

HERMAPHRODITISM AND SEX REVERSAL IN THE FOUR COMMON OVIPAROUS SPECIES OF OYSTERS FROM THE COAST OF KARACHI

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Abstract

In the four common oviparous oysters from the coast of Karachi, *Crassostrea rivularis*, *C. madrasensis*, *Saccostrea glomerata* and *S. cucullata*, the gonad appeared at the age of 2-3 months, at a length of 0.4-0.6 cm. Sex is determined from the origin and hermaphrodites are rare, their percentage among the population increasing as growth proceeds, but is not affected by changes of the seasons. Incidence of hermaphrodites and changes in sex ratio suggest a change of sex as seen in oysters of temperate zones.

Introduction

In most of the bivalve molluscs the sex is labile due to the simplicity of the reproductive system, which is devoid of duct, gland, reservoir and copulatory organ (Yonge, 1967). In oviparous oysters the sex is stable while it is unstable in larviparous oysters, owing to the rare or common occurrence of hermaphrodites in their populations (Giese & Pearse, 1974). The presence of hermaphrodites is histologically established in a few families of bivalves including Ostreidae. Studies of sex change has been mostly carried out on *Crassostrea virginica* (Kennedy & Battle, 1963), *C. gigas* (Katkansky & Spark, 1966) and *C. (Saccostrea, Stenzel, 1971) glomerata* (Dinamani, 1974) from the coast of temperate regions, which oysters have an annual reproductive cycle. From the tropical region hermaphrodites are reported in *C. madrasensis* (*C. catakinesis*) (Rao, 1953) and *S. cucullata* (Awati & Rai, 1931). From oviparous oysters of Karachi coast, hermaphrodites have been recorded, although they have a pro-

longed gonadal activity with a biannual or continuous reproductive cycle (papers under publication). Keeping in view the marked differences between the gonadal activity of temperate oysters and the oysters of this coast, the incidence of hermaphrodites, sex ratio and sex reversal in the population of the four species of oysters of this coast have been discussed in this paper.

Material and method

Random samples consisting of 30-50 oysters of *Crassostrea rivularis*, and *C. madrasensis* (= *C. catakinesis*) from Korangi Creek, *Saccostrea glomerata* from Manora Channel and *S. cucullata* from Gadani Beach of the coast of Karachi were collected at fortnightly to monthly intervals. The sexes of these species were studied on the basis of living gametes and histology of the gonad. In the living gametes the sex of size classes, having a difference of one cm, was determined. To avoid difficulties in histological preparations, only three size groups, ranging from 0.5-1.5, 1.6-3.0 and 3.1-8.0 cms in length were observed for determination of sex and presence of hermaphrodites. The procedure of Kennedy and Battle (1963) was followed for histological treatments.

Observations and results

Histological study

In all 3,471 individuals of *Crassostrea rivularis*, *C. madrasensis*, *Saccostrea glomerata* and *S. cucullata* were studied histologically during the years 1971-1973.

