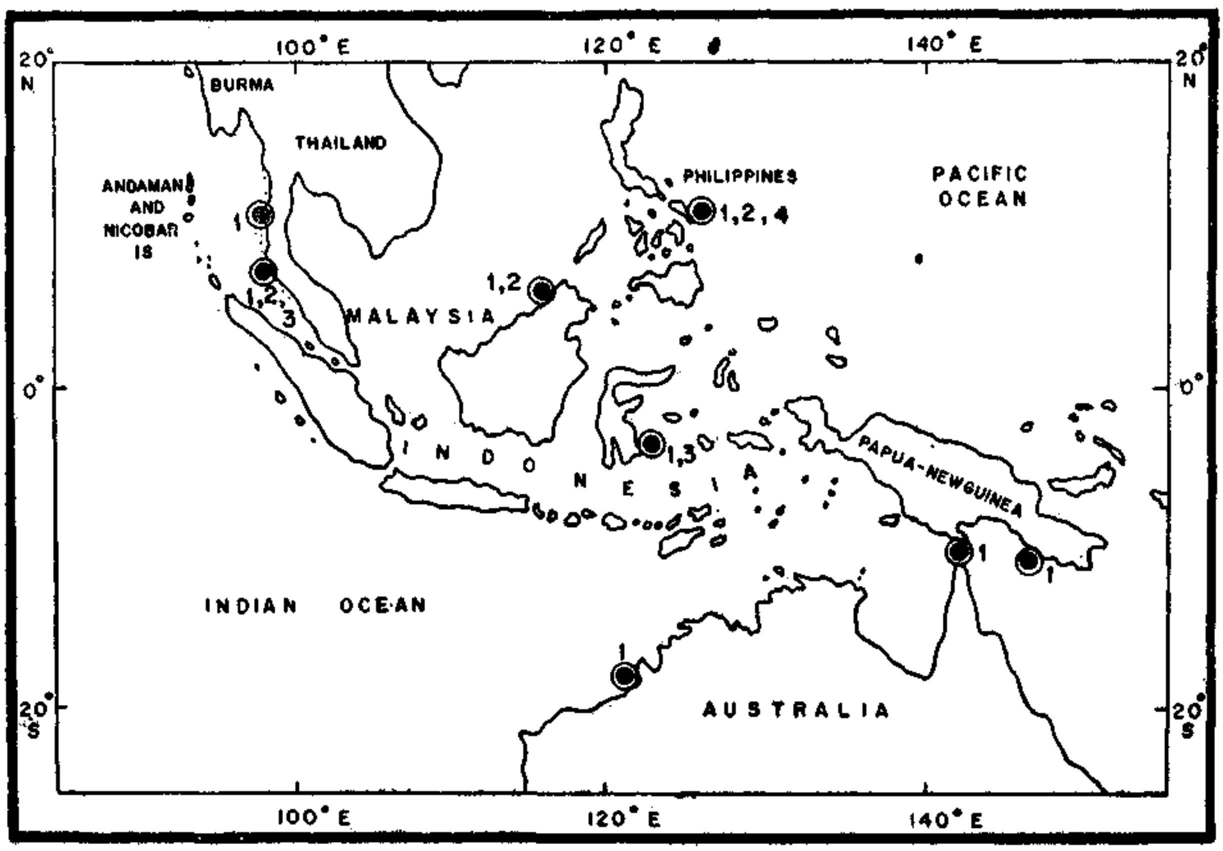


Fig. 7. Map of the Indo-Australian Archipelago, showing by enclosed dark circles the countries having commercial pearl culture operations. The Arabic numerals near the circles indicate species of pearl oysters used ; 1-*Pinctada maxima*, 2-*P. margaritifera*, 3-*Pteria penguin*, 4-*Pteria macroptera*.

Mayabunder, Havelock Is. and Camorta showed a good number of pearl oysters would indicate that a better population could be raised in column waters than on the reef flat. In the Red Sea, the healthiest of pearl oysters are stated to be found in less than 5 fm (9 m) (Gideiri, 1980) and 3-5 fm was found to be the suitable depth stratum for spat collection (Crossland, 1957). The mother-of-pearl shell industry of Sudan in Dongonab Bay depends on collection of *P. margaritifera* spat in the column waters by using split bamboo shelf collectors and rearing them in nurseries and grow-out farms (Crossland, 1957 ; FAO, 1962). Lock (1982) reports that spat collection of black-lip oyster on plain nylon ropes was extremely successful in Papua New Guinea. It is possible to use one of these two methods of spat collection for the species in the Andaman and Nicobar Islands, especially at Mayabunder, Havelock Is. and the Nancowry region to augment the resource for pearl culture.

Mizumoto (1979) considers *P. margaritifera* the most suitable for the production of steel black pearls and half pearls. Outside the Indo-Australian Archipelago, the species is used in the Okinawa area of Japan, Tahiti and Fiji (Mizumoto, 1979 ; AQUACOP, 1982). Sudan made an attempt on pearl culture, as reported by Shirai (1970), but the oysters suffered a mass mortality in 1973 and 1975 (Gideiri, 1980). According to Shirai (1970), this species is more difficult to obtain, to raise and to use for culturing purposes. Therefore, it would be necessary to develop appropriate technologies for rearing this species and production of cultured pearls.

Pearl culture with *P. maxima* depends on natural stocks at all centres of culture and the major problem of this industry is the dwindling stocks. Only very recently some success has been achieved in the artificial breeding of this species in Australia (Tanaka and Kumeta, 1981). AQUACOP (1982) could succeed in rearing *P. margaritifera* larvae up to day 10 and only a few larvae developed normally to spat. Mizumoto (1979) observes that if technique of artificial seed production is established more stable production of pearls may be expected in *P. maxima* and *P. margaritifera*. In 1981, India achieved a major breakthrough in developing techniques for artificial breeding of *P. fucata* (Alagarswami *et al.*, 1983). This technology can be adapted with modifications for the artificial breeding of *P. margaritifera*.

Transplantation of *P. maxima* from the Mergui Archipelago or neighbouring region to Andaman and Nicobar Islands may be attempted. The material can be used as broodstock for experimental hatchery production of seed. Such transplantation should be through strict quarantine measures against introduction of diseases, parasites and predators. *P. maxima* of Western Australia has shown unusually high mortality rates in the recent years and this has been of considerable concern to the Australian pearl culture industry (Dybdahl, pers. comm.).

Summing up, it is evident that there are two favourable factors, namely a suitable ecosystem and the presence of the black-lip pearl oyster *Pinctada margaritifera*, for considering immediate development of pearl culture in the Andaman and Nicobar Islands. A research and development effort combined with more specific and target-oriented surveys should precede, for working out the details of resource development and techniques of pearl production. The wing shell *Pteria penguin* would form a supporting species. Hatchery production of pearl oyster would be required for sustained pearl production. Transplantation of gold-lip oyster *Pinctada maxima* is a distinct possibility.

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