J. NARA, 31, (1984) 109—122

A Comparative Study of the Morphometrics and the Proximate Composition of Two Edible Molluscs *Crassostrea cuculata* (Born) and *Perna perna* (L)

By

W. M. INDRASENA*

ABSTRACT

The morphometrics and the bio-chemical characteristics of the common oyster, *Crassotrea cuculata* (Born) and the mytilid, *Perna perna* (L) were studied.

In the oyster, the length was found to be positively correlated with breadth and total body weight. There was also a positive relationship between the total body weight and the total muscle weight. In the mytilid the total body weight was positively correlated with length and total muscle weight. The muscle weight was also found to be highly correlated with the length. In both animals the relationship between the length and the total body weight was curvilinear. In the oyster, the protein content was found to increase with the total body weight and the total muscle weight. In the mytilid the protein content increased not only with the total body weight but also with the length. In both animals, the relative content of protein is higher than that of carbohydrates, lipids and ash.

Introduction

The oyster, *Crassostrea cuculata* (Born) and the mytilid, *Perna perna* (L) are both edible, bivalve molluscs. *Crassostrea cuculata* is characterised by strong chomata which circle the entire margin of both valves. The right valve is flat and carries many growth squamae. The left valve has a large attachment area and on the surface a number of non appressed growth squamae and a series of rough irregular rounded dichotomous radial folds.

Perna perna is elongate, trigonal and large in size and is commonly known as "the brown mussel". The valves are strongly inflated particularly at the anterior region. The shell is covered with a thin brown periostracum and the interior is pearly. The brown colour is more pronounced at the ventral and posterioventral margin. The beak is close to the anterior margin and the ventral margin is entire.

* National Aquatic Resources Agency, Crow Island, Colombo 15, Sri Lanka.

Mitchel (1915), showed that the glycogen content of oysters changes with the seasons. Their chemical contents were also found to vary with the seasons, but not with the size or weight. Masumoto et al (1934) working on the oyster, *Ostrea gigas* reported that the glycogen, fat and total nitrogen content also showed seasonal fluctuations which correlated with the reproductive cycle.

Other workers who have studied the bio-chemistry of bivalves include Hatawa (1952), Venkataraman & Chari (1957), Collyer (1959) Giese (1969), Kaister et al (1969), and Idler et al (1972). Certain morphometric parameters for *Mytilus viridis* of Indo-Pacific region have been given by Kew et al (1972).

Until now very few biological studies have been carried out on Sri Lankan marine bivalves.

Perera & Arudpragasam (1966) worked on the animals living in association with *C. cuculata*. Pinto & Wignarajah (1980) who worked on the ecology of *C. cuculata* have shown that the largest number of living oysters along with spat occur during the month of April in the South West parts of Sri Lanka. This study was undertaken to obtain information regarding the morphometrics and the bio-chemistry of *C. cuculata* and *P. perna* as related species have been reported to be rich sources of protein.

Materials and Methods

Oysters and mytilids of medium size were collected from the Negombo reef. They were brought to the laboratory immersed in sea water. The parameters such as total body weight, length, weight without shell (total muscle) and maximum breadth were measured. The fresh muscle was then transferred to individual foil containers and placed in a oven maintained at 80°C. After 2–3 days, when their weight was more or less constant, they were powdered and transferred to clean, dry, glass vials and stored in a dessicator.

For the determination of protein content, Biuret reagent was used (Rayment, 1964) Total carbohydrate content was determined according to Dubois, 1956. The total lipid content was obtained using chloroform-methanol extraction method according to Floch (1957) and ash content was obtained according to the method adopted by Giese, 1967. The water content was obtained by weighing before and after drying the muscle.

Results

The relationship between log-length and log-total body weight is shown in Fig. (1) and the relationship of total body weight and total muscle weight is shown in Fig. (2). The correlation coefficient, slope, regression equations and the significance of relationships of length and breadth, length and muscle weight are shown in Tables (1) & (2).

