Pakistan J. Sci. Ind. Res., Vol. 23 Nos. 1-2, February-April, 1978

VARIATIONS IN ALLOMETERIC GROWTH IN THE SHELLS OF *CRASSOSTREA RIVULARIS* (GOULD), *SACCOSTREA GLOMERATA* (GOULD) AND *S. CUCCULLATA* (BORN) FROM THE COAST OF KARACHI

M. Asif

Institute of Marine Biology, University of Karachi, Karachi-32

(Reccived February 15, 1978; revised September 12, 1978)

Abstract. The dimensional relationship of the shells of the oysters, *Crassostrea rivularis*, *Saccostrea glomerata*, and *S. cuccullata*, occurring at the coast of Karachi, have been investigated. *C. rivularis* attains greater shell dimensions than the other two species. *S. cuccullata* requires greater width and thickness of shell than *S. glomerata*. In *C. rivularis* the shells of its Sonari population are greater in dimension and thickness than those of the Korangi Creek population, and there is also a differential orientation in the two populations. In all the five populations of the three species the length/height relationship has always been curvilinear and that of the width/height linear. The indices of shape show that there is a great variation in the shells of the wild and exploited populations of these species. The difference in the pattern of growth of the shells of these populations seems to be influenced by ecological factors like the density of population, surf action, and exposure trait.

Introduction

A review of literature on allomteric growth (relative growth of body parts) of molluscs is given by Wilbur and Owen[18] and the noteworthy work in this aspect on several species of bivalves is largely related to mussels[6, 9, 13-15], clams[4, 7, 17] and scallops.[10] Oysters, being sedentary in habitat, however, present quite a difficult problem to this study and thus little has been reported in this connection (*Crassostrea angulata*,[12] *C. virginica*).[5] So far as the oysters of the coast of Karachi are concerned, none has reported allometric growth of these oysters. The three species under consideration are identified as *C. rivularis* Gould, *Saccostrea glomerata* Gould and *S. cuccullata* Born, on the basis of Ahmed[1] and the recent review of the nomenclature of oysters[16] (and personal communication from J. B. Glude and T. Habe). In this paper an attempt has been made to throw light upon the allometric growth of the five populations of these oysters in relation to certain ecological factors.

Material and Method

Random sampling of *Crassostrea rivularis* was done from Korangi Creek (18 miles south of Karachi) and Sonari (40 miles west of Karachi): of *Saccostrea glomerata* from Manora Channel and Korangi Creek and of *S. cuccullata* from Gadani Beach (35 miles west of Karachi) at monthly intervals from June 1971 to July 1972. The height, length and width of the oysters (Fig. 1) were measured according to the definitions of these parameters by Yonge.[19] The monthly samples, consisting of 60-70 oysters, did

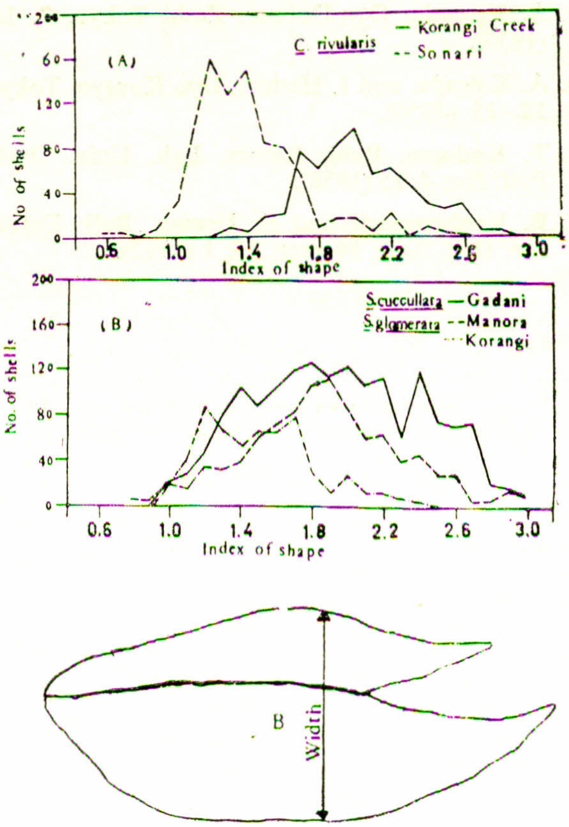

Fig. 1. Index of shape height+width. (A) *C. rivularis* from Korangi Creek area exploited stock, broken line) and from Sonari (unexploted stock, solid line; (B) *S. cuccullata* (solid line); *S. glomerata* from Korangi (broken line with dots.)

