THE PEARL OYSTERS OF INDIAN WATERS.

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The present paper on the true pearl-oysters of the genus *Pinctada* Röding found in the Indian waters is based on a prolonged study of the extensive collections of these shells in the Indian Museum. The senior author has also had the advantage of examining the extensive collections of these forms in the British Museum (Natural History), South Kensington, London, the " Siboga " collections and a very rich collection from the Philippine waters which was sent to him for identification by the authorities of the United States National Museum, Washington, D. C.

The species of the genus *Pinctada* are very variable and it is almost impossible to find any well-marked characters for the identification of the various species. In the following pages we have given detailed notes on the species which we recognise as valid, and have also tried as far as possible, to clear up the very confused synonymies of the different species.

We are able to recognize the following species from the Indian waters:-

1. *Pinctada margaritifera* (Linn.).
2. *Pinctada vulgaris* (Schumacher).
3. *Pinctada chemnitzi* (Philippi).
4. *Pinctada anomioides* (Reeve).
5. *Pinctada atropurpurea* (Dunker).

Genus **Pinctada** Röding.

1798. *Pinctada* (ex parte), Röding, *Mus. Boltenianum*, p. 166.
1931. *Pinctada*, Grant and Gale, *Mem. San Diego Nat. Hist.*, I, p. 147.
1932. *Pinctada*, Prashad, " *Siboga* " *Exped.*, LIIIc, *Pelecypoda*, p. 97.

The pearl oysters were for a long time given the generic name *Margaritifera*, but this name is pre-Linnaean and as has been shown by Iredale[1], Grant and Gale and Prashad, the correct name for the genus is *Pinctada* Röding. The genus is well defined by Adams[2], Fischer[3], Jameson[4] and lately by Grant and Gale; the latter authors, however, consider it to be a subgenus of *Pteria* Scopoli, a view to which we are unable to subscribe.

Jameson in his revision of the Pearl Oysters remarked that " the species of *Margaritifera* are difficult to separate from one another by hard and fast lines, owing to the absence of well-marked diagonistic characters, and to the extraordinary amount of geographical and casual variation." We have after an examination of large series of specimens

[1] Iredale, T.—*Proc. Malacol. Soc. London*, XI, p. 305 (1915).
[2] Adams, H. and A.—*Gen. Rec. Moll.*, II, p. 525 (1857).
[3] Fischer, P.—*Man. Conchyliol.*, p. 952 (1886).
[4] Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 372 (1901).

found his remarks to be fully justified. In the following account we have in addition to giving the diagnostic characters of the various species included measurements of a number of shells from various localities to show the range of variability in shape and size of the species.

Jameson's divisions and subsections based mainly on the form of shells and the presence or absence of a hinge tooth are, in our opinion, very artificial, and we have, as indicated above, failed to find any other characters on which the division of the various species into groups or subgroups could be based. It may also be noted that the presence or absence of scales on the external surface of the valves and the differences in colour of the valves, on which the earlier authors relied for the distinction of several species, are of no value whatsoever. Fresh and young shells usually have scales and concentric imbricated laminae on the external surface of the valves but the imbrications wear out with age and in full grown shells traces of imbrications or scales are only rarely to be found. The thickness of the hinge-line, the development of the anterior and posterior auricles and the extent of the internal nacreous layer also exhibit a considerable amount of variation in shells of different ages of the same species. Further, most species of this genus have a very wide range of distribution, and shells from different localities and even from the same area often vary in form, outline, thickness of valves, colour, etc.

Pinctada margaritifera (Linn.).

1758. *Mytilus margaritiferus*, Linnaeus, *Syst. Nat.* (ed. X), p. 704.
1931. *Pinctada margaritifera*, Faustino, *Philippine Journ. Sci.*, XLV, p. 328, pl. ii.
1932. *Pinctada margaritifera*, Prashad, "*Siboga*" *Exped.* LIIIc, *Pelecypoda*, p. 98.

As remarked in Prashad's work, cited above, there has been a great deal of confusion regarding the Linnaean species *Mytilus margaritiferus*. A detailed synonymy of the species is published in the work cited, but it may be noted that on examination of the material from the Mergui Archipelago referred to this species by von Martens[1] we find that all the specimens are true *P. vulgaris* (Schumacher).

In the Indian Museum *P. margaritifera* is represented by a fair series of shells of various ages from a number of localities in the Indian Ocean. After a careful examination of these shells we are of opinion that they must all be referred to Jameson's var. "*typica*"[2]. Some of the shells from the Andamans and Nicobars resemble var. *zanzibarensis* Jameson in the colour of the nacre, but we are unable to separate them from other shells of the var. *typica* from the same locality or from other areas.