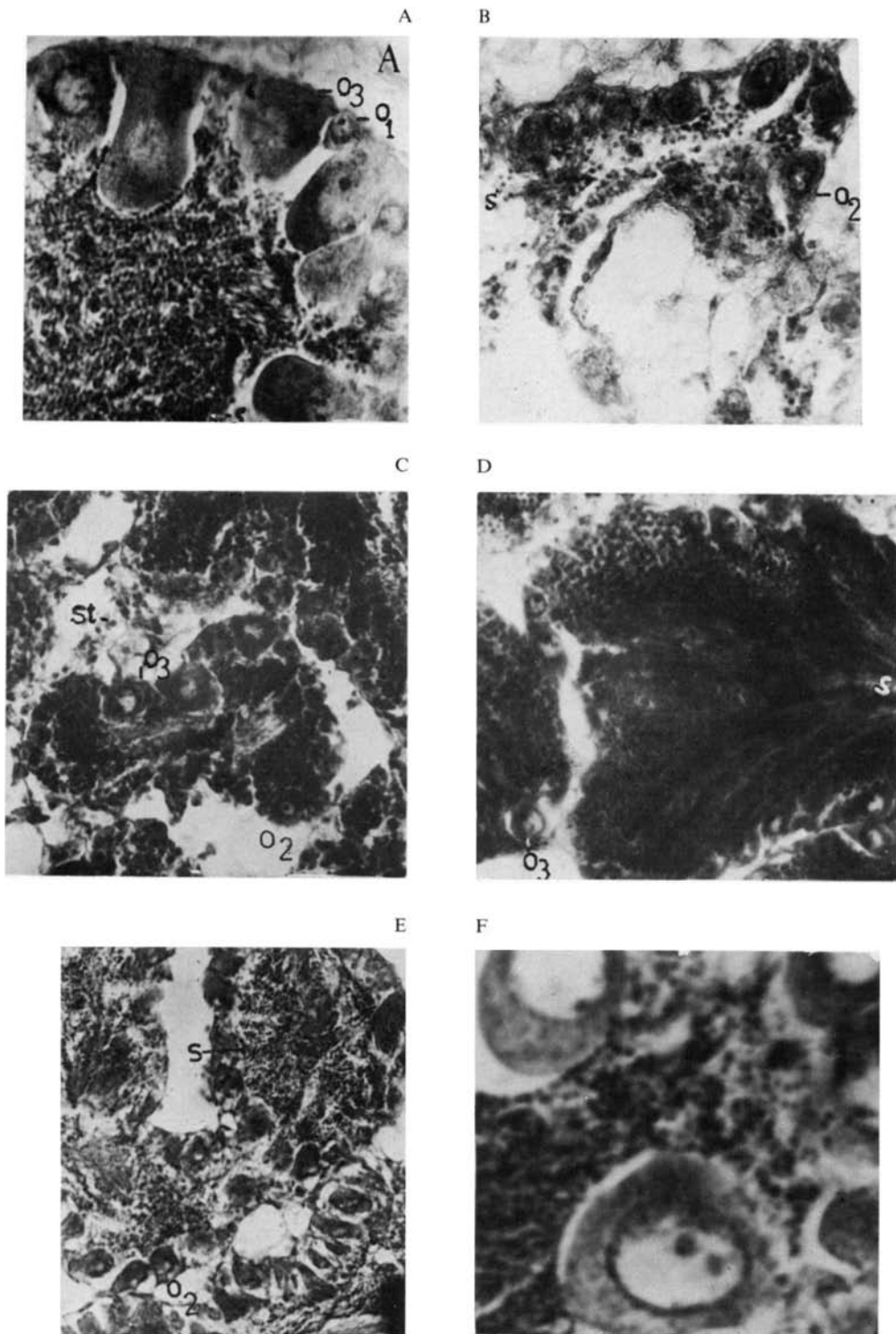


Plate I. T. S. across the gonad. Protandric hermaphrodites in *Saccostrea cucullata* (A), *Crassostrea rivularis* (B), Protogynic hermaphrodites in *C. rivularis* (C) and *C. madrasensis* (D); and *S. glomerata* (E); Functional hermaphrodite in *S. cucullata* (F) (A-E 130X, F 250X).

