# ON THE PROBABLE CHANGE OF FORM IN THE CLAM *MERETRIX CASTA* (CHEMNITZ) DURING ITS GROWTH[1]

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ABSTRACT

While examining large samples of the clam *Meretrix casta* of different sizes from Athankarai estuary near Mandapam for its biological studies, it was noticed that the form of the clam was not constant in different size-groups. The smallest clams were more or less regular and equilateral in form while the largest had their posterior regions slightly produced thereby giving an impression of inequilaterality.

To verify this, 40 clams from each of the three size-groups were opened and five selected external and internal dimensions of the right valves of their shells measured. The regressions of each of these characters with respect to length were compared for the three size-groups by the method of analysis of covariance.

The results tend to indicate that the clam grows rapidly at its posterior region than at the anterior region and there is no equality of growth rate in the three size-groups of the clam. These suggest a change of form during growth in the case of the clam *M. casta* inhabiting Athankarai estuary. This may perhaps be due to the younger clams preferring the soft soil while the older ones generally inhabiting a hard soil.

## INTRODUCTION

THE change of form due to the different environmental conditions and habits has long been known in the animal world. The relative growth of different parts of the body changes, thereby bringing about the change in form. Huxley (1932) has contributed greatly to the study of such differential growth processes. He recognised heterogonic and isogonic growth depending upon whether the rate of growth of a body part is different from or similar to that of the body.

A study on the change in form in the case of molluscs has been attempted by Hamai (1934) who found local variations in the shell of *Meretrix meretrix*. Those, he felt, were the effects of environmental conditions such as temperature, physical nature of sand, and salinity. In a later publication, Hamai (1935) observed the change of shape to be related to the substratum. This he confirmed by actual transplantation experiments (Hamai, 1938). Durve and Dharma Raja (1965) investigated the differences in the dimensional relationship in the clam *M. casta* collected from the marine fish farm and Athankarai estuary near Mandapam.

The change in form during ontogeny associated with the change in life habits has been worked out by Kristensen (1957) who showed that the burrowing ability is critical in juveniles of *Cardium edule* L., and that it decreases with increasing size. This is accompanied by a change in form from juvenile to adult cockles. Pohlo (1964) observed the same phenomenon in the case of the bivalve *Tresus nuttalli*.

The present study deals with such a change of form in the case of *Meretrix casta* from small to large size. The phenomenon of the change of form in this bivalve was first noticed when large samples of this clam belonging to different size-groups were being collected from Athankarai estuary near Mandapam, for biological studies.

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## MATERIAL AND METHODS

Clams of different sizes were collected from Athankarai estuary from stations 2, 3, and 4 (refer Durve and Alagarswami, 1964). The smallest clams occur in station 2 and the size increases as one proceeds to station 4 where the largest clams occur. The clams at any station belong to more or less the same size-group. The size-groups collected were 16·0–18·3, 27·0–30·3, and 38·0–43·6 mm. in length (or width) and were designated as smallest, larger and largest groups respectively. The clams were cleaned, opened, and the meat scooped out. The empty shells with both the valves attached together were allowed to dry for some time and a few selected measurements were taken of the right valve alone, with vernier callipers and a fine mathematical divider correct to 0·1 mm. The dimensions measured were as follows (*see* also Fig. 1):

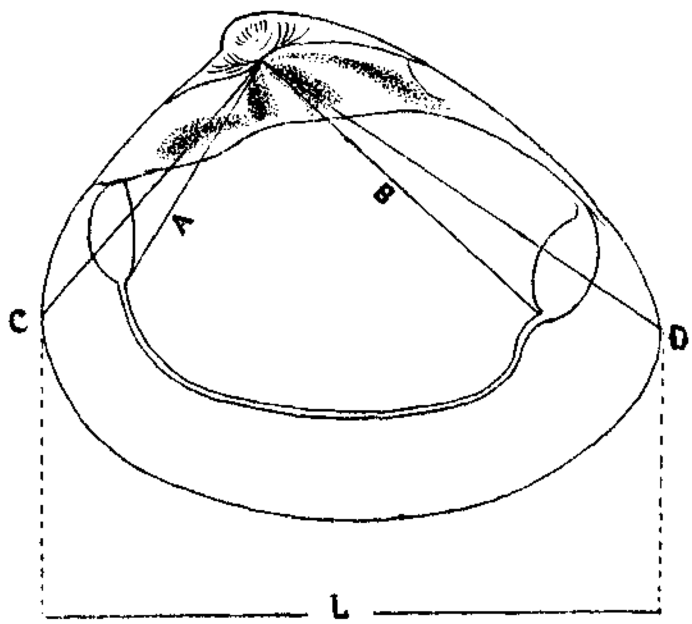


FIG. 1. The right valve of *Meretrix casta* showing dimensions used for the study. (For explanation, please see the text)