Jameson and Faustino have described the species in detail and notes on the form of the muscle-scar of this species will be found in Odhner's work.[3]

The large series of shells in the Indian Museum collection from the Andamans shows a variation in form and outline similar to that noticed by Prashad in the case of the "Siboga" material.

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[1] von Martens, E.—*Journ. Linn. Soc. London*, (*Zool.*), XXI, p. 202 (1887).
[2] Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 374 (1901).
[3] Odhner, N. Hj.—*Kungl. Svensk. Vet. Handl.*, LII, no. 16, p. 16 (1917).

The chief characters on which we have relied for the identification of the species are the convexity of the valves, the hinge-margin being only slightly more than half the length of the nacreous area of the valves in the antero-posterior direction, the entire absence of *teeth* and the colour of the shells. The external colour, as noted by Jameson, is very variable, the ground colour being " pale yellowish brown, green olive, reddish grey, dark brown or black. It is characteristically marked with about 10 to 18 radial rows of white or yellow spots, running from the umbo to the margin." The margin of the nacre is usually dark or smoky and often radiating from it are a series of dark bands alternating with narrower bands of light yellowish colour.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10	11	12
Maximum length	61	12·7	35	112	60	61	63	68	74	117	95	173
Height	60	12	31	118	64	77	90	77	88	111	64	152
Maximum thickness	17	4	10	44	20	21	22	20	29	33	30	51
Hinge-line (including the auricle).	42	12	25·4	71	51	51	50	40	44·8	63	57	115

Specimen 1 is from Mauritius, 2-4 from Ceylon, 5-9 from the Andaman Islands, 10 from the Nicobars, 11 from the Mergui Archipelago, and 12 from the Persian Gulf.

Distribution.—P. margaritifera and its varieties are widely distributed in the Indo-Pacific area. The var. *typica* is represented in the Indian Museum collection from Mauritius, the Persian Gulf, the Mergui Archipelago, the Andaman and Nicobar Islands.

Remarks.—As noted above, we are rather sceptical about the validity of Jameson's var. *zanzibarensis.* From the Persian Gulf we have seen a single large shell labelled var. *persica* Jameson, but this shell, except for its large size, so closely resembles the typical form that we are inclined to doubt the validity of Jameson's variety from the Persian Gulf. The measurements of this shell are given in the above table under No. 12.

Pinctada vulgaris (Schumacher).

1817. *Perlamter vulgaris*, Schumacher, *Essai Nouv. Syst.*, p. 108, pl. xx, figs. 3*a*, *b*.
1929. *Pinctada* (*P.*) *vulgaris* and *P.* (*P.*) *lentiginosa*, Lamy, *Bull. Mus. d'Hist. Nat. Paris*, (2) I, pp. 114, 115.
1932. *Pinctada vulgaris*, Prashad, " *Siboga* " *Exped.*, LIIIc, *Pelecypoda*, p. 99.

Pinctada vulgaris is, as one of us has pointed out in the paper cited above, a very variable species, and several variations of it have been described as distinct species under the names *albina* Lam., *fucata* Gould, *perviridis* Reeve, *occa* Reeve, *aerata* Reeve, and *varia* Dunker. There is also reason to doubt the validity of such species as *imbricata* Reeve and *nebulosa* Conrad, but with the material before us we do not feel justified in relegating these forms to the synonymy of *P. vulgaris.* The case of *P. lentiginosa* Reeve[1] is, however, different. Cooke[2] included

[1] Reeve, L.—*Conch. Icon.*, X, *Avicula*, pl. vi, fig. 13 (1857).
[2] Cooke, A. H.—*Ann. Mag. Nat. Hist.*, (5), XVII, p. 137 (1886).

it in the synonymy of *P. vulgaris*, but Jameson[1] considered it distinct and remarked that it differs " mainly from *M. vulgaris* in being larger, somewhat flatter, and of a greyish external colour." We also were originally inclined to treat it as a distinct species, but after an examination of a large series of fresh young shells from the Ceylon beds (*vide infra*) we are of opinion that Reeve's *lentiginosa* is based on slightly variable shells of *P. vulgaris*. The characters, noted by Jameson, are not constant, and the only important difference is the marked development of a posterior auricle of a triangular shape in some shells; this distinction also is purely arbitrary, as in a large series of shells we found that whereas some are provided with a well developed posterior auricle in others there is no indication of this structure. A few photographs of shells showing the variability of this character were published by Herdman and Hornell[2] in their paper on the anatomy of *P. vulgaris*. In view of the above remarks we consider that *lentiginosa* Reeve can definitely be assigned to the synonymy of *P. vulgaris*.