not show any definite pattern and the data for the whole year were added and their mean, range and coefficient of variation was calculated (Table 1). Linearity between length and height or width and height was calculated according to the following equation :

$$Y = \bar{Y} - r\frac{\delta x}{\delta y}(X - \bar{X})$$

(where Y is the length or width, $\bar{Y}$ is the mean length or width, r is the correlation coefficient between length and height or width and height, X is the height, and the $\bar{X}$ mean height, with δx and δy being the standard deviation of X and Y respectively). To arrive at the definite shape of the oysters their indices of shape were calculated according to the formula of Crozier,[4] i.e. height + width/length, and their values are plotted in Fig. 2.

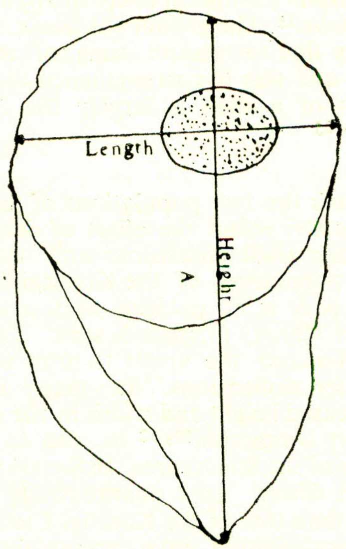

Fig. 2. The principal axis and the measurement of height and length (A) and of width (B), (*S. cucculIata*)

Observations and Results

Among the three species studied, *C. rivularis* is an inhabitant of muddy environment. In the Korangi Creek, where this species is exploited, the shells are scattered and apparently there exists no space competition, while the wild population of Sonari is crowded and short of space, which presumably resulted in differential mode of attachment in the two areas. In the Korangi Creek, where there is no space problem, the oysters are attached to the rocks or stones horizontally, while those of Sonari grow upward with the umbo downwards. In *S. glomerata* the individuals are generally scattered in the Korangi Creek but crowded in Manora. In the latter locality they are exposed to air and subjected to a somewhat greater surf action; however, in both cases they are attached to rocks or stones horizontally. *S. cuccullata* which is found on the exposed rocks near the high water mark at Gadani Beach are crowded. But in *S. glomerata* and *S. cuccullata* the crowding is never so intensive as observed in *C. rivularis* of the Sonari population.

The results of shell dimensions of all the three species are shown in Table I, which indicates that the population of *C. rivularis* growing in Sonari has greater shell dimensions as compared to those of the Korangi Creek; *S. glomerata* of the Korangi Creek; and among the three species the shell dimensions of *C. rivularis* is found to be far greater than that of the other two species.

Relation between length and height, width and height of the shells. For comparison among individuals of the same species from different localities and also among different species, the rate of increase of length and width in relation to height in five populations of the species is computed according to the equation of sample regression. On computation of the equation of sample regression in *C. rivularis*, it is found that the rate of increase of length in relation to height is linear upto the height of 8 cm. and then it declines to some extent, indicating a curvilinear relationship between these parameters in both populations of the Korangi Creek and Sonari. For width against height the equation of sample regression show linearity in the two parameters and the equations for the localities are as follows:

$$Y = 2.0396 - 0.7711\frac{1.1250}{2.9682}(X - 6.3976) \quad \text{(Korangi Creek)}$$

$$Y = 3.7199 - 0.8467\frac{1.8812}{5.4550}(X - 11.605) \quad \text{(Sonari)}$$

The correlation coefficients between the width and height of the shells of Korangi Creek and that of Sonari populations are 0.7711 and 0.8467 respectively, which suggest that the latter population acquires greater width in relation to height than that of the former population.