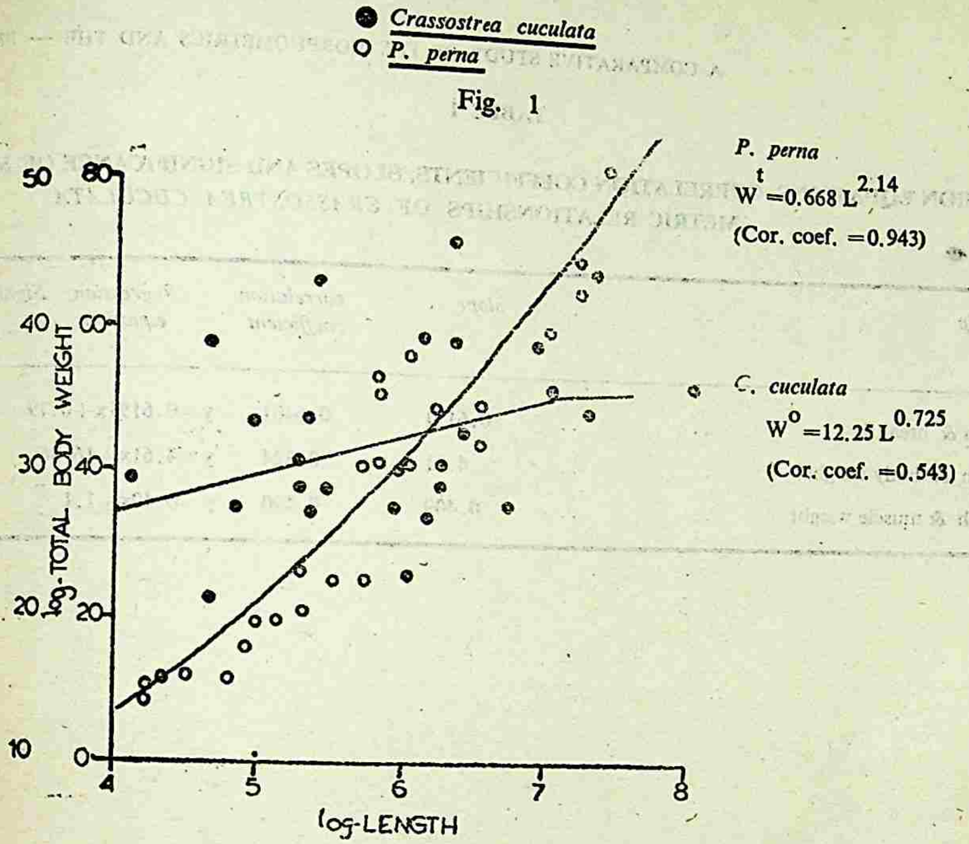

Fig. 1

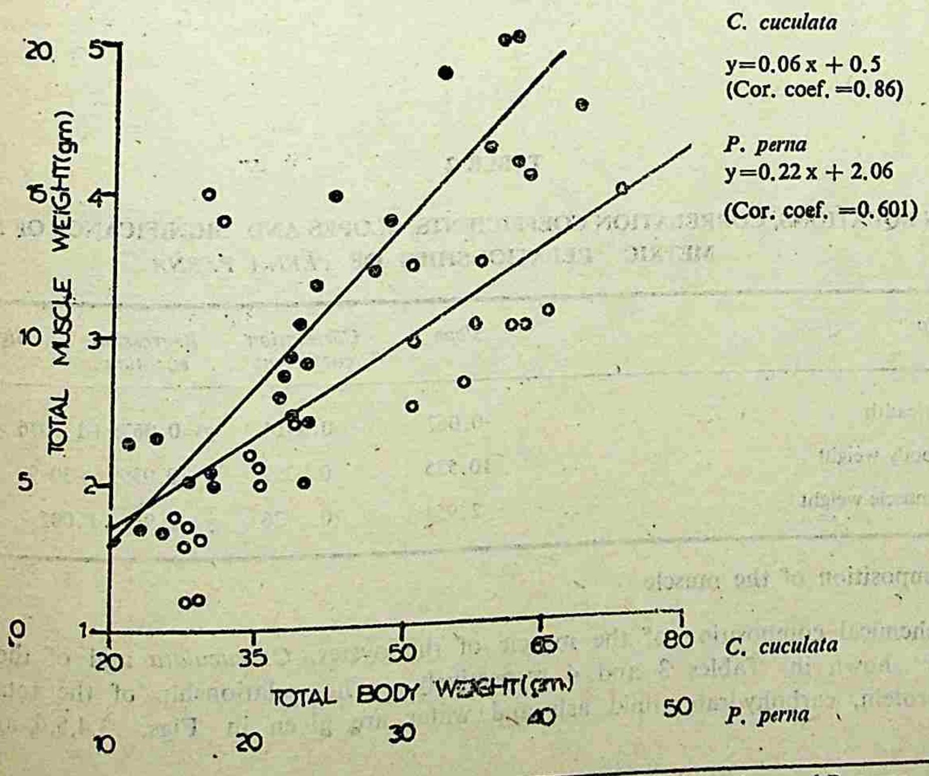

Fig. 2

Fig. 1.— Relationship between Log-length and Log-total body weight of *C. cuculata* and *P. perna*.

Fig. 2.— Relationship between total body weight and total muscle weight.

TABLE 1

REGRESSION EQUATIONS, CORRELATION COEFFICIENTS, SLOPES AND SIGNIFICANCE OF MORPHOMETRIC RELATIONSHIPS OF *CRASSOSTREA CUCULATA*

Relationship	*slope*	*correlation coefficient*	*Regression equation*	*Significance*
1. Length & breadth	0.6191	0.6401	y=0.6191x+0.79	S
2. Length & body weight	4.61	0.324	y=4.61x+16.36	NS
3. Length & muscle weight	0.409	0.390	y=0.40x+1.1	NS

TABLE 2

REGRESSION EQUATIONS, CORRELATION COEFFICIENTS, SLOPES AND SIGNIFICANCE OF MORPHOMETRIC RELATIONSHIPS OF *PERNA PERNA*

Relationship	*slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Length & breadth	0.067	0.8414	y=0.067x+1.5076	S
2. Length & body weight	10.535	0.9399	y=0.9399x+30.99	S
3. Length & muscle weight	2.954	0.6926	y=2.95x+8.002	S

Chemical composition of the muscle

The chemical composition of the muscle of the oyster, *C. cuculata* and of the mytilid, *P. perna* is shown in Tables 3 and 4 respectively. The relationship of the total muscle weight to protein, carbohydrate, lipid ash and water are given in Figs. 3,4,5,6, and 7 respectively.