From an examination of specimens of *P. martensi* (Dunker) from the Japanese waters we agree with Jameson (*loc. cit.*, p. 386) that this species is probably nothing more than a geographical variety of the wide-spread *P. vulgaris*.

P. vulgaris is the common Indian pearl oyster found in abundance on the Pearl Banks round Tuticorin in the Gulf of Manaar and round Ceylon. Both the valves of this species are convex, the left being more so than the right. The species is of a moderate size with a triangular anterior auricle and often with a small or even well developed posterior auricle. The hinge-area is moderately broad, and a small tooth or a thickening of the hinge-line is usually present in front of the ligament. The surface of the valves in most of the old specimens is generally smooth, but in fresh and young shells imbricate scales arranged in radial rows are present. The nacre is fairly thick, of a whitish shining mother-of-pearl colour, with iridescent areas of various hues along the border. The non-nacreous margin shows alternate dark and light bands in most of the shells before us.

Young shells of *P. vulgaris* collected from the Ceylon Pearl Banks and varying in size from 14 to 24 mm. along the hinge line are subquadrate in outline. The right valve is only slightly convex but the left is greatly excavated for the soft parts. The ground colour of shells preserved in spirit is creamy white and a number of brownish red radiating rays are prominently marked. In other cases, the radiating rays may be darker, almost black or green. The posterior auricle, which is distinctly marked in most young shells, is also of a brownish red colour. The surface of the shells is covered by concentric imbricating laminae, with, in most, cases a large number of short scale-like spines, or " long ribbon-like spines," such as are shown in the figure of *Avicula hystrix* Reeve (*Conch. Icon.*, X, *Avicula*, pl. viii, fig. 18) arising from the margin of the laminae. Some of the shells bear rays of a light shining greenish colour.

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[1] Jameson, H. L.—*Proc. Zool. Soc. London*, I, p. 387 (1901).

[2] Herdman, W. A. and Hornell, J.—*Report Ceylon Pearl Oyster Fisheries*, II, pl. i, figs. 1-4 (1904).

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10
Maximum length	51	17·7	40·2	41·8	45	43	46	37·5	45	72
Height	52·2	24·5	43·1	43	48	46	49	38	43	81
Maximum thickness	18·4	8	20	12	20	13	17·4	12·5	16	36·7
Hinge-line (including the auricle).	47	25	45	33	41·5	40	43·7	31·2	42	63·2

Specimens 1 and 2 are from Baluchistan, 3 from Aden, 4 from the Andamans, 5 from the Nicobars, 6 from the Mergui Archipelago, 7 from Penang, 8 from Singapore, 9 from Anneseley Bay and 10 from Ceylon.

Distribution.—P. vulgaris is a widely distributed species; it has been recorded from the Red Sea, the Persian Gulf, all over the Indian Ocean and in the Pacific Ocean from round Australia to north of the Philippines. For a detailed list of localities of this species reference may be made to Jameson's paper.

In the Indian Museum collection the species is represented by a good series of shells from Aden, Henjam (Persian Gulf), Baluchistan, Trincomali (Ceylon), Vizagapatam, Arakan, the Mergui Archipelago, the Andamans and Nicobars, Penang, Singapore, the East Indies and Anneseley Bay.

Pinctada chemnitzi (Philippi).

1785. *Concha margaritifera laevis* etc., Chemnitz, *Conch.-Cab.*, VIII, pl. lxxx, fig. 720.
1849. *Avicula Chemnitzii*, Philippi, *Zeitschr. Malakozool.*, VI, p. 19.
1857. *Avicula praetexta*, Reeve, *Conch. Icon.*, X, *Avicula*, pl. vii, fig. 15.
1872. *Avicula (Meleagrina) Chemnitzii and A. (M.) praetexta*, Dunker, in *Martini Chemn. Conch.-Cab.*, (*N. F.*), VII (3), *Avicula*, p. 15, pl. iii, fig. 5, p. 38, pl. xii, fig. 1.
1901. *Margaritifera praetexta* and *M. chemnitzii*, Jameson, *Proc. Zool. Soc. London*, I, pp. 387, 388.

