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Comparative Morphological Characteristics of Mangrove Oysters

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Three kinds of mangrove oysters, species of high commercial value in tropical regions, were collected in Cocineta Bay, Venezuella in 1976, at the mouth of Hoffman River, Liberia in 1978 and at the West Coast of Benzina, Indonesia in 1984.

Crassostrea rhizophorae from Venezuella showed the most round shell form and greatest shell capacity. In addition, the fatness condition of 9.63% topped the other two species.

Crassostrea tulipa inhabiting Liberia had the most elongated shell form. Although shell capacity of this species was almost similar to *Crassostrea rhizophorae*, it took up intermediate position in fatness condition with 8.15%.

Crassostrea belcheri from Indonesia, just as rounded as *C. rhizophorae*, showed the biggest values in total weight and shell weight but the least fatness with 6.62%.

Introduction

Mangrove oysters inhabiting tropical swamps are considered staple and subsistent sea food of the coastal people in places like Indonesia, Liberia and Venezuella.

Although these oysters are conmercially valuable items among the sea foods in these areas, it is not in sufficient supply owing to the fact that nearly every fisherman is only interested in cathing wild stock. In addition, overfishing and industrial pollution have nowadays greatly reduced wild mangrove oyster population in these areas.

Until present time, the oyster culture techniques used in these areas are rather primitive and progress is slow and retarded by poor financial support from the authorities concerned, although the state governments give fresh impetus to promote all the forms of oyster culture in order to increase the supply of protein foods and improve the living standard of fishermen and coastal inhabitants.

Prior to the development of culture techniques, an understanding of species-specific characteristics in conjunction with their ecological environment, is an important task for planning large scale oyster culture.

There are limited reports on mangrove oyster: Chin *et al.* (1975) on general aspects, Choo(1974) on culture, Okada (1963) on culture experiment and Yoo (1979) on external morphology.

The present study describes the comparative morphological characteristics of three mangrove oyster species from Indonesia, Liberia and Venezuella in order to investigate more exact species-specific features available for feasible oyster culture in these areas.

Materials and Methods

Three kinds of mangrove oysters were sampled in three tropical waters: One hundred-twenty individuals of *Crassostrea rhizophorae* from Cocineta

Bay, Venezuella, March 14th 1976, one hundred of *C. tulipa* from at the mouth of Hoffman River, Maryland County, Liberia, August 3rd 1978, and one hundred-sixty one of *C. belcheri* from the West Coast of Benzina, Indonesia, January 3rd 1984.

The collected specimens were measured for shell length, shell breadth, shell height, total weight, live meat weight and shell weight with Vernier caliper and balance measurable down to 1/10 *mm* and 10 *mg* respectively.

From the data analized, each growth parameter was plotted dependent on the shell height increase by 10 *mm* intervals (Figs. 2a, 2b, 4a, 4b and 4c).

In order to investigate outer shell-form differences by species, the shell form index expressed in percentage of the ratio of shell length to shell height (shell length/shell height×100), and shell-capacity index in percentage of ratio of shell breadth to shell height (shell breadth/shell height×100) were compared within the same shell height ranges (40.01~70.00 *mm*) of the 3 species (Figs. 3a, 3b, 5a, 5b, Tables 1 and 2).

The fatness index expressed in percentage of ratio of meat weight to total weight, and outer shell weight index by the percentage of ratio of shell weight to total weight were studied in the same manner.

Results

The size of shell height of *Crassostrea rhizophorae* ranged from 49.50 to 140.51 *mm* with mean value of 87.16 *mm* (Fig. 1c). And *C. tulipa* and *C. belcheri* varied from 40.00 to 80.60*mm* with mean of 59.7 *mm* and from 26.58 to 64.69 *mm*, mean 45.94 *mm*, respectively(Figs. 1a and 1b).