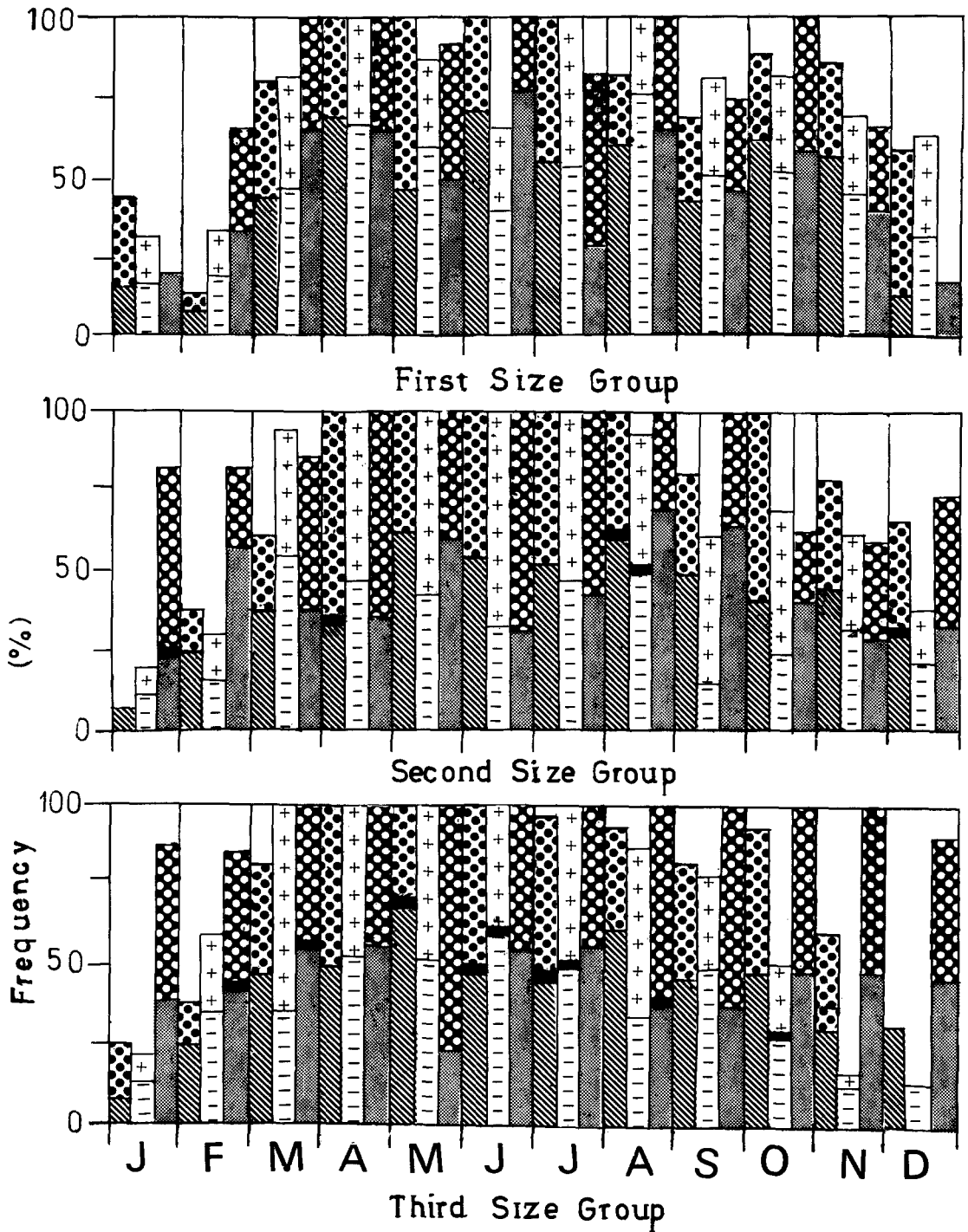


Fig. 1. Histogram showing seasonal changes in the composition of males, females, hermaphrodites and indifferent gonads in the different size groups, based on the added data of histological study during 1971-1973 (■ hermaphrodite; ▤ indifferent gonad; ▨ male, ● female in *C. rivularis*, ● female in *S. glomerata* and ▩ female in *S. cucullata* respectively).

The gonad appeared at the level of 0.4-0.6 cm in length and the percentages of males were 62.3%, 66.6%, 59.1% and 73.2% respectively. They were gonochoristic from the very beginning owing to progression of either spermatogenesis or oogenesis at the youngest size group. In the population of all species, the transitional stages of the sexes have been examined, which are here considered as hermaphrodites (Plate I. A-F). They were protandric (Plate I. A, B, D) as well as protogynic (Plate I. C,E), showing regression of male gametes and development of female gametes in the former case and the reverse condition in the latter. 18 protandric and 6 protogynic individuals were found during the study, suggestive of a greater possibility of protandric than of protogynic hermaphrodites in the population. Only two hermaphrodites possessed mature ova and sperms at the same time, which presumably indicates true hermaphroditic condition (Plate I. F).

In the first size group no hermaphrodite was seen in all species, which presumably indicates that ambisexuality or initiation of the second phase of gametogenesis did not occur at the level of 1.5 cms in length in these oysters. In the second size group, hermaphrodites were observed in all species and the presence of hermaphrodites was maximum in *C. rivularis* and minimum in *S. glomerata* (Table I). In the third size group, incidence of hermaphrodites was maximum in *S. cucullata* and minimum in *S. glomerata* (Table I).

The seasonal data show that the indifferent individuals were common in winter and became rare in other seasons (Fig. 1). The data of sexes did not indicate any marked influence of season even after adding the data of three years (Fig. 1). In *C. rivularis*, *C. madrasensis* and *S. glomerata* hermaphrodites were found in summer and autumn while in *S. cucullata* they were present in winter and spring (Table I). It indicates that the hermaphrodites may be found all the year round and presumably this is due to the prolonged gonadal activity of these species.