Chemnitz described and figured a shell from the Tranquebar Coast as "*Concha margaritifera laevis, tenuis, ex subalbido radiata*," this form and some shells from the China Sea were later described under the name *Avicula Chemnitzii* by Philippi in the paper cited above. After a careful comparison of the description and figures of this species we are convinced that *Avicula praetexta* Reeve from the Island of Corrigidor, Philippines, is synonymous with Philippi's species. We cannot, however, agree with Dunker's suggestion that Reeve's *lentiginosa* is probably a synonym of *P. chemnitzi*, for as has been remarked above (pp. 169, 170) Reeve's *lentiginosa* is a synonym of *P. vulgaris*. Jameson in his revision included Reeve's *praetexta* as a separate species but suggested that probably this species and Philippi's *chemnitzi* are both synonymous with *P. vulgaris*.

The shells which we identify as *P. chemnitzi* are suborbicular, not very convex, somewhat inequivalve, with a moderately developed triangular anterior auricle and a well marked, rather broad and elongated posterior auricle. The posterior auricle is distinctly marked off by a broad sinus from the posterior margin of the valves and though lined by a thin nacreous layer has a narrow non-nacreous margin. The hinge-line is moderately broad, usually with a distinct tooth anterior to the ligament. The nacreous portion is not very extensive and is bordered

by a fairly broad darker non-nacreous region. The muscle scar is rather long with a comparatively broad upper portion. The external surface of the valves is of a horny colour with a few deep brownish bands radiating from the umbones. The marginal part of the external surface of the valves, and the posterior wing bear broad concentric rows of scaly imbrications with a few distinctly marked scales arising from the lower margin.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8
Maximum length	44·5	51	56	35	49	55	58·4	28·5
Height	47·2	52	57	34·6	56·2	60	60	29·6
Maximum thickness	15·6	16	17	10	19·8	19	18	13
Hinge-line (including the auricle)	57	64	66	41	54	65·4	58	40

Specimens 1-3 from the Tavoy Sea Coast, 4 from Hongkong, 5 from Penang, 6 from the Mergui Archipelago, 7 from Trincomali (Ceylon), and 8 from Aden.

Distribution.—*P. chemnitzi* is represented in the Indian Museum collection from Aden, Ceylon, Balassore Bay (Orissa Coast), the Mergui Archipelago, Penang and Hongkong.

Remarks.—The less convex valves and the well-developed elongated, tongue-like posterior auricle, usually separated off by a broad notch from the rest of the shell make it possible to distinguish *P. chemnitzi* from *P. vulgaris*.

Pinctada anomioides (Reeve).

1857. *Avicula Anomioides*, Reeve, *Conch. Icon.*, X, *Avicula*, pl. ix, fig. 26.
1932. *Pinctada anomioides*, Prashad, "*Siboga*" *Exped.*, LIIIc, *Pelecypoda*, p. 100, pl. iii, figs. 5-8.

For other references to *P. anomioides* the work of Prashad, cited above, may be referred to. In the Indian Museum collection this species is represented by a good series of shells, and it is, therefore, possible to discuss it in some detail.

The shells before us vary from almost white, yellow, light brown to green in colour; they often have a number of rays of a lighter colour radiating from the umbonal area to the margins. Most of the shells are smooth and do not show any scales, but in a number of cases distinct radially arranged imbricated scales are present. The right valve is almost flat, and the left is only moderately convex. The narrow hinge-line is almost straight, without or with only a trace of a tooth anterior to the ligament in the right valve. There is a well marked anterior auricle separated by a deep byssal notch from the rest of the shell; in the left valve the anterior margin extends in a straight line outside the nacreous area. The posterior nacreous border forms almost a right angle with the nacreous part of the hinge-line.

In fresh shells from the Mergui Archipelago there are rather low and hardly prominent scaly imbrications of a light brownish colour along the lower margin.

Measurements (in millimetres).

	1	2	3	4	5	6	7	8	9	10	11
Length (including the auricle)	29	33	37·5	41	30	34	31	32	17·5	40	31
Height	25	31·5	39	46	29	28	39	27	20	38	21
Maximum thickness	6	8·9	10	12	8	7·5	10	7	5	9	6

Specimens 1-4 are from the Andaman Islands, 5 and 6 from Trincomali, 7 and 8 from Bombay, 9 and 10 from Baluchistan and 11 from the Tavoy Coast.

A shell from the Andaman Islands, the measurements of which are 48 mm.×40 mm.×8 mm. agrees almost exactly with Reeve's descriptions and figure both in outline and form of the valves, but the " rudely jagged " lamination along the margin mentioned by Reeve, is not so marked; other shells from the same locality, however, show a distinct lamination along the margins.