The variation of shell length with shell height was shown in Fig. 2a. The shell lengths of all 3 species compared showed increasing tendency with shell height increment. In case of *C. rhizophorae*, above 85 *mm* in shell height the shell length had a constant value of *ca.* 60 *mm*. In the range of 40.01~70.00 *mm* in shell height, the maximum

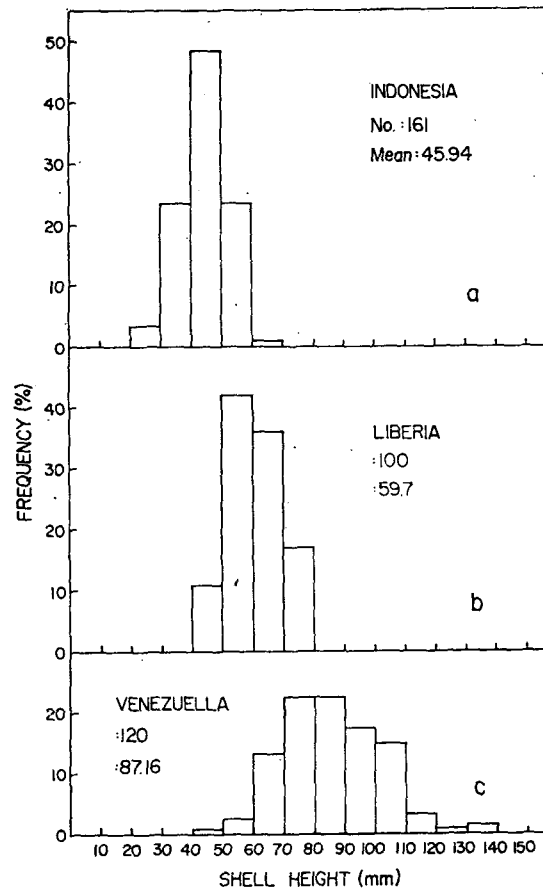

Fig. 1. Shell height distribution frequency of three kinds of mangrove oysters sampled from Indonesia(a), Liberia(b) and Venezuella(c)

mean value of shell length appeared in *C. rhizophorae* with 46.66 *mm*, the intermediate in *C. belcheri* with 39.76 *mm* and the minimum in *C. tulipa* with 35.31 *mm*. The relationships between shell length and shell height were expressed by linear equation in Table 1.

The variations of shell breadth with shell height were shown as in Fig. 2b. Both in *C. rhizophorae* and *C. tulipa*, the shell breadth increased slightly dependent on shell height increment. But when the shell height of *C. rhizophorae* reached above *ca.* 85 *mm*, it showed a stagnant or rather decreasing tendency. On the contrary, *C. belcheri* consistently decreased in shell breadth. Among 3 species, in the same shell height range falling into 45.0~65.0 *mm*, *C. rhizophorae* showed

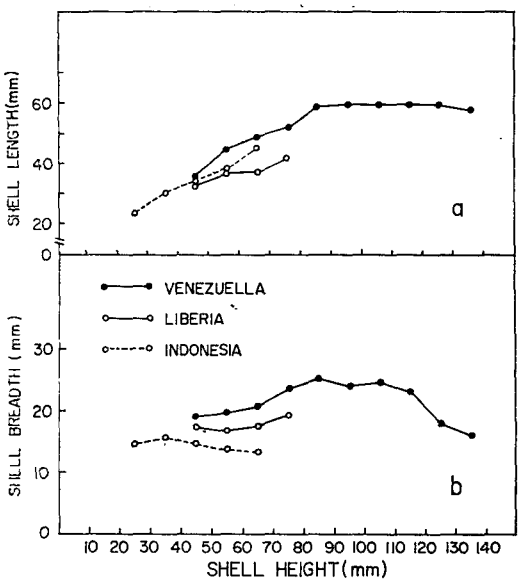

Fig. 2. The variations of shell length(a) and shell breadth(b) with shell height increase. In the upper part (a) the closed black circles denote the mean values of 54.65 and 46.66 *mm* in the total and 40.01~70.00 *mm* range of shell height respectively: dotted line with open circles 34.29 and 39.76 *mm* and straight line with open circles 37.2 and 35.31 *mm*. In the lower part (b) the closed circles shows the mean values of 23.47 and 19.92 *mm* of shell breadth in the total and 40.01~70.00 *mm* range in shell height: straight open circles 17.61 and 17.33 *mm*; dotted open circles 14.94 and 14.48 *mm*

the maximum in mean shell breadth with 19.92 *mm*, *C. tulipa* the intermediate with 17.33 *mm* and *C. belcheri* the least with 14.48 *mm*. In this shell height range, the relationships between shell breadth and height were expressed in Table 1.

