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The autecology of the edible oyster Crassostrea cucullata Born, 1778: size related vertical distribution at Mkomani, Mombasa

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SUMMARY

The littoral oyster *Crassostrea cucullata* occurs between 1.05-3.35 m above chart datum with the highest density occuring between 1.85-2.75m. Its distribution is size-related as demonstrated by computation of correlation coefficients *(r)* and regression equations. The shell lengths (i.e. maximum linear dimension) decreases in an upshore direction. The analysis show high *r*-values which are significant at $p<0.001$. The equations and the *r*-values are as follows: 1. for the lower level oysters between 1-1.85 m: $y = 43.64 - 6.49\,x$, $r = -0.659$; 2. for the mid-level oysters between 1.86-2.75 m: $y = 62.67 - 17.14\,x$, $r = -0.941$; and 3. for the high level oysters between 2.76-3.35 m: $y = 91.44 - 24.85\,x$, $r = -0.899$; where y stands for the mean shell length (mm) and x is the mean height (m) above datum. The elevation and density related effects on the shell lengths of the oysters are discussed.

INTRODUCTION

Crassostrea cucullata is a littoral oyster found on the trunks, stilt roots and pneumatophores of mangrove plants and rocky substrata in brackish-marine environments. Zoogeographically it is an Indo-West Pacific species (Day 1974). The ecological studies of this species in the western Indian Ocean from the Seychelles (Taylor 1968), Aldabra (Taylor 1970), Tanzania (Hartnoll 1976), Somalia (Chelazzi and Vannini 1980) and Kenya (Ruwa 1984), indicate that it is abundantly found in the upper eulittoral zone following the shore terminology of Lewis (1964) and Hartnoll (1976). In some cases its upper limit is known to be slightly (0.3-0.5 m) above the mean high water spring tide level, probably changing with wave action (Hartnoll 1976; Chelazzi and Vannini 1980)

Various studies on vertical distribution of molluscs on the sea shores have demonstrated that they may be size-related both interspecifically and intraspecifically (Vermeij 1972, 1973; Ruwa and Brakel 1981). Similar quantitative studies on *Crassostrea cucullata* are non-existent to the best of our knowledge. Since this is an economically important species which can be cultured (Van Someren and Whitehead 1961) this study was aimed at defining the levels which support large sizes of oysters and where they are found in highest densities on the cliffs.

The tides on which the oysters depend for their filter feeding (Morton 1977) exhibit a large range in this portion of the western Indian Ocean and are semi-diurnal. According to Brakel (1982) the average tidal ranges at spring tide days and neap tide days are 3.2 m and 1.0 m respectively. The extreme high water spring (EHWS) is 4.0 m above chart datum; mean high water spring (MHWS), 3.5 m; mean high water neap (MHWN), 2.4 m; mean low water neap (MLWN) 1.4 m; mean low water spring (MLWS), 0.3 m; and the extreme low water spring (ELWS), — 0.1 m.

MATERIALS AND METHODS

The study was carried out at Mkomani rocky cliffs, Mombasa (figure 1), on a randomly chosen population of *Crassostrea cucullata* covering an area measuring about 4 x 2.5 m on a vertically rising cliff in March/April 1985.

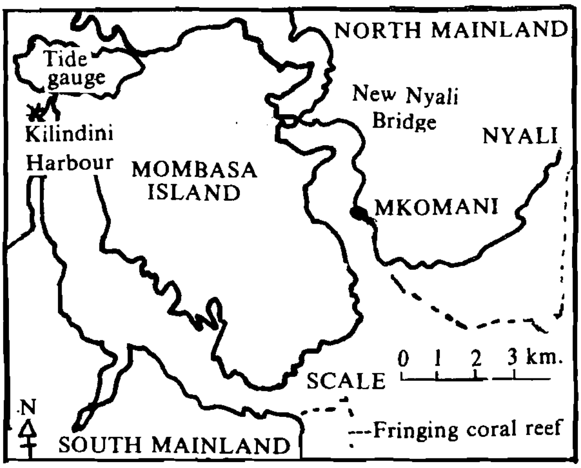

Figure 1: Map of the study area.