Fig. 3

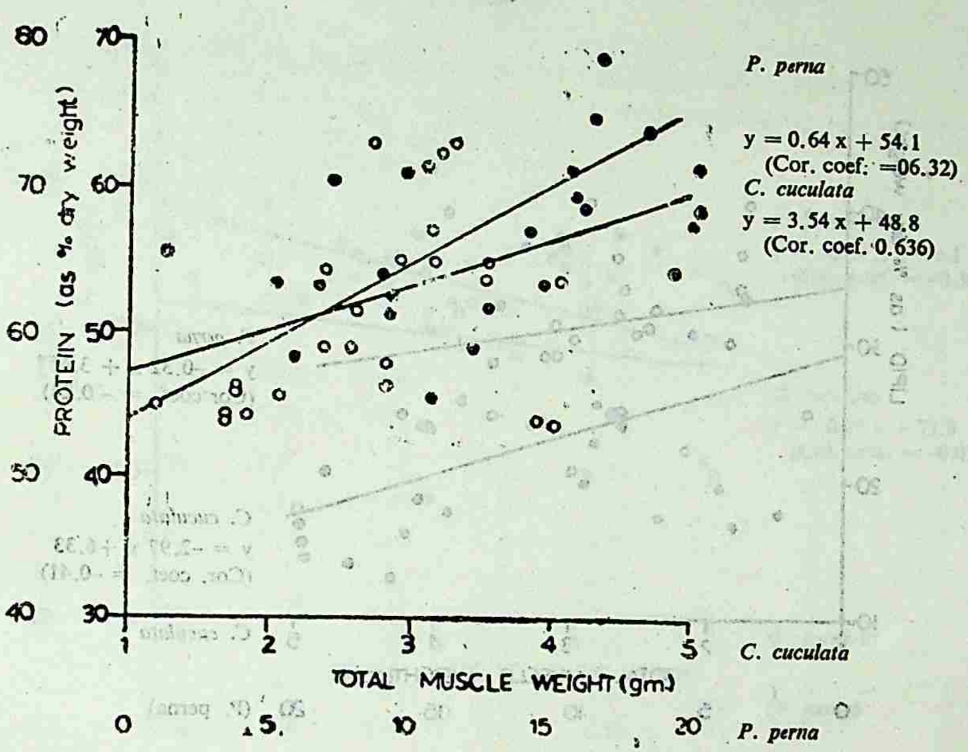

Fig. 4

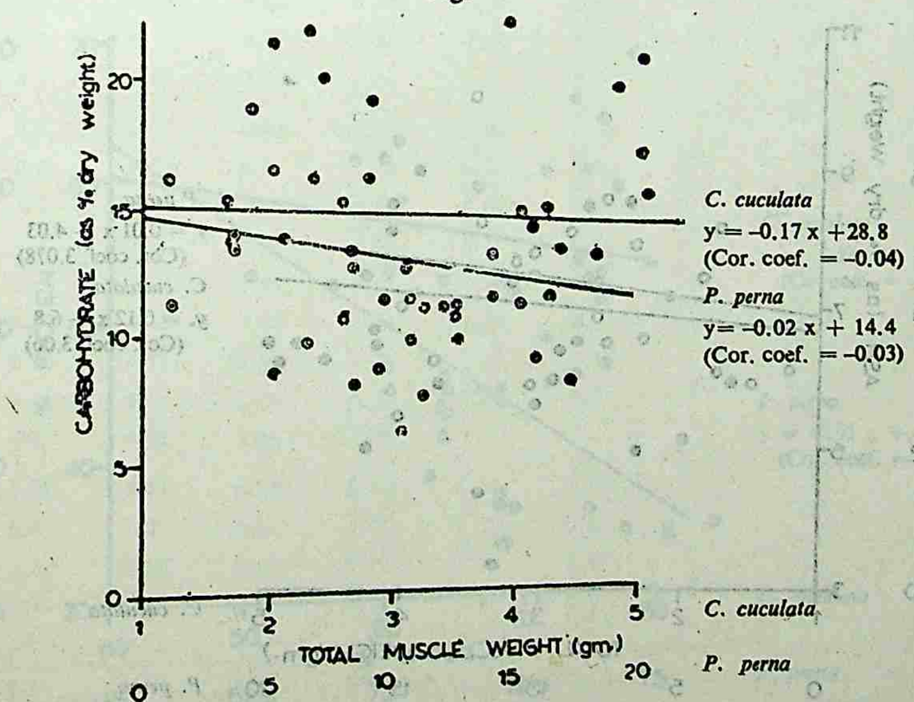

Fig. 3.— Relationship between total muscle weight and protein content of *C. cuculata and P. perna*.
Fig. 4.— Relationship between total muscle weight and carbohydrate content of *C. cuculata and P. perna*.