L : The maximum linear dimension along the antero-posterior axis of the shell.

A : The linear distance between the umbo and the origin of the pallial line at the base of the anterior adductor impression.

B : The linear distance between the umbo and the point of merging of the pallial line with the posterior adductor impression.

C : The maximum distance from the umbo to the anterior edge.

D : The maximum distance from the umbo to the posterior edge.

It was felt that these dimensions will alone give some idea about the change of form, if any, in the clam under investigation. The measurements A, B, C and D were independently plotted against the measurement L for each size-group on separate bivariate scatter diagrams. A straight line appeared to be the best fit for each scatter diagram of the three groups. For plotting the straight line, the regression equation of the form $y = a + bx$ where $y$ represents the length L and $x$ the four dimensions A, B, C and D, was employed. The regressions of each of these four dimensions with regard to length were compared for the three size-groups by the method of analysis of covariance with the significance of all tests judged at 5% level of probability.

## Results and Discussion

The regression relations of the four dimensions A, B, C and D to the length L for the three size-groups are:

*Dimension A*

Smallest : A = 2·8245 + 0·2885 L
Larger : A = 6·4443 + 0·2099 L
Largest : A = 9·3996 + 0·1787 L

*Dimension B*

Smallest : B = 3·9654 + 0·3176 L
Larger : B = 2·6587 + 0·5068 L
Largest : B = 8·2296 + 0·4197 L

*Dimension C*

Smallest : C = 2·0122 + 0·5372 L
Larger : C = 2·4668 + 0·5052 L
Largest : C = 11·0360 + 0·2811 L

*Dimension D*

Smallest : D = 5·2084 + 0·4557 L
Larger : D = 3·8241 + 0·6693 L
Largest : D = 9·0533 + 0·6273 L

The regression lines are plotted in Fig. 2.

Comparisons were made by the analysis of covariance to test the significant difference of the regressions for the three size-groups. *Appendix I* (*a* to *d*) and *Appendix II* (*a* to *d*) give the statistical calculations of Sums of Squares and Products, Mean Squares, and the test of analysis of covariance. The Table showing F values based on the results given in Appendices I and II is given below.

*Table showing F values*

| | 1 Dimension | 2 Between $S_1$ and $(S_2+S_3+S_4)$ | 3 Between $S_2$ and $S_3$ | 4 Between $(S_1 + S_2)$ and $S_3$ |
|---|---|---|---|---|
| 1. | A | $\frac{1·7893}{0·3191}$ = 5·61‡ (4,114) | $\frac{0·3191}{0·08825}$ = 3·62 (114,2) | $\frac{3·3485}{0·3151}$ = 10·63‡ (1,116) |
| 2. | B | $\frac{1·9362}{0·3313}$ = 5·84‡ (4,114) | $\frac{0·3313}{0·19185}$ = 1·73 (114,2) | $\frac{0·3289}{0·0096}$ = 34·26 (116,1) |
| 3. | C | $\frac{1·0756}{0·3977}$ = 2·70* (4,114) | $\frac{0·7883}{0·3977}$ = 1·98 (2,114) | $\frac{1·2988}{0·4044}$ = 3·21 (1,116) |
| 4. | D | $\frac{4·9928}{0·3880}$ = 12·69‡ (4,114) | $\frac{0·3880}{0·27045}$ = 1·43 (114,2) | $\frac{8·3662}{0·3860}$ = 21·67‡ (1,116) |

* indicates significance at 5% probability level.
‡ indicates significance at 1% probability level.
Figures within brackets indicate the respective degrees of freedom.