The shell lengths (i.e. maximum linear dimension) of all live oysters in this population were measured using vernier callipers to the nearest 0.1 mm in consecutive 10 cm vertical bands going perpendicualrly upwards to the base of the cliff to as far as the oysters were encountered. From several measurements of the time at which the water level reached the base of the cliff during the calm water around neap tide days, the height of the base above datum was determined according to the Kenya Ports Authority (1985) tide tables. This enabled the heights of the oyster bands to be expressed above datum.

RESULTS

A total of 1470 oysters were measured. From these measurements a frequency table for each oyster band was made at the following size intervals: 1.0 - 10.9 mm, 11.0 - 20.9 mm, 21.0 - 30.9, 31.0 - 40.9 mm, 41.0 - 50.9 mm and 51.0 - 60.9 mm, to study the changes of the modal class from one level of the oyster band to the other. From these data, percentages were worked out and used to construct histograms (figure 2).

The histograms showed that the modal class shifts left-wards, towards the y-axis when traced from the lowest to the highest oyster levels. The modal class shifted from size range 31.0 - 40.9 mm at the levels between 1.0 - 1.10 m and 1.80 - 1.90 m to size range 21.0 - 30.9 mm at the levels between 1.90 - 2.00 m and 2.20 - 2.30 m. It then subsequently shifted to 11.0 - 20.9 mm at the levels between 2.30 - 2.40 m and 3.00 - 3.10 m and finally to size range 1.1 - 10.9 mm at the levels between 3.10 - 3.20 m and 3.30 - 3.40 m.

The mean heights (elevation) of the oyster bands and the mean shell sizes of the oysters were computed. The mean shell sizes were then plotted against elevation (figure 3). Figure 3 shows that three linear regressions could conviniently be fitted to describe the relationship. The regression equations were calculated and fitted. The correlation coefficients *(r)* were all significant ($p<0.001$) and negative.

A further comparison was made to find out if there were density related effects on the mean shell lengths of the oysters with height on the cliffs. To facilitate the comparisons plots of the number of oysters per band at each mean height or elevation were plotted along with their values of mean shell lengths in figure 3. The densities at the peaks and troughs indicated with the alphabetical letters A to J were used for comparisons.

The area between 1.85 and 2.75 m above datum had the highest density of oysters. The comparisons showed that even for almost similar numbers of oysters e.g. B and E, C and J, D and F; the samples B, C and D at lower levels had bigger mean shell lengths than their counterparts. Similarly, even for situations where, for example, D and G, F and I, H and J where D, F and H are lower level samples with larger numbers of individuals than their counterparts they still showed bigger mean shell lengths. These results indicate that the changes in mean shell size between the lower and higher level oysters are independent of their densities.