Fig. 5

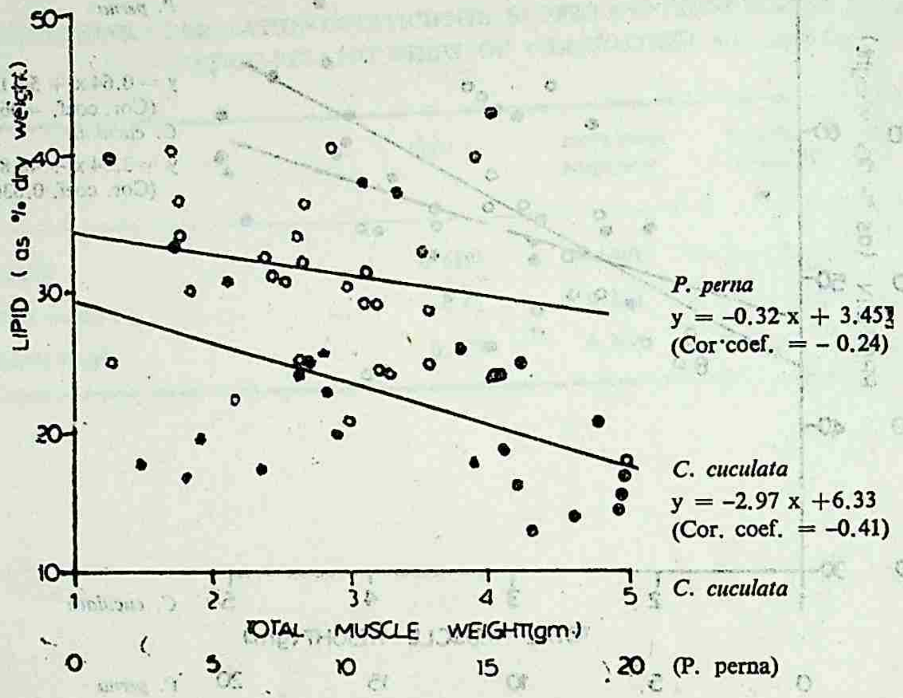

Fig. 6

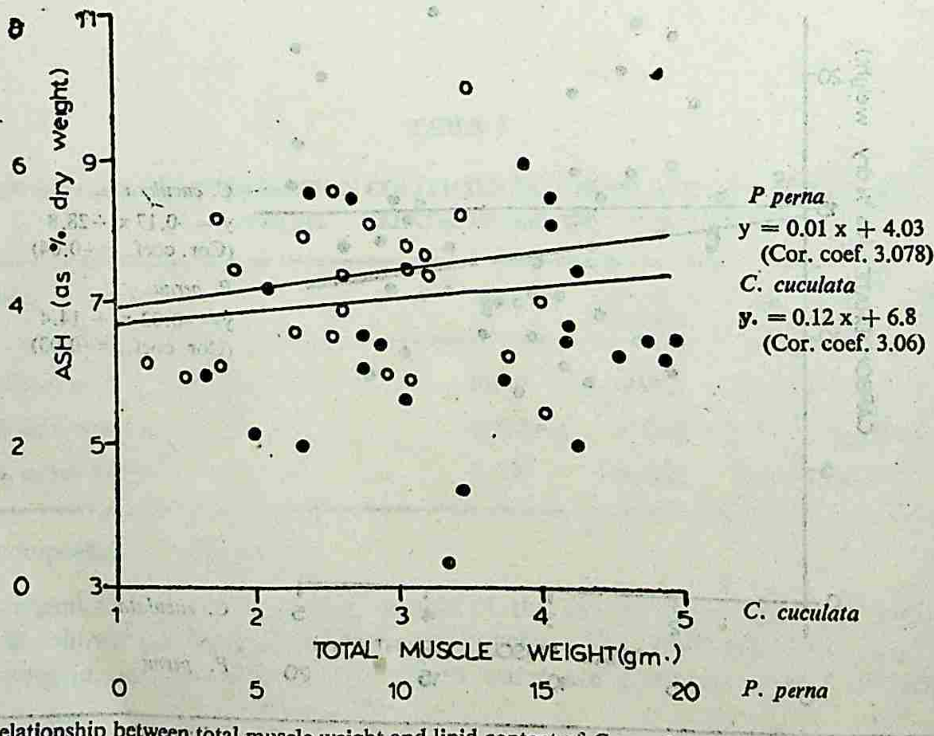

Fig. 5.— Relationship between total muscle weight and lipid content of *C. cuculata and P. perna*

Fig. 6.— Relationship between total muscle weight and ash content of *C. cuculata and P. perna*