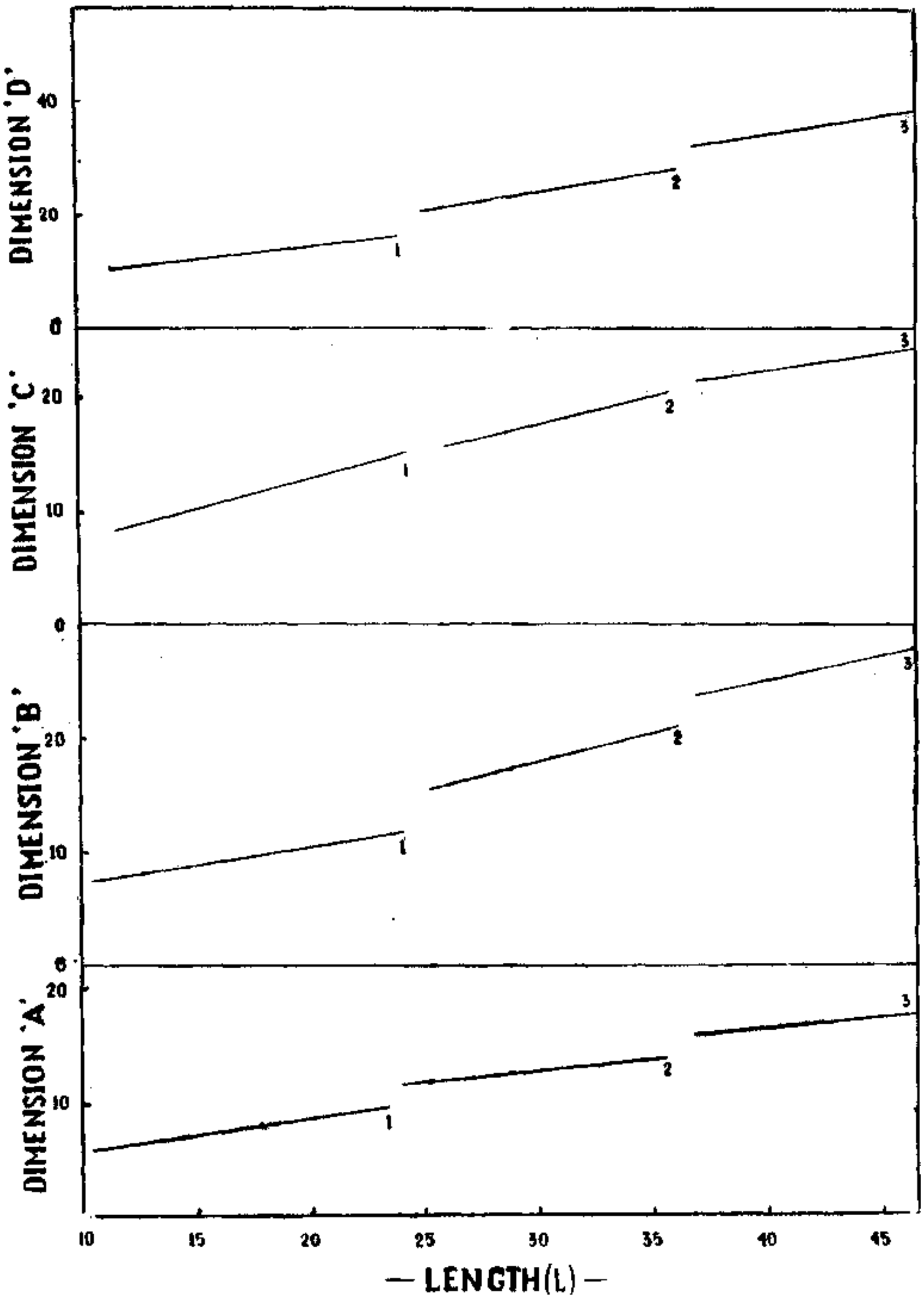


FIG. 2. Regressions of different dimensions on length in the three size-groups of *Meretrix casta*. (Size-groups: 1—smallest, 2—larger, 3—largest)

Column 2 in the previous table gives observed F values and all the values are found to be significant at 5% probability level. Further, excepting for dimension C, the F values are significant even at 1% probability level. This indicates that there are real differences between groups and a single line will not represent all the three groups (Fig. 2).