Study of living gametes

In *C. rivularis* and *C. madrasensis* the sex ratios of the different size classes, based on the study of living gametes of 1,870 individuals during 1971-1973, show a gradual decline in the percentage of males with increasing size classes. Beyond the size class 5.0-5.9 cm in *C. rivularis* and 6.0-6.9 cm in *C. madrasensis* the percentage of females increased over the males (Table II). Similar trends were noted in *S. glomerata* and *S. cucullata* during the study of 3,955 individuals, with the exception that the propor-

tion of females increased over males at earlier size classes viz. 2.0-2.9 cm and 3.0-3.9 cm respectively (Table II). From these observations, it is obvious that in all these species a marked tendency exists for the female sex to increase with the growth of the oysters.

Discussion

The histological study of the four species of oysters show that the gonad is primarily developed at an early age (0.4-0.6 cm in length), which is not very different from the observations on *Crassostrea virginica* from temperate regions (Menzel, 1951). The gonad at this stage is mostly male, but it is not ambisexual, suggesting that the sex is determined at the origin of the gonad. On the contrary, Coe (1932) reports that the primary gonad in *C. virginica* is ambisexual and female gametes are resorbed at their initial stage allowing the progress of spermatogenesis only. This is not valid for any species of this coast and it is also against the polygene hypothesis for sex determination in *C. virginica* (Montalente & Bacci, 1951).

Considering the ambisexuality in the different size groups, there is an increase in the incidence of hermaphrodites with the ascend of the size groups in all four species. In the population, the hermaphrodites are rare (0.32%-1.27%) and their percentages fall close to the reports in other oviparous species of oysters e.g. 0.4-1.0% in *C. virginica* (Needler, 1942; Kennedy & Battle, 1963) and 0.26-3.0% in *C. gigas* (Katkansky & Spark, 1966) and the same species from other coasts (0.05% in *C. madrasensis*, Rao, 1953; 0.75% in *S. glomerata*, Dinamani, 1974; 2.9% in *S. cucullata*, Awati & Rai, 1931; from the coasts of Madras, New Zealand and Bombay respectively). To date no author has reported hermaphrodites in *C. rivularis*, which are found in 0.81% of the animals from this coast. Although hermaphrodites are rare, these transitional stages obviously suggest a change of sex in these species.

Since it is possible that hermaphrodites are short-lived and rapidly pass into an alternate sexual phase in oviparous oysters (Coe, 1942), data on sex ratio at different seasons and size classes may throw light on the sex change in the population. The seasonal influence on the sex ratio at different size groups is not found to be significant, however, the proportion of female tends to increase with the ascend of size classes. Increase in female proportion in between spat and adult is reported in *C. virginica* (Needler, 1942) and *S. glomerata* (Dinamani, 1974). The predominance of females over males is found to occur at

TABLE 1

Percentage of hermaphrodites in Crassostrea rivularis, C. madrenensis (C. catakinesis), Saccostrea glomerata and S. cucullata from the coast of Karachi, during 1971 - 73 (data of different years lumped).

Species	No. of oysters examined	Percentage of hermaphrodites	Period of incidence	Third size		Second size		First size	
				Group	Group	Group	Group	Group	Group
				Oysters examined	Oysters examined	Oysters examined	Oysters examined	Oysters examined	Percentage of hermaphrodites.
<u>Crassostrea rivularis</u>	955	0.81	May-July	525	0.79	205	1.46	225	Nil
<u>C. madrenensis</u>	502	1.00	June-August	340	1.17	162	0.63	Nil	Nil
<u>Saccostrea glomerata</u>	1,235	0.32	June-October	701	0.43	368	0.27	166	Nil
<u>S. cucullata</u>	779	1.27	January-March	402	1.35	245	0.41	132	Nil
Total	3,471	0.69		1,968	0.91	980	0.61	523	Nil

much higher size classes in *C. rivularis* and *C. madrasensis* than in *S. glomerata* and *S. cucullata*. It is noteworthy that growth rate in the species of the genus *Crassostrea* is greater than those of the genus *Saccostrea* (Stenzel, 1971), which has presumably influenced this difference.