Fig. 7

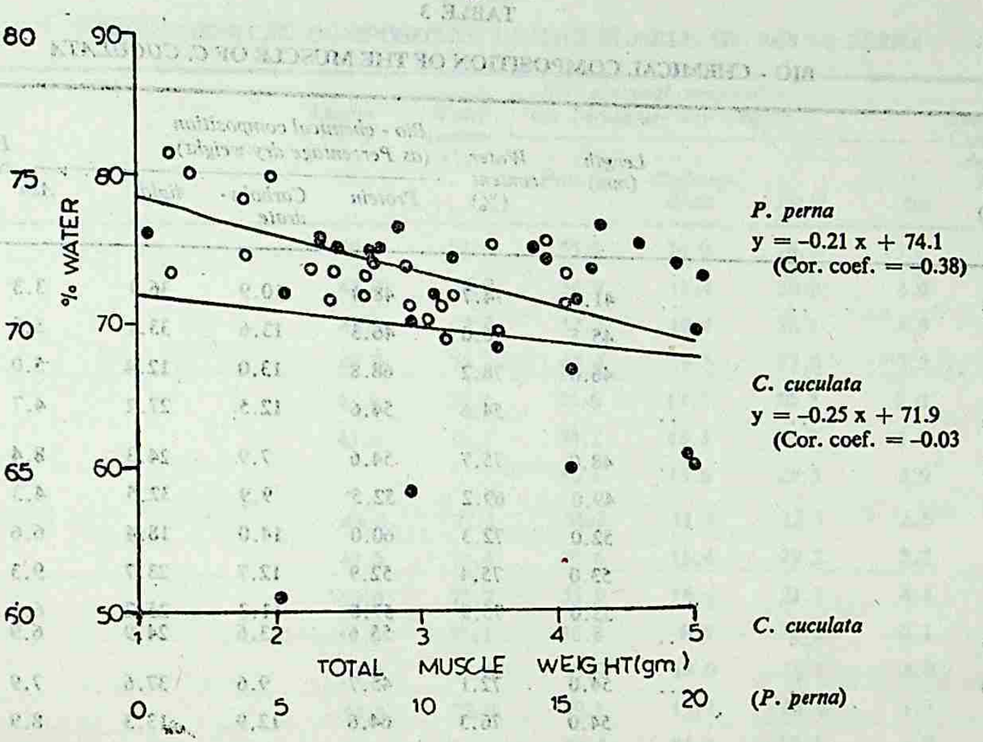

Fig. 8

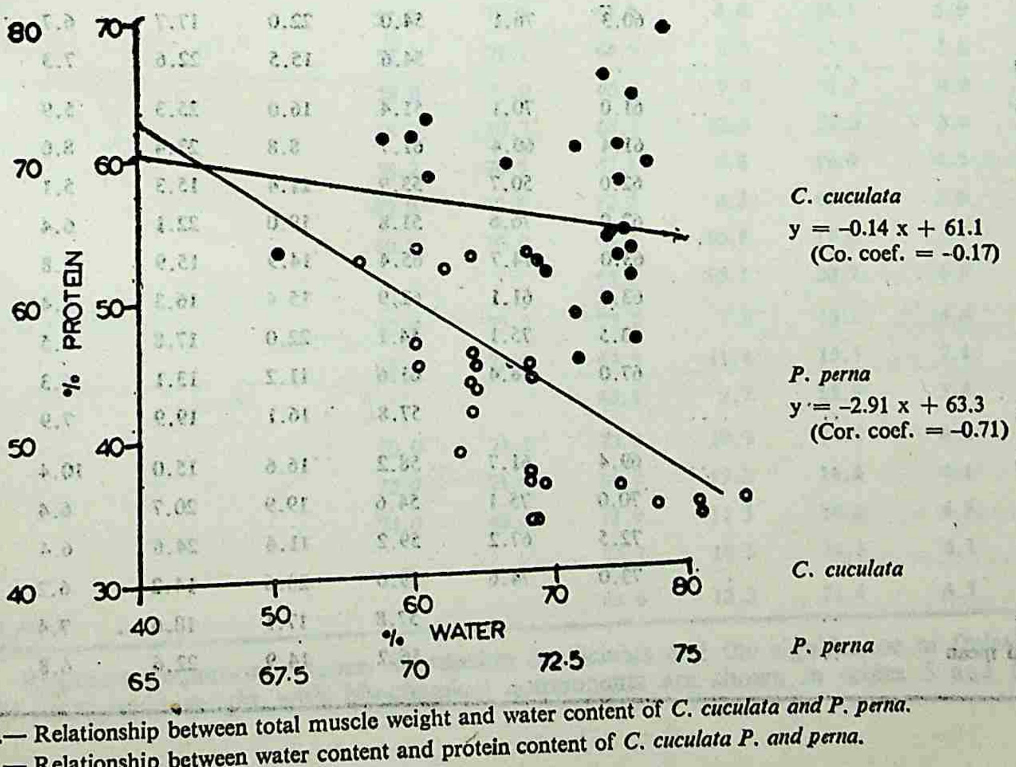

Fig. 7.— Relationship between total muscle weight and water content of *C. cuculata and P. perna.*

Fig. 8.— Relationship between water content and prótein content of *C. cuculata P.* and *perna.*

TABLE 3

BIO - CHEMICAL COMPOSITION OF THE MUSCLE OF *C. CUCULATA*

Size group (mm)	*Length (mm)*	*Water content (%)*	*Bio - chemical composition (as Percentage dry weight)*				*Protein+ carbohydrate +lipid +Ash*
			Protein	*Carbohy- drate*	*lipid*	*Ash*	
40–46	41.0	74.7	48.4	10.9	36.1	3.3	
	45.5	76.0	46.5	13.6	33.1	5.9	
	46.0	78.2	68.8	13.0	12.4	5.0	
Mean		54.6	54.6	12.5	27.2	4.7	99.1
47–53	48.0	75.7	54.6	7.9	24.3	8.4	
	49.0	69.2	52.5	9.9	32.5	4.3	
	52.0	72.3	60.0	14.0	18.4	6.6	
	53.0	75.4	52.9	12.7	23.7	9.3	
	53.0	75.9	57.8	11.3	25.2	6.1	
Mean			55.6	13.6	24.9	6.9	101.0
54–60	54.0	72.1	45.7	9.6	37.6	7.9	
	54.0	76.3	64.6	12.9	13.3	8.9	
	59.0	75.9	60.5	20.1	11.0	8.6	
	59.0	72.6	48.4	13.6	33.6	6.8	
	60.3	76.1	54.0	22.0	17.7	6.7	
Mean			54.6	15.5	22.6	7.3	100.0
61–67	61.0	70.1	51.4	16.0	25.3	5.9	
	61.4	60.4	61.7	8.8	23.4	8.0	
	62.0	50.7	53.9	21.4	15.3	5.1	
	62.0	76.6	51.8	19.0	22.1	6.4	
	63.0	74.7	65.4	14.9	15.9	5.8	
	63.0	61.1	62.9	15.4	16.3	6.4	
	63.5	75.1	54.1	22.0	17.8	5.5	
	67.0	58.4	61.6	11.2	13.1	6.3	
Mean			57.8	16.1	19.9	7.9	101.7
68–74	69.4	61.7	58.2	16.6	15.0	10.4	
	70.0	75.1	54.6	19.9	20.7	6.4	
	72.5	67.2	59.2	11.4	24.6	6.4	
	73.0	74.6	59.0	20.6	14.2	6.2	
Mean			57.8	17.1	18.6	7.4	100.5
Grand mean			56.2	14.9	22.6	6.8	100.5