Column 3 in the previous table gives the observed F values for comparing the deviations from within-group regressions with the differences of regresssions among the groups. All the F values are found to be non-significant at 5% level and hence the hypothesis of equality of regressions within groups cannot be rejected. The F values corresponding to comparison of deviations from average within-group regressions with those from regression through group means are given in column 4. The F values are significant for the dimensions A and D, but non-significant for the dimensions B and C. This means that while for the dimensions A and D, the hypothesis of linearity of regressions of group means should be rejected; the same cannot be rejected for the dimensions B and C.

Thus for dimensions A and D, heterogeneity is suspected among the 3 groups, *i.e.*, the regressions of these dimensions are different among the 3 groups. In the case of dimensions B and C, the adjusted mean values for the three groups are different and this is to be expected since the size ranges of the 3 groups are different but the hypothesis of equality of regressions within the 3 groups cannot be rejected. From a comparison of $b$ values in A and D dimensions, it is found that for A dimension, $b$ decreases from the smallest to the largest group, while for the dimension D, $b$ increases from the smallest to largest groups, and as for the other dimensions, no statistically significant from the noticed.

The above observations, especially the significant differences between the regressions of dimensions A and D discussed above, indicate that the clam *M. casta* grows more rapidly at its posterior region than at the anterior one during its growth span. This results in the change of form in this clam from its small to large size, the posterior end becoming more wedge-shaped and the anterior remaining roundish. In short, the clam which is almost equilateral during its early life becomes more or less inequilateral as it grows. However, it is necessary to confirm this by more detail study. It is further felt that this change of form may not be continuous. It stops after a certain stage as no large *M. casta* of abnormally elongated or different form has so far been observed in the locality. There is a possibility, as Hamai (1938) has observed, that the change of form depends upon the adaptability in each case to the respective environment. Thus, once the form best suited for the environment is attained, there is no further change in it. However, this hypothesis needs confirmation.

The studies made on the density of clams of different sizes in relation to substratum reveal that small-sized clams invariably prefer a soft soil with more water content, finer grade particles and silt; while the larger clams were found to be more in the areas where the soil contained all the above ingradients in lesser quantity (Durve, unpublished). This may perhaps be the reason for the change of form in the clam *M. casta* as it grows. It is likely that burrowing and reorientation after disturbance is easier in soft soil than in the one containing less of water and finer grade particles with the result, active smaller clams need not have sharper and more pointed posterior ends. These features, perhaps, are necessary for the larger, more or less stationary clams, in order to help them in anchorage and keep their siphonal regions above the hard soil of coarse particles. This, however, needs verification. Hamai (1935) has observed, as stated earlier, that the elongated type of *M. meretrix* grows on a sandy shore facing the open sea and the roundish type in a calm sea with a slightly muddy bottom.

## ACKNOWLEDGEMENTS

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## LITERATURE CITED

DURVE, V. S. AND K. ALAGARSWAMI 1964. An incidence of fish mortality in Athankarai estuary near Mandapam. *J. Mar. biol. Ass. India*, **6** (1): 147–150.

—— AND S. K. DHARMA RAJA 1965. A study on the dimensional relationship in the clam *Meretrix casta* (Chemnitz) collected from two localities. *Ibid.*, **7** (1): 69–79.

HAMAI, I. 1934. On the local variation in the shells of *Meretrix meretrix* (L.), with special reference to growth of organism. *Sci. rep. Tôhoku Imp. Univ. Biol.*, **9**: 131.

——— 1935. A study of one case in which different environmental conditions produce different types of *Meretrix meretrix*. *Ibid.*, **10**: 485.

———. 1938. Relative growth of *Meretrix meretrix* and its local variation, as shown by experiments in rearing. *Ibid.*, **13** (2): 205–220.

HUXLEY, J. S. 1932. *Problems of Relative Growth*. The Dial Press, New York, 276.

* KRISTENSEN, I. 1957. Differences in density and growth in a cockle population in the Dutch Waddensea. *Arch. Neerland. Zoologie*, **12** (3): 315–453.

POHLO, R. H. 1964. Ontogenetic changes of form and mode of life in *Tresus nuttalli* (Bivalvia: Mactridae). *Malacologia*, **1** (3): 321–330.

* Not referred to in original.