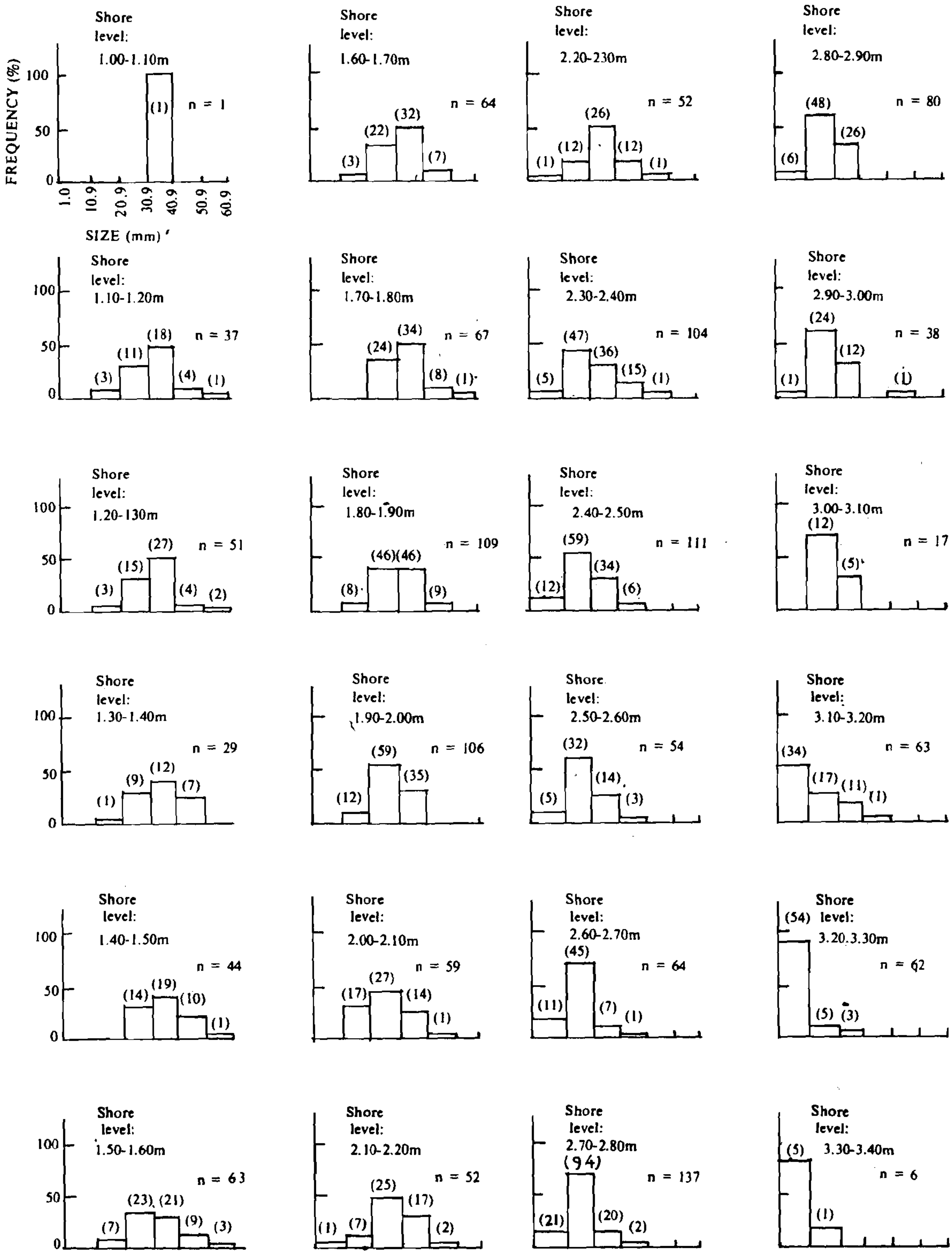

Figure 2: Histograms to show distribution of *Crassostrea cucullata* born by size classes in various levels of the cliff. The number of oysters in each size class are shown in parentheses and n stands for total number of oysters.