TABLE 4

BIO - CHEMICAL COMPOSITION OF THE MUSCLE OF *PERNA PERNA*

Size group (mm)	*Length (mm)*	*Water content (%)*	*Bio.- chemical composition (as Percentage dry weight)*				*Protein+ Carbohydrate+ Lipid+ Ash*
			Protein	*Carbohydrate*	*Lipid*	*Ash*	
40–46	40.0	74.5	55.9	14.0	26.5	3.2	
	40.0	76.0	54.9	11.4	30.0	4.0	
	42.0	72.0	54.2	19.4	20.1	4.5	
	42.0	75.2	65.4	16.3	15.6	3.2	
	43.0	75.3	54.6	13.5	30.2	3.0	
	45.0	72.5	54.2	15.3	24.2	5.2	
Mean			56.5	15.0	29.3	3.9	104.7
45–53	48.0	72.1	54a2	11.4	32.3	2.5	
	49.0	73.4	54.6	13.4	29.2	3.2	
	50.0	73.2	55.9	16.6	21.3	4.4	
	51.0	72.1	56.8	8.8	32.2	5.1	
	53.0	72.0	57.9	14.0	26.5	3.9	
	53.0	72.0	59.1	15.3	22.4	3.6	
Mean			56.4	13.3	27.0	3.8	100.5
54–60	5.0	71.8	59.2	16.3	20.5	3.6	
	57.0	71.2	62.0	8.8	24.1	5.6	
	57.0	71.1	64.9	8.8	22.2	5.0	
	58.0	71.0	65.4	9.9	21.3	4.8	
	58.0	70.7	65.3	12.8	20.5	3.0	
	58.2	70.5	67.1	9.8	19.0	4.3	
	60.0	70.6	72.2	6.3	19.0	3.0	
	60.0	70.0	65.4	10.8	19.0	5.2	
Mean			65.2	10.3	20.7	4.3	100.5
61–57	62.0	72.2	73.9	7.9	15.6	4.4	
	65.0	72.0	64.9	11.4	15.5	7.1	
Mean			69.4	9.7	15.5	5.8	100.4
68–74	70.0	71.1	73.2	10.9	14.5	4.2	
	72.0	71.0	64.9	15.2	14.8	4.1	
	74.0	69.8	73.9	11.3	14.2	4.7	
Mean			70.7	18.5	14.5	4.3	102.0
Grand mean			63.6	12.2	21.4	4.5	101.4

Regression equations, slopes, correlation coefficients and the significance of frelationships of the total body weight with bio-chemical components are shown in tables 5 and 6.

TABLE 5

REGRESSIONS EQUATIONS AND THEIR SIGNIFICANCE OF RELATIONSHIPS OF THE TOTAL BODY WEIGHT WITH BIO-CHEMICAL COMPONENTS OF *C. cuculata*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Protein & Total body weight	3.168	0.7007	y=3.168x+42.09	S
2. Carbohydrate & Total body weight ..	-0.0169	-0.052	y= -0.01x+15.5	NS
3. Lipid & Total body weight	-0.265	-0.476	y= -0.21x+8.152	NS
4. Ash & Total body weight	0.026	0.218	y=0.096x+5.34	NS
5. Water & Total body weight	-1.579	-0.366	y= -1.579x+178.2	NS

TABLE 6

REGRESSION EQUATIONS AND THEIR SIGNIFICANCE OF RELATIONSHIPS OF THE TOTAL BODY WEIGHT WITH BIO-CHEMICAL COMPONENTS OF *P. PERNA*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Protein & Total body weight ..	0.518	0.841	y=0.518x+48.1	S
2. Carbohydrate & Total body weight ..	-0.148	-0.413	y= -0.148x+11.74	NS
3. Lipid & Total body weight	-0.361	-0.512	y= -0.362x+31.49	NS
4. Ash & Total body weight	0.023	0.288	y=0.023+x3.4	NS
5. Water & Total body weight	-0.115	-0.734	y= -0.115+75.09	S

The regression equations, slopes, correlation coefficient and significance of relationships of the length with protein, carbohydrate, lipid, ash and water are shown in tables 7 and 8 respectively.

TABLE 7

REGRESSION EQUATIONS, SLOPES, CORRELATION COEFFICIENT AND THEIR SIGNIFICANCE OF RELATIONSHIPS OF THE LENGTH WITH BIO-CHEMICAL COMPONENTS OF *CRASSOSTREA CUCULATA*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Protein & length	1.667	0.240	y=1.667x+49.59	NS
2. Carbohydrate & Length	-0.358	0.472	y= -0.358x+10.93	NS
3. Lipid & Length	-0.717	-0.3339	y= -2.717x+37.65	NS
4. Ash & Length	0.484	0.2521	y=0.484x+3.75	NS
5. Water & Length — ..	-2.980	-0.372	y= -2.98x+88.259	NS

TABLE 8

REGRESSION EQUATIONS, SLOPES, CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE OF RELATIONSHIPS OF THE LENGTH WITH BIO-CHEMICAL COMPONENTS OF *P. PERNA*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Protein & Length	0.6465	0.1378	y=0.6465x+53.6	NS
2. Carbohydrate & Length	-0.5513	-0.0465	y= -0.551x+20.77	NS
3. Lipid & Length	-3.919	-0.3682	y= -3.919x+43.299	NS
4. Ash & Length	0.370	0.348	y=0.37x+2.176	NS
5. Water & Length	-1.5171	-0.82	y= -1.511x+80.324	S

The regression equations, slopes, correlation coefficient and the significance of relationships of the breadth with protein, carbohydrate, lipid, ash and water contents are shown in Table 9 and 10.