## DISCUSSION

Dr. A. D. Ansell: Do the animals on different substrates while in migration from one type of environment to another involve in change of form ?

Dr. V. S. Durve: Here we have to distinguish between two types of migrations. First, a temporary migration and second a permanent migration involving a change in the mode of life. The possibility of the change of form is only in the animals involved in the second type of migration. Such a change of form is evident in certain pelagic crabs which migrate from shallow to deeper waters and also in the bivalves *Cardium edule* and *Tresus nuttalli* which change their substrata and thereby the mode of life during early period of their life. Hamai has confirmed this change of form due to change in the substratum by actual transplantation experiments in the case of *Meretrix meretrix*.

Further, I feel, the change in form need not necessarily be due to the migrations alone, but may even be caused by the change in the substratum itself by several natural causes such as shifting sands or mud banks, currents, cyclones, etc., However, this needs confirmation.

(Answer subsequently obtained.)

APPENDIX I (*a*)

*Statistics describing sums of squares and products for the dimension A in relation to length L*

| Size-group | D.F. | $Sx^2$ | $Sxy$ | $Sy^2$ | $b$ | D.F. | S.S. | |
|---|---|---|---|---|---|---|---|---|
| Within smallest group .. | 39 | 17·8875 | 5·1602 | 5·7698 | 0·2885 | 38 | 4·2812 | 36·3787 ($S_1$) |
| Within bigger group .. | 39 | 26·2190 | 5·5045 | 12·2198 | 0·2099 | 38 | 11·0642 | |
| Within biggest group .. | 39 | 75·5110 | 13·4920 | 23·4440 | 0·1787 | 38 | 21·0333 | |
| Within groups .. | 117 | 119·6175 | 24·1567 | 41·4336 | 0·2019 | 116 | 36·5552 | ($S_1+S_2$) |
| Between groups .. | 2 | 11243·7517 | 4240·4453 | 1602·5811 | 0·3771 | 1 | 3·3485 | ($S_3$) |
| TOTAL .. | 119 | 11363·3692 | 4264·6020 | 1644·0147 | 0·3753 | 118 | 43·5360 | ($S_4$) |

S.S.—Sum of Squares $Sy^2-(Sxy)^2/Sx^2$. D.F.—Degrees of Freedom.

APPENDIX I (*b*)

*Statistics describing sums of squares and products for the dimension B in relation to length L*

| Size-group | D.F. | $Sx^2$ | $Sxy$ | $Sy^2$ | $b$ | D.F. | S.S. | |
|---|---|---|---|---|---|---|---|---|
| Within smallest group .. | 39 | 17·8875 | 5·6818 | 8·5378 | 0·3176 | 38 | 6·7330 | 37·7735 ($S_1$) |
| Within bigger group .. | 39 | 26·2190 | 13·2890 | 15·1590 | 0·5068 | 38 | 8·4235 | |
| Within biggest group .. | 39 | 75·5110 | 31·6930 | 35·9190 | 0·4197 | 38 | 22·6170 | |
| Within groups .. | 117 | 119·6175 | 50·6638 | 59·6158 | 0·4235 | 116 | 38·1572 | ($S_1+S_2$) |
| Between groups .. | 2 | 11243·7517 | 7563·4687 | 5087·8201 | 0·6727 | 1 | 0·0096 | ($S_3$) |
| TOTAL .. | 119 | 11363·3692 | 7614·1325 | 5147·4359 | 0·6701 | 118 | 45·5181 | ($S_4$) |

S.S.—Sum of Squares $Sy^2-(Sxy)^2/Sx^2$. D.F.—Degrees of Freedom.

APPENDIX I (*c*)

*Statistics describing sums of squares and products for the dimension C in relation to length L*

| Size-group | D.F. | $Sx^2$ | $Sxy$ | $Sy^2$ | $b$ | D.F. | S.S. | |
|---|---|---|---|---|---|---|---|---|
| Within smallest group .. | 39 | 17·8875 | 9·6092 | 12·2478 | 0·5372 | 38 | 7·0857 | 45·3356 ($S_1$) |
| Within bigger group .. | 39 | 26·2190 | 13·2465 | 16·1878 | 0·5052 | 38 | 9·4953 | |
| Within biggest group .. | 39 | 75·5110 | 21·2235 | 34·7198 | 0·2811 | 38 | 28·7546 | |
| Within groups .. | 117 | 119·6175 | 44·0792 | 63·1554 | 0·3685 | 116 | 46·9122 | ($S_1+S_2$) |
| Between groups .. | 2 | 11243·7517 | 5376·2956 | 2572·0245 | 0·4782 | 1 | 1·2988 | ($S_3$) |
| TOTAL .. | 119 | 11363·3692 | 5420·3748 | 2635·1799 | 0·4770 | 118 | 49·6382 | ($S_4$) |