The presence of a greater proportion of males in the earliest size class, increase in the tendency towards hermaphrodites with increase in size, greater chances of protandric than protogynic changes and ultimately occurrence of a greater percentage of females than males in

TABLE II

Sex ratios in various size classes* of *Crassostrea rivularis*, *C. madrasensis* (*C. catakensis*), *Saccostrea glomerata* and *S. cucullata* from the coast of Karachi, during 1971- 73 (all the data of the years lumped).

Species	Size class (cms.)	Sample size	No. of males	No. of females	Proportion of male	Confidence limit
<i>C. rivularis</i>	0.1 - 0.9	52	33	19	0.635	0.755 - 0.506
	1.0 - 1.9	191	113	78	0.592	0.670 - 0.484
	2.0 - 2.9	124	74	50	0.596	0.683 - 0.510
	3.0 - 3.9	157	94	63	0.598	0.675 - 0.521
	4.0 - 4.9	154	82	72	0.532	0.611 - 0.453
	5.0 - 5.9	180	92	88	0.511	0.652 - 0.370
	6.0 - 6.9	126	60	66	0.476	0.564 - 0.388
	7.0 - 7.9	74	32	42	0.432	0.545 - 0.318
8.0 - 8.9	32	12	20	0.375	0.542 - 0.208	
Totals		1,092	592	498	0.543	0.643 - 0.443
<i>C. madrasensis</i> (<i>C. catakensis</i>)	0.1 - 0.9	44	31	13	0.721	0.840 - 0.611
	1.0 - 1.9	72	53	19	0.736	0.816 - 0.656
	2.0 - 2.9	107	75	32	0.701	0.787 - 0.615
	3.0 - 3.9	93	60	33	0.602	0.700 - 0.504
	4.0 - 4.9	120	65	55	0.541	0.605 - 0.476
	5.0 - 5.9	112	59	53	0.526	0.602 - 0.432
	6.0 - 6.9	114	51	63	0.447	0.537 - 0.357
	7.0 - 7.9	77	27	50	0.349	0.416 - 0.282
8.0 - 8.9	39	12	27	0.307	0.450 - 0.264	
Totals		778	433	365	0.556	0.589 - 0.523
<i>S. glomerata</i>	0.1 - 0.9	249	162	87	0.651	0.711 - 0.592
	1.0 - 1.9	465	255	210	0.548	0.593 - 0.451
	2.0 - 2.9	706	300	406	0.425	0.461 - 0.389
	3.0 - 3.9	457	215	242	0.470	0.516 - 0.424
	4.0 - 4.9	124	55	69	0.444	0.534 - 0.354
<i>S. cucullata</i>	0.1 - 0.9	84	60	24	0.714	0.896 - 0.532
	1.0 - 1.9	264	148	116	0.561	0.621 - 0.501
	2.0 - 2.9	446	227	219	0.509	0.555 - 0.463
	3.0 - 3.9	642	306	336	0.477	0.480 - 0.474
	4.0 - 4.9	377	168	209	0.446	0.556 - 0.336
5.0 - 5.9	141	60	81	0.426	0.508 - 0.344	
Totals		1,954	969	985	0.496	0.518 - 0.474

* Size classes on the basis of length of shell.

higher size groups, suggest that sex reversal should have occurred in the population of the species from this coast. The causes of sex change and sex ratio in these species need further investigation.

Summary

There are four common oviparous species of oysters in the coast of Karachi. Two of them, namely *Crassostrea rivularis* and *C. madrasensis* are backwater oysters found in muddy environment and the rest, *Saccostrea glomerata* and *S. cucullata* are rocky oysters. The gonad appears at the age of 2-3 months (0.4-0.6 cm in length) and the sex is determined at its very origin in these species. The hermaphrodites are found in population ranging from 1.5 cms in length onward and their probability of incidence is rare but increases with the ascend of the size groups. The sex ratio varies with the growth in size of the oysters, but it is not affected by the changes of the seasons. The incidence of hermaphrodites and changes in the sex ratios, obviously suggest a change of sex. This is just like the pattern seen in the oviparous oysters of temperate zones indicating that difference in ecological habitat, prolonged gonadal activity and high temperature conditions do not effect the pattern of sex reversal in oviparous oysters and that certain genetical mechanisms control the process.

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