TABLE 9

REGRESSION EQUATIONS, SLOPES, CORRELATION COEFFICIENTS AND THE SIGNIFICANCE OF THE RELATIONSHIPS OF THE BREADTH WITH BIO-CHEMICAL COMPONENTS OF *CROSSOSTREA CUCULATA*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1 Protein & Breadth	0.993	0.165	y=0.993x +51.94	NS
2. Carbohydrate & Breadth	-0.083	0.031	y= -0.083x +16.84	NS
3. Lipid & Breadth	-1.917	-0.257	y= -1.917x +30.46	NS
4. Ash & Breadth	0.297	0.163	y=0.279x +5.42	NS
5. Water & Breadth	-1.179	-0.168	y= -1.179x + 75.854	NS

TABLE 10

REGRESSION EQUATIONS, SLOPES, CORRELATION COEFFICIENTS AND THE SIGNIFICANCE OF THE RELATIONSHIPS OF THE BREADTH WITH BIO-CHEMICAL COMPONENTS OF *PERNA PERNA*

Relationship	*Slope*	*Correlation coefficient*	*Regression equation*	*Significance*
1. Protein & Breadth	0.646	0.137	y=0.646x +53.6	NS
2. Carbohydrate & Breadth	-0.413	-0.123	y= -0.413x +14.73	NS
3. Lipid & Breadth	-6.075	-0.481	y= -6.075x +38.57	NS
4. Ash & Breadth	-0.502	-0.136	y= -0.502x +5.13	NS
5. Water & Breadth	-3.456	-0.306	y= -3.456x +78.4	NS

The relationship between protein content and water content is shown in Figure 8. Regression equations, slopes, correlation coefficients and the significance of the relationship of water with percentage lipid in *C. cuculata* and *P. perna* are shown in Table 11.

TABLE 11

REGRESSION EQUATIONS, SLOPES, CORRELATION COEFFICIENTS AND THE SIGNIFICANCE OF THE RELATIONSHIP OF WATER WITH PERCENTAGE LIPID IN *C. CUCULATA* AND *P. PERNA*

Relationship			*Slope*	*Correlation coefficient*	*Regression equation*	*Signifiicance*
C. cuculata	1. Lipid & water	..	–0.494	–0.358	y= –0.494x +86.1	NS
P. perna	2. Lipid & water	..	0.003	0.088	y=0.003x +21.5	NS

Discussion

Merphometrics :

According to Fernando (1970), the bivalve molluscs show an increase in length which is accompanied by an increase in total body weight. In the present study, the mytilid show a significant relationship between the length and total body weight, length and breadth and length and total muscle weight. The regression analysis shows that in oysters, the correlation coefficient between total body weight and length is 0.3126 with a non significant positive relationship between the two parameters. This correlation coefficient is even higher than the above value when the graph is curvillinear (The relationship between Log-weight and loglength). This result is seen more clearly for mytilids than for oysters. This may be due to the fact that the true total body weight of the oyster was difficult to ascertain as complete extraction of the oyster from the substratum was very difficult. The relationship between total body weight and length for *Crassostrea cuculata* was very similar to that obtained by Wilber (1966) for *Ostrea.*

Increase in shell length for both oyster and mytilid is seen to be accompanied by an increase in total body weight. Total muscle weight also increases significantly, with increase in total body weight in both organisms. These conclusions for the mytilid are similar to these shown by Kow et al (1972) who analysed the morphometric parameters of *M. viridis* of the Indo-Pacific region.

Chemical composition of body Muscle :

From the present study it is evident that the total muscle weight, total body weight length and breadth each separately had a nonsignificant negative relationship with percentage water content.

In the case of mytilid, the relationship between total body weight and the percentage water content were found to be statistically significant at 5% significant level. This negative relationship may be due to the substitution of synthesized bio-chemical components in place of water. This phenomenon has been reported also for fish by Zaitesey et al (1969).

Total muscle weight, total body weight, length and breadth separately had a positive relationship with percentage water content. Percentage water content decreases with increase, in protein content (Fig. 8). This could be explained on the basis that synthesized amino acids may replace water in intesticial tissues.

Total muscle weight, total body weight, length and breadth each separately had a nonsignificant negative relationship with percentage carbohydrate content. However the total carbohydrate content of both oyster and mytilid, when compared with that of fishes is rather high. This is probably because both mytilid and oyster are filter feeders feeding mainly on algae, phytoplankton and other small organisms.

All these parameters show nonsignificant relationships with lipid content although the lipid content decreases with increase in size and the weight of the body. When the lipid contents of the oyster and the mytilid are compared it is seen that in the oyster, the lipid content is greater than in the mytilid.

In both animals the ash content increased non significantly with length, breadth, total muscle weight and total body weight. They live in aquatic environments and therefore they need to osmoregulate. For this purpose they have to obtain various ions from the environment and retain these ions in the blood and body fluids. These ions are proportionately more in large individuals and therefore the ash content will be more in large animals. That various ions K, Na, Ca, Mg, P, are retained in this manner in *Mytilus edulis* have been reported by Robertson (1949) and Robertson (1964).