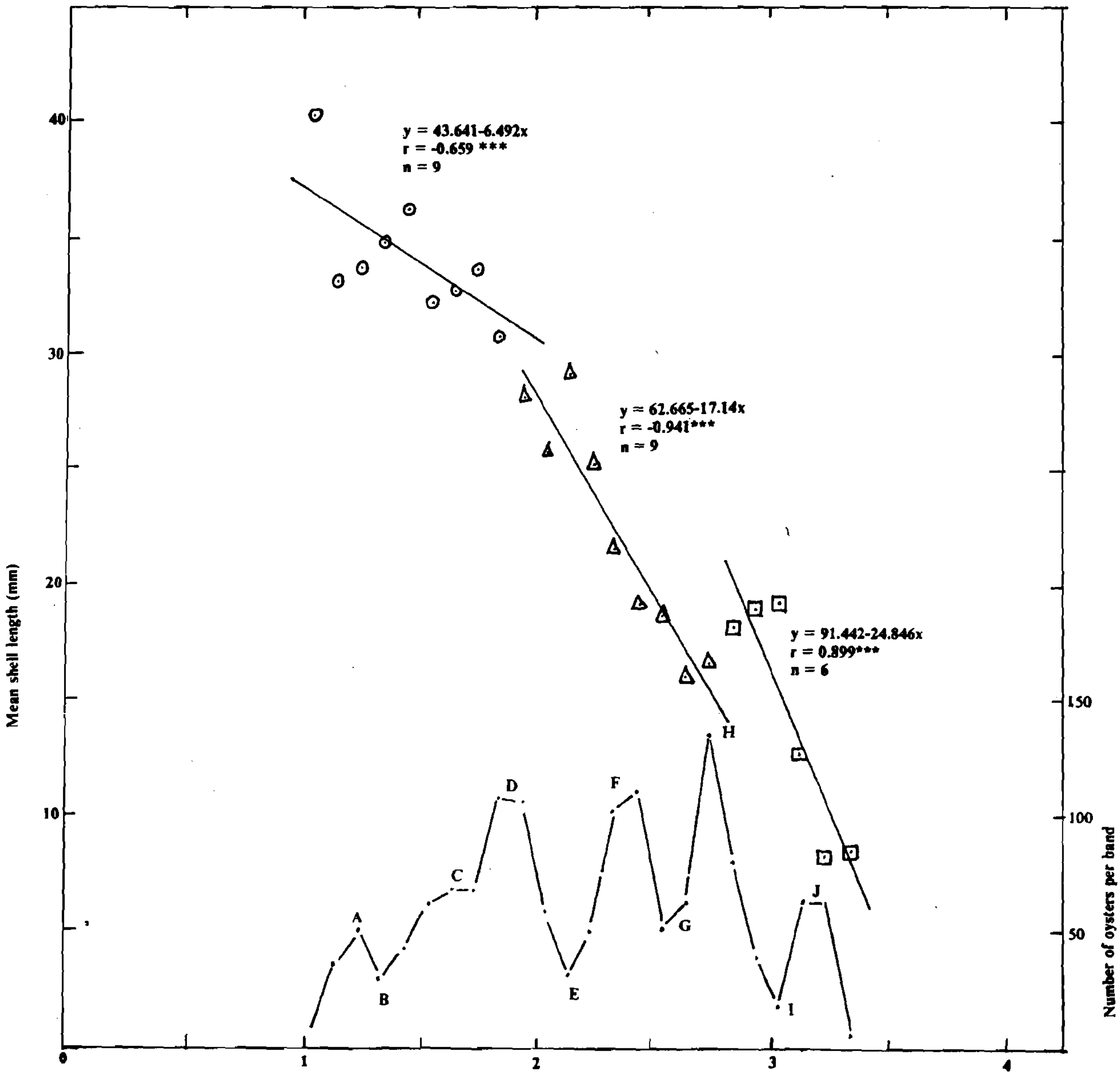

Figure 3: Density and relationship between mean shell lengths of *Crassostrea cucullata* born and shore levels (elevation) above datum.

DISCUSSION

The high negative correlation coefficients *(r)* significantly ($p<0.001$) demonstrate that *Crassostrea cucullata* exhibits size-related patterns in its vertical distribution with an upshore reduction in shell length. The results clearly show that the upshore reduction in shell length is caused by the abundance of small-sized oysters in the upper levels whereas conversely, the lower levels support a larger number of relatively bigger-sized oysters. A similar type of size gradient was described in the filter feeding mussel *Mytilus edulis* L. populations by Newcombe (1935) and Seed (1968). They showed that the growth rate in this mussel at lower levels was greater than at higher levels. Thus the lower level mussels grow to larger sizes than the higher level ones. From our study we do not have data on growth rates and of ages of the oysters for comparison. However, from the knowledge that oysters are filter feeders which depend on the high tides for their feeding action to take place (Morton 1977) and that the duration of continuous submersion and frequency of the latter decrease in an upshore direction, it seems likely that the causes and consequences are the same as those of the equally filter feeding mussels. The longer duration and higher frequency of submersion allows the lower level oysters to acquire more food because they can feed for longer periods and consequently grow faster than their higher level counterparts.