The shell form index, the ratio of shell length to shell height consistently decreased with shell height increment (Fig. 3 a). In the same shell height range, the mean value of *C. rhizophorae* was the highest with 72.7, the next was in *C. belcheri* with 71.9 and the least in *C. tulipa* with 65.2.

Shell capacity index, the ratio of shell breadth to shell height ratio, functioned negatively with shell height(Fig. 3 b). Among 3 species examined,

Table 1. The linear regressions of shell length (SL) and shell breadth (SB) as a function of shell height (SH) ranging from 40.01 to 70.00 *mm* of 3 kinds of mangrove oysters

Species y=a+bx	Venezuella (*C. rhizophorae*)	Liberia (*C. tulipa*)	Indonesia (*C. belcheri*)
SL(y), SH(x)			
a	5.7224	22.8163	13.5872
b	0.6423	0.2413	0.4555
r	0.6182	0.7963	0.8856
SB(y), SH(x)			
a	0.3957	12.6426	17.4749
b	0.2491	0.0803	−0.0603
r	0.7749	0.6812	−0.0939

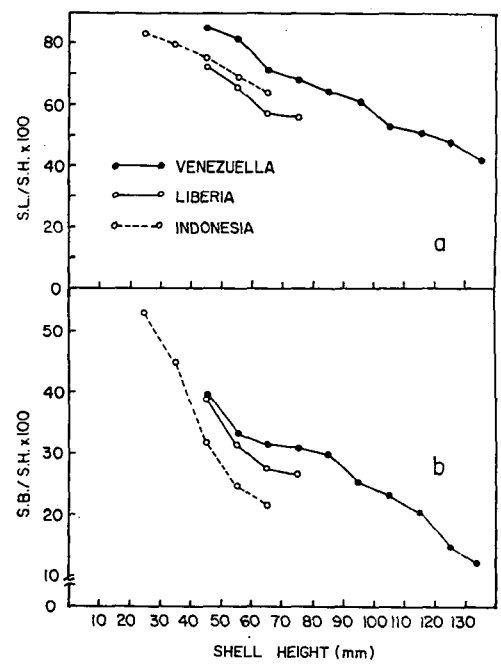

Fig. 3. The variations of shell form index expressed by SL(shell length)/SH (shell height)×100 and of shell capacity index by SB (shell breadth)/SH(shell height)×100. In the upper part straight line with closed circles denotes the mean values of 60.84 and 72.70, in the total and 40.01~70.00 *mm* range of shell height: dotted open circles 63.15 and 65.20, and straight open circles 75.75 and 71.90. In the lower part closed circles show the mean values of 25.46 and 32.86: straight open circles 31 and 32.60, and dotted open circles 35.23 and 26.00