We also refer, with some hesitation, a very large shell from the Andamans to this species. The measurements of this shell are 13·2 cm.× 12·2 cm.×2·5 cm., the valves are over 2 mm. thick, but even with this thickness the shell is transluscent. It is of a dirty yellowish brown colour with a moderately developed pearly nacreous layer, and a band of a greenish yellow colour along the border. The outer surface of the right valve is laminated, while there are traces of scales along the almost concentric laminae of the left valve. The hinge-line is straight, moderately thick and without any trace of a tooth. The general outline of the shell is similar to that of the younger shells.

Distribution.—The types of *P. anomioides* were without any definite locality, but as noted in Prashad's work there are shells of this species in the British Museum collection from Bazaranto Islands and some shells from Nangamessi Sumba from the " Siboga " Expedition were also, referred to this species. In the Indian Museum there is a good series of shells of this species from Aden, Baluchistan, Bombay, Trincomali (Ceylon), the Tavoy Sea-Coast, the Mergui Archipelago and the Andaman Islands.

Remarks.—We cannot agree with Cooke[1] that *P. anomioides* is synonymous with *P. vulgaris* (Schumacher); the general facies and the form of the shell are quite different. We have examined a very larger series of shells of *P. vulgaris* but have never come across a single specimen in which the shell is so thin, flat or rayed as in *P. anomioides*. Further the valves of *P. vulgaris* are always more convex and exhibit a distinct sinus in the posterior margin. In *P. anomioides* the hinge-line is relatively much narrower, and the upper part of the muscular scar is very narrow and generally less than $\frac{1}{3}$ the total length of the scar.

Pinctada atropurpurea (Dunker).

1852. *Avicula (Meleagrina) atro-purpurea*, Dunker, *Zeitschr. Malakozool.*, IX, p. 76.

1872. *Avicula (Meleagrina) atropurpurea*, Dunker, *in Martini Chemn. Conch.-Cab.*, (N. F.), VII (3), *Avicula*, p. 14, pl. iii, fig. 3.

1877. *Avicula atropurpurea*, von Martens, *Journ. Linn. Soc. London, (Zool.)*, XXI, p. 203.

1901. *Margaritifera atropurpurea*, Jameson, *Proc. Zool. Soc. London*, I, p. 384.

[1] Cooke, A. H.—*Ann. Mag. Nat. Hist.*, (5) XVII, p. 137 (1886).

Dunker described a shell of unknown habitat from Scheepmaker's collection under the name *Avicula atropurpurea* and the species remained as doubtful till von Martens referred a young shell from the Mergui Archipelago to it. Jameson apparently did not have any shells of the species for his revision of the pearl oysters, but included the species in his *section b.* (*loc. cit.*, p. 380). In the Indian Museum collection are the Mergui specimen referred to this species by von Martens, a shell from Trincomali, Ceylon, and two fresh shells from the Andamans. The following notes on these shells should prove useful for future reference.

Shell rotundate-ovate, with the rather narrow hinge-margin almost straight; valves very thin, transluscent, of a deep copper-red colour with a few lighter rays radiating from the umbonal area to the lower margin. Right valve only slightly convex, left with a moderately deep cavity in the umbonal region; nacre very thin, of a bluish white colour extending over the greater part of the shell and bordered by a dark coppery non-nacreous margin; the nacreous part of the hinge-line forms an acute angle with the posterior margin of the nacreous area; the rostrum is short, of a triangular lappet-shaped form, separated laterally from the main part of the shell by a shallow ridge and in the byssal region by a deep notch. There is a slight trace of a tooth in front of the ligament in the Trincomali and Andaman specimens.

In a young fresh shell from the Andamans there are a few radially arranged scales of a creamy colour arising from low concentric laminations.

Measurements (in millimetres).

	Trinco-mali shell.	Mergui shell.	Fresh Andaman shells.	
			1	2
Length (including the auricle) .	39·8	22	33·2	38·2
Height .	38·3	18·5	36·8	38·2
Maximum thickness	9·2	4·5	10	9

Distribution.—The specimens in the Indian Museum, which we assign to *P. atropurpurea*, are from Pilai Bay (Mergui Archipelago), Trincomali, and the Andamans. We have also seen a shell of this species from the Philippine waters.

Remarks.—*P. atropurpurea* is closely allied to *P. anomioides* (Reeve) but differs in its peculiar colouration, much thinner and more transluscent shell and in the nacre along the posterior margin meeting the hinge-line in a more acute angle.