There are demonstrations that in some littoral bivalves density may affect their growth rates and size (Trevallion, Edwards and Steel 1970). In our study it can be notably seen that at non-successive levels the mean shell size is still larger for oysters in comparatively lower levels even for situations where the lower level samples have larger numbers of individuals than the higher level samples. The difference in size between the lower and higher level oysters may therefore principally be due to the differences in the duration and frequency of feeding periods rather than their differences in densities.

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REFERENCES:

Brakel, W.H. (1982). Tidal patterns on the East African coast and their implications for littoral biota. *UNESCO/ALESCO Symposium on the Coastal and Marine Environment of the Red Sea, Gulf of Aden and Tropical Western Indian Ocean.* The Red Sea & Gulf of Aden Environmental Programme. Jeddah: UNESCO/ALESCO, 2: 403-418.

Chelazzi, G., and M. Vannini (1980). Zonation of intertidal molluscs on rocky shores of southern Somali. *Estuarine Coastal Mar. Sci.* 10: 569-583.

Day J.H. (1974). *A Guide to Marine Life of South African Shores.* 2nd edition. Cape Town: Balkema, 300pp.

Hartnoll, R.G. (1976). The ecology of some rocky shore in Tropical East Africa. *Estuarine Coastal Mar. Sci.* 4: 1-21.

Kenya Ports Authority (1985). *Tide Tables for East African Ports.* Mombasa: Rodwell Press Ltd., 48 pp.

Lewis J.R. (1964). *The Ecology of Rocky Shores.* London: Hodder & Stoughton Ltd., 323 pp.

Morton B.S. (1977). The tidal rhythm of feeding and digestion in the Pacific oyster, *Crassostrea gigas* (Thunberg). *J. Exp. Mar. Biol. Ecol.* 26: 135-151.

Newcombe, C.H. (1935). A study of the community relationships of the sea mussel, *Mytilus edulis* L. *Ecology* 16: 234-243.

Ruwa, R.K. (1984). Invertebrate faunal zonation on rocky shores around Mombasa, Kenya. *Kenya Journal of Science and Technology series B,*5(1 and 2): 49-65.

Ruwa, R.K. and Brakel, W.H. (1981). Tidal periodicity and size-related variation in the zonation of the gastropod *Nerita plicata* on an East African rocky shore. *Kenya Journal of Science and Technology Series B* 2 (2): 61-67.

Seed, R. (1968). Factors influencing shell shape in the mussel *Mytilus edulis*. *J. Mar. Biol. Assoc. U.K.* 48: 561-584.

Taylor, J.D. (1968). Coral reef associated invertebrate communities mainly Molluscan) around Mahe, Seychelles. *Philos. Trans. R. Soc. London Ser. B.* 254: 129-206.

———. (1970). Intertidal zonation at Aldabra atoll. *Philos. Trans. R. Soc. London Ser. B.* 260: 173-213.

Trevallion, A., Edwards, R.R.C., and Steel, J.H. (1970). Dynamics of a benthic bivalve, pp. 285-295. In: J.H. Steel (ed) *Marine Food Chains*. Los Angeles: University of California Press.

Van Someren, V.D. and Whitehead, P.J. (1961). An investigation of the biology and culture of an East African oyster, *Crassostrea cucullata*. *Fishery Publication* No. 14; 30 pp.

Vermeij, G.J. (1972). Intraspecific shore-level size gradients in intertidal molluscs. *Ecology* 53(4): 693-700.

———. (1973). Morphological patterns in high intertidal gastropods:: Adaptive strategies and their limitations. *Marine Biology* 20: 319-346.

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