Comparison of bio-chemical components in both animals :

A considerable proportion of the percentage dry weight in both animals is protein and there is no significant difference in percentage protein in the two organisms. There is also no significant differences in the percentage lipid content in both animals. Similarly there is also no significant difference in the percentage water content in both animals.

The range of protein as percentage dry weight is wide (oyster, 45%-78%; mytilid 54%-78%) when compared with other bio-chemical components (Table 12).

TABLE 12

RANGE OF BIO-CHEMICAL COMPONENTS

Bio-chemical Component	*C. cuculata*		*P. perna*	
	Dry	*Wet*	*Dry*	*Wet*
1. Protein ..	.. 45.0%—78.0%	13.5%—17.5%	54.0%—78.0%	15.1%—19.9%
2. Carbohydrate ..	.. 1.8%—22.0%	0.4%— 6.5%	6.0%—21.0%	0.7%— 5.4%
3. Lipid ..	.. 8.9%—37.6%	2.0%—11.1%	5.6%—34.4%	1.6%— 9.0%
4. Ash ..	.. 2.2%—13.2%	0.4%— 2.9%	1.8%— 7.1%	0.4%— 1.9%

ACKNOWLEDGEMENTS

This work was carried out in the department of Zoology, University of Kelaniya, I wish to thank Prof. H. H. Costa for providing me with laboratory facilities and for help in the preparation of this paper, Dr. Mrs. M. M. Fernando for suggesting the problem and Prof. S. S. de Silva for providing me with relevant literature

My sincere thanks also go to Mr. M. J. S. Wijeratne for helping me with the statistical analysis, Miss, M. Rangoda and Mr. U. Wanigaseekra for helping in the technical work and to the technical staff of the Department of Zoology, University of Kelaniya, especially to Mr. W. D. Francis for assisting me in the collection of specimens.

REFERENCES

COLLYER (1957)
Variability and glycogen reserves in the newly liberated larvae of *O. edulis* – *J. Mar. Biol. Asso. U.K.*, 36 : 335–37 pp.

DUBOIS, M.; GILES, K. A.; HAMILTON. K.; ROBERS, P. A. and SMITH, F. (1956)
Colorimetric methods for determination of sugars and related substances – *Anal. Chem.* 28(3); 380–86 pp.

FERNANDO, D. H. (1977)
Lamellibranchiate fauna of the estuarine and coastal areas in Sri Lanka (Ceylon) Vol. 27 *Bull. Fish. Res. Stn.* (1977), 22–52 pp.

FLOCH M. LEES and SLONAE STANLEY, G. H. (1957)
A simple methods for the isolation and purification of total lipids from animal tissues – *J. Biol. Chem.* 226 pp.

GIESE, A. C. (1967)
Some methods for the study of the bio-chemical constitution of marine invertebrates – *Oceanogr. Mar. Biol. Ann.* Rev. 1967, 159–186 pp.

GIESE, A. C. (1969)
A new approach to the bio-chemical composition of the mollusc body – *Ocenogr. Mar. Biol. Ann. Rev.*, 7 175–227 pp.

IDLER and WIEMAN, P, (1972)
Molluscan sterols – Ann. Rev. J. Fish, *Res. Bd. Canada* 29 : 385–98 pp.

JANAKA and HATAWA (1952)
Energy formation and glycogen synthesis – *J. Expt. Biol.* 34 : 620–21 pp.

KAISTER et al (1969)
Amino acid synthesis in molluscs – Phy. of Moll. Vol. III. Acad. Pres. New york London, 431–32 pp.

KARL M. WILBER (1964)
Shell formation and regeneration – Phy. of Moll. Vol. I – Acad. Pres. New York London, 248–49 pp.

MASUMOTO, B; MAUMO, M. and BINOM (1934)
Bio-chemical studies of O. *gigas* **Sci., Hiroshima. Unive. Ser. A.* 4 : 47–56 pp.

MITCHEL, P. H. (1915)
Nutrition of oysters, glycogen formation and storage – *Bull. U. S. Bur. Fish.* 35 : 151–62 pp.

PERERA. M. M. and ARUDPRAGASAM, K. D. (1966)
Animals living in association with *O. virginica* at Batticaloa, *Ceylon J. Sci.* (*Bio. Sci.*) 6 (1), 20–25 pp.

PINTO, L. and WIGNARAJAH, S. (1980)
Some esological aspects of the edible oyster *C. cuculata* Born' occurring in association with mangroves in Negombo lagoon, Sri Lanka – *Hydro. Bio.* Vol. 69, 1–2, 11–19. pp.

RAYMENT, J. E, G.; AUSTIN, J.; and LIFORD, E. (1964)
Bio-chemical studies on marine zoo plankton and the bio-chemical composition of *Neemysis integer J. cons. perma. Int. Explor. Mer.*, 28, 354–63 pp.

ROBERTSON, J. D. (1949)
Ionic regulation in some marine invertebrates *J. Exptl. Biol.*, 26, 182–200 pp.

RODHOUS, P. C. (1978)
Energy formation by the oyster, *O. edulis* in a temperate estuary – *J. of. Exptl Mar. Bio. & Eco.* 1; 20-21 pp.

THAM AH KOW, YANG SWEE LING (1972)
Experiments in coastal aquaculture in Singapore – Coastal Aquacul. in Indo-Pacific region – 375–79 pp.

VENKATARAMAN, R. and CHARI, S. T. (1951)
Studies of oysters and clams, bio-chemical variation – *Indian J. Med. Res.* 39; 533–41 pp.

ZAITSEV et al (1969)
Fish curing and processing – MIR Publishers, Moscow. 604–605 pp.