In *S. glomerata* a curvilinear relation exists between the length and height and a linear relation between width and height of the shells in the populations of Manora and Korangi Creek like *C. rivularis*. On computation of the equation of sample regression for the rate of increase of length against height for the two localities, it is found to be linear upto the height of 5 cm and then it declines. The correlation coefficients in the two populations are 0.660 and 0.715 respectively, indicating that the shells of the Korangi Creek population are greater in length in comparison to height than those of Manora. For width against height the equations of sample regression for the localities are as follows:

$$Y = 1.1226 - 0.5282\frac{0.5086}{1.2453}(X - 3.749) \quad \text{(Manora)}$$

$$Y = 0.7870 - 0.5269\frac{0.4530}{1.3770}(X - 4.306) \quad \text{(Korangi Creek)}$$

The correlation coefficients between width and height are 0.5282 and 0.5269 in the shells of the Manora and the Korangi Creek respectively, suggesting that a little greater width is acquired in relation to height by the former population than that of the latter.

In *S. cucullata* the relationship in between length and height and that of width and height are curvilinear and linear respectively like the other two species. The rate of increase of length in relation to height is found to be linear upto 5 cm as in *S. glomerata*. The equation of sample regression obtained for the width and height is as follows:

$$Y=1.798-0.7948\frac{1.0478}{2.1062}(X-5.0236)$$

When the correlation coefficients of the two species of genus *Saccostrea* are compared, it is obvious that the increase in length and width in relation to height is greater in *S. cucullata* than in *S. glomerata*, which may be due to the fact that *S. cucullata* is exposed to water front and has to face greater surf action than the two populations of *S. glomerata.*

Shape index. The shape of the shells varies considerably under the influence of many ecological factors, and this variability is sometimes indicated by the index of shape. It is evident that the spread of the indices is very high in all the five populations of the oysters (Fig. 2-A and 2-B), suggesting great variability in the shell shape of the oysters. In *C. rivularis* the absolute density of the population of the Korangi Creek (exploited stock) is 1.2 (Fig. 2-A), indicating that majority of the shells of these oysters are nearly round and shallow as the additive products of height and width is not much greater than the length. On the contrary, the absolute density in Sonari population is 2.0 (Fig. 2-A), indicating that majority of the shells of *C. rivularis* in this population are elongated and deeply cupped than those of Korangi Creek. In *S. glomerata* the absolute densities are 1.9 and 1.2 in the populations of the Manora Channel and Korangi Creek respectively, indicating that the growth of height plus width in relation to length is greater in the population of the Manora Channel than that of the Korangi Creek. In *S. cucullata* of Gadani the absolute density is 1.8 as in the *S. glomerata* of the Manora Channel (Fig. 2-B).

Discussion

It is obvious from the results of the observations that *C. rivularis* attains greater dimensions than the other two species, namely, *S. glomerata* and *S. cucullata. C. rivularis* is an inhabitant of muddy environment with low surf action and containing high organic material resulting in rich phytoplankton production (personal communication with Dr. Saifullah). This presumably has helped the species to attain greater dimensions of the shell than the other two species, which are specifically inhabitants of a rocky shore with high surf action. In *S. glomerata* this presumption requires further consideration because the species is not only found on rocky shore but also in muddy environment. This species is always present at higher water level than *C. rivularis* and the difference of habitat and also in their genera has perhapes, helped to acquire greater dimension in *C. rivularis* than *S. glomerata.* The dimensions of *S. cucullata* fall closer to *S. glomerata* (particularly from the Korangi Creek) than *C. rivularis* and the main difference between the two species is reflected in the width and thickness of the shell, which is much greater in *S. cucullata* than *S. glomerata. S. glomerata* is deeper in its habitat than that of *S. cucullata* and the latter species is an inhabitant of the open sea front having strong surf action. The greater time of exposure to air has possibly influenced *S. cucullata* to acquire greater width for holding water within the shell to respire during exposure to air, as suggested in *Mytilus edulis.*[15] The greater thickness of the shell is presumably due to greater time of exposure in *S. cucullata* and this has strengthened the view that the thickness of a shell is largely the function of exposure.[3, 9, 15]