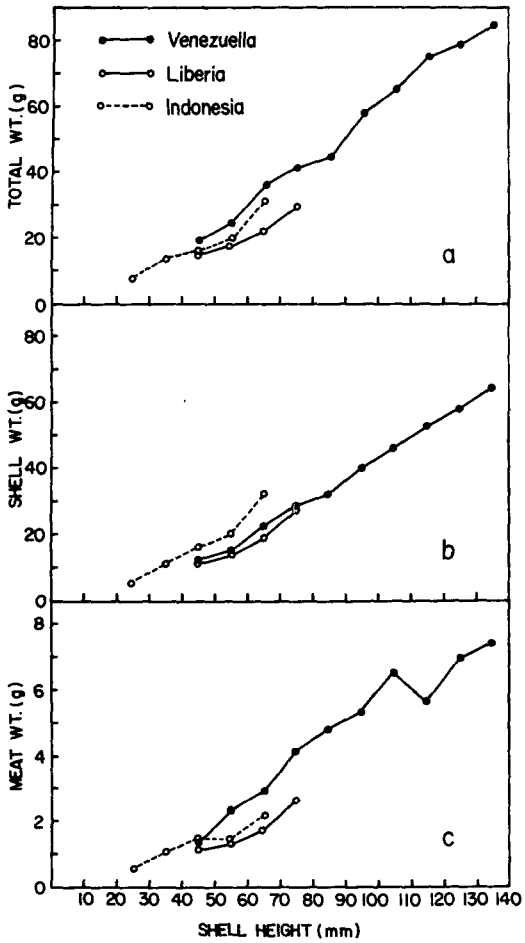

Fig. 4. The variations of total weight (a), shell weight (b) and meat weight (c) with shell height increase. In the upper part closed circles show the mean values of 49.48 *g* in total shell height range and 28.77 *g* in 40.00~70.00 *mm* range: dotted open circles 19.03 and 18.93 *g*, and straight open circles 20.41 and 18.91 *g*, respectively. In the middle part, dotted open circles indicate 15.74 and 17.35 *g*, closed circles 34.02 and 16.23 *g*, and straight open circles 17.42 and 15.04 *g*, respectively. In the lower part closed circles 4.64 and 2.72 *g*, dotted open circles 1.32 and 1.32 *g*, and straight open circles 1.67 and 1.58 *g*, respectively

C. rhizophorae showed the maximum in its mean value in the shell height range of 45~65 *mm*, *C. tulipa* the intermediate with 32.6. *C. belcheri* decreased more sharply in its value with the least of 26.

The total weight as function of shell height increased and showed the mean value of 28.77, 19.63 and 21.09 *g* in *C. rhizophorae*, *C. tulipa* and *C. belcheri* respectively (Fig. 4 a).

The shell weight invariably increased as a function of shell height as shown in Fig. 4 b. The mean value of *C. belcheri* in the shell height range of 45.0~65 *mm* came out at the top with 17.35, *C. rhizophorae* occupied the intermediate with 16.23 and *C. tulipa* the lowest with 15.04 *g* respectively.

The wet meat weight was outweighed in *C. rhizophorae* with mean value of 2.72 in the common shell height range. Those of *C. tulipa* and *C. belcheri* were 1.58 and 1.32 *g* respectively (Fig. 4 c).

The shell weight index expressed by the percentage of shell weight to total weight ratio was shown in Fig. 5 a. *C. rhizophorae* decreased slightly with shell height by showing the mean of

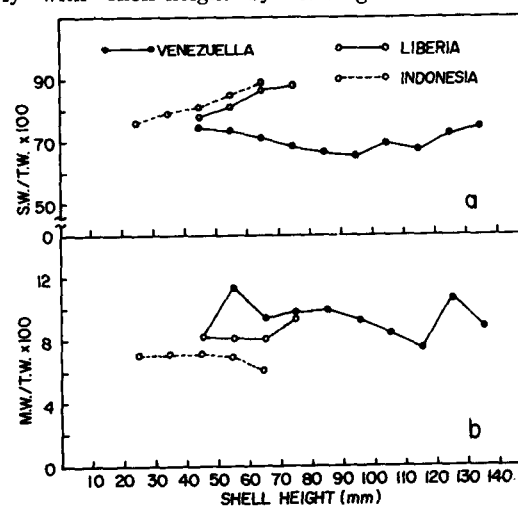

Fig. 5. The variations of shell weight index (upper part) and fatness index (lower part) with shell height increase. In the upper part dotted open circles denote the mean values of 80.25 and 86.29 in the total and 40.01~70.00 *mm* in the range of shell height: straight open circles 85.58 and 81.86, and closed circles 70.39 and 73.26, respectively. And the initial SW means shell weight, TW total weight and MW meat weight

73.26. Instead C. *belcheri* and C. *tulipa* had some reversed tendencies by showing 86.29 and 81.86 respectively. And the corelations between species were depicted in Table 2.