In *C. rivularis* the two populations of the Korangi Creek and Sonari reflect the effect of density of the oysters on their shell dimensions and their orientation. The population of the Korangi Creek is exploited and space is no problem while in the population of Sonari scarcity of space is seen. This presumably has influenced the shells to grow upward and acquire greater dimensions. In many species of molluscs increased height and width in the population of high density is reported[10, 12] as seen in the shells of *C. rivularis* of the Sonari area. In Sonari the salinity (40-42%) and silting (not quantitatively measured) are greater than that of the Korangi Creek (36%). These ecological factors have, presumably, affected the thickness of the shells, as the shells of the Sonari population are thicker than those of the Korangi Creek population. Similar effects are reported in *Mytilus edulis.*[13]

In the five populations of the three species a more or less linear relationship exists between shell width and height but the rate of increase of shell length to height becomes steep slightly with the growth of the shell. In *S. glomerata* the rate of increase of shell length in relation to height is greater in the population of Korangi Creek than that of Manora but a low rate of increase in the shell width in relation to height in the later locality is observed, which may be due to lesser surf action in Korangi Creek.

The indices of shape in the five populations of the oysters show great variablity in the shell shape specially in their wild populations. Generally the wild stock of *C. rivularis* of the Sonari population is elongated and deeply cupped while it is round and shallow in the Korangi Creek. In the majority of the populations of the Korangi Creek height plus width varies closely with length of the shell while in the Sonari the population shell height plus width varies twice as great as the length. In *S. glomerata* a similar difference between the two populations of Manora and the Korangi Creek exists, which may the fact that the latter is thinly populated and greatly be due to exploited. This difference in the index of shape in the exploited and wild populations has also been reported in *C. virginica*.[5]

Acknowledgments. I wish to express my gratitude to Prof. S. M. Haq, Director, Institute of Marine Biology, University of Karachi, for his guidance, encouragement and useful criticism during this work. I am highly indebted to Dr. J. B. Glude, Deputy Regional Director, Marine Fisheries, Seattle, USA and T. Habe, Chief and Curator, Mollusca Division, National Museum, Japan, for confirming the identification of the species referred to in this paper.

References

1. M. Ahmed, Pakistan J. Zool., **3** (2), 230-34 (1971).
2. P. R. Awati and H. S. Rai, Indian Zool. Mem., **3,** 107 (1931).
3. R. H. Baird and R. E. Drinnan, J. du Cons., **22,** 329-336 (1957).
4. W. J. Crozier, Zool. Jawbibucher, *Ableilungfur Anatomia und Ontogenie der Tiere,* Band, **38,** 577-598 (1914).
5. P. S. Galtsoff, U. S. Wildlife Serv. Fish. Bull., **64,** 480 (1964).
6. S. Genevese, Atti. Soc. pilorit. Sci. Fis. Mat. Nat., **7,** 333-53 (1960).
7. N. A. Holmes, J. Mar. Biol. Assoc. U. K., **41,** 405-722 (1961).
8. H. Leenhardt, Inst. Oceanogr. Anales, New Ser., **3** (1), p. 90 (1926).
9. C. M. Lent, Chesapeak Sci., **8** (4), 221-27 (1967).
10. J. Mason, J. Mar. Biol. Assoc. U. K., **36,** 437-92 (1957).
11. Ohba, Biol. J. Okayama Univ., 2, 169-73 (1956).
12. J. H. Orton, Nature, **133,** 466-67 (1936).
13. R. Seed, J. Mar. Biol. Assoc. U. K., **48** (3), 561-84 (1968).
14. R. Seed, Ocecologia (Berl.), **3,** 317-50 (1969).
15. R. Seed, Proc. Malac. Soc. Lond., **40,** 343-57 (1973).
16. H. B. Stenzel, Mollusca, **6** Bivalvia, Oysters, 3 (Part N), N1128-N1137 (1971).
17. E. P. Swan, Ecol., **33,** 365-74 (1952).
18. K. M. Wilbur and G. Owen, *Physiology of Mollusca,* **1,** 211-42 (1964).
19. C. M. Yonge, Collins, St. James Place, London, p. 200 (1967).