The fatness index, the percentage of meat weight to total weight ratio, remained unchanged with shell height in *C. belcheri* with the mean of 6.62, the least of compared. In *C. rhizophorae*, it decreased suddenly above the shell height of 85 *mm*. Below 65 *mm* in shell height, it had undefined variation with the maximum of 9.63. *C. tulipa* showed some constant index within the shell height range of 45~65 *mm* with the intermediate mean of 8.15. This relationship between meat weight and total weight was expressed by linear regression line in Table 2.

Table 2. The linear regressions of meat weight (MW) and shell weight (SW) as a function of total weight (TW) in the range of 40.01~70.00 *mm* in shell height of 3 kinds of mangrove oysters

Species y=a+bx	Venezuella (*C. rhizophorae*)	Liberia (*C. tulipa*)	Indonesia (*C. belcheri*)
MW(y), TW(x)			
a	0.7369	0.2700	0.3201
b	0.0690	0.0670	0.0530
r	0.6258	0.7630	0.8414
SW(y), TW(x)			
a	0.4944	1.5910	0.3518
b	0.6994	0.8060	0.7753
r	0.9867	0.8676	0.9470

Discussion

Shell shape of bivalve is extremely variable and depends not only on environmental conditions but also on the age of the animal(Seed, 1968). In addition, the Pacific oyster *Crassostrea gigas* is greatly affected in shell form including shell size, fatness index and water content by local situations (Yoo *et al.* 1972 and 1973). From the viewpoint of this morphological characteristics dependent on locality, such parameters as the ratios of shell breadth to shell length and meat weight to shell weight can be used as indicators for oyster species (Yoo, 1971 and 1977).

As the habitats of mangrove oysters are frequently exposed to extreme variations in salinity (22 to 40%) caused by heavy rainfall and drought, the inner and outer morphological variations are subjected to their locality. For example, fatness of Malaysian mangrove oyster heavily decreased in periods immediately after heavy and continual rains(Chin *et al.*, 1975).

Comparing the shell forms of three mangrove oysters, *Crassostrea rhizophorae* from Venezuella showed the highest shell form index(shell length /shell height×100) of 72.7 and the highest value of shell capacity index (shell breadth/shell height ×100) of 32.86 (Figs. 3a, 3b and Table 1). This means that this species is characteristic of most rounded and convex shell shape. The more convex the shell shape is, the more meat it may contain in its shell cavity. This fact can be supported in Figs. 4c, 5a and Table 2 which show the maximum meat weight value of 2.72 *g* and the highest fatness index value of 9.63.

Crassostrea belcheri from Indonesia had very similar outer shell form with *C. rhizophorae* in that it showed almost the same value of shell form index of 71.9 (Fig. 3a). However, since it had the least shell capacity index, the meat weight and fatness index were lower than the other two species (Fig. 3b, 4c, Tables 1 and 2). By the way, it is very doubtful and mysterious that this species showed a negative response of shell length to the shell height increment as shown in Table 1 and Fig. 2 b. Whether this phenomenon may result from samping error or from species-specific growth characteristics should further be studied based on year-round survey.

Crassostrea tulipa from Liberia revealed somewhat elongated shell form compared the other two species in that it showed the lowest shell form index value of 65.2 (Fig. 3a and Table 1). On the contrary, in shell capacity index, it had almost similar value with *C. rhizophorae*(Fig. 3b). In spite of wide shell cavity favorable for more

meat contents, it gave intermediate fatness index value owing to its highest shell weight index (shell weight/total weight×100)(Figs. 5a, 5b and Table 2).

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Mangrove Oyster의 形態 比較

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열대수역에 서식하는 3종류의 Mangrove 굴을 대상으로 하여 각각의 형태적 특성을 비교하였다.

Venezuella 산인 *Crassostrea rhizophorae* 는 가장 둥근형태이며 각내용적(殼內容積)이 가장 컸다. 비만도도 가장 높아 9.63%였다.

Liberia 산인 *Crassostrea tulipa* 는 외형에서 가장 길죽한 형태이며 각내용적은 크지만 비만상태는 8.15%로 중간이었다.

Indonesia 산인 *Crassostrea belcheri* 는 Venezuella 산과 같이 둥근 형태이며, 전체 무게와 껍데기 무게는 가장컸지만 비만도는 가장 낮아 6.62% 였다.