S.S.—Sum of Squares $Sy^2-(Sxy)^2/Sx^2$ D.F.—Degrees of Freedom.

APPENDIX I (*d*)

*Statistics describing sums of squares and products for the dimension D in relation to length L*

| Size-group | | D.F. | $Sx^2$ | $Sxy$ | $Sy^2$ | $b$ | D.F. | S.S. | |
|---|---|---|---|---|---|---|---|---|---|
| Within smallest group | .. | 39 | 17·8875 | 8·1505 | 10·4390 | 0·4557 | 38 | 6·7252 | 44·2332 ($S_1$) |
| Within bigger group | .. | 39 | 26·2190 | 17·5495 | 22·6698 | 0·6693 | 38 | 10·9232 | |
| Within biggest group | .. | 39 | 75·5110 | 47·3650 | 56·2950 | 0·6273 | 38 | 26·5848 | |
| Within groups | .. | 117 | 119·6175 | 73·0650 | 89·4038 | 0·6108 | 116 | 44·7741 | ($S_1 + S_2$) |
| Between groups | .. | 2 | 11243·7517 | 10263·3248 | 9376·7461 | 0·9128 | 1 | 8·3662 | ($S_3$) |
| TOTAL | .. | 119 | 11363·3692 | 10336·3898 | 9466·1499 | 0·9096 | 118 | 63·9245 | ($S_5$) |

S.S.—Sum of Squares $Sy^2 - (Sxy)^2/Sx^2$. D.F.—Degrees of Freedom.

APPENDIX II (*a*)

*Analysis of Covariance—Dimension A*

| Source of variation | D.F. | S.S. | M.S. |
|---|---|---|---|
| Deviation from individual within group regressions .. | 114 | 36·3787 ($S_1$) | 0·3191 |
| Difference between regressions .. .. .. | 2 | 0·1765 ($S_2$) | 0·08825 |
| Deviation from average within group regressions ($b_o$) .. | 116 | 36·5552 ($S_1+S_2$) | 0·3151 |
| Deviation from regression through group means ($b_m$) .. .. | 1 | 3·3485 ($S_3$) | 3·3485 |
| Deviation between $b_e$ and $b_m$ .. .. .. | 1 | 3·6323 ($S_4$) | 3·6323 |
| Deviation from common (Total) regression ($b_o$) .. .. | 118 | 43·5360 ($S_5$) | |

D.F. = Degrees of Freedom. S.S. = Sum of Squares. M.S. = Mean Square.

APPENDIX II (*b*)

*Analysis of Covariance—Dimension B*

| Source of variation | D.F. | S.S. | M.S. |
|---|---|---|---|
| Deviation from individual within group regressions .. .. | 114 | 37·7735 ($S_1$) | 0·3313 |
| Difference between regressions .. .. .. | 2 | 0·3837 ($S_2$) | 0·19185 |
| Deviation from average within group regressions ($b_e$) .. | 116 | 38·1572 ($S_1+S_2$) | 0·3289 |
| Deviation from regression through group means ($b_m$) .. .. | 1 | 0·0096 ($S_3$) | 0·0096 |
| Deviation between $b_e$ and $b_m$ .. .. .. | 1 | 7·3513 ($S_4$) | 7·3513 |
| Deviation from common (Total) regression ($b_o$) .. .. | 118 | 45·5181 ($S_5$) | |

D.F. = Degrees of Freedom. S.S. = Sum of Squares. M.S. = Mean Square.

APPENDIX II (*c*)

*Analysis of Covariance—Dimension C*

| Source of variation | D.F. | S.S. | M.S. |
|---|---|---|---|
| Deviation from individual within group regressions .. .. | 114 | 45·3356 ($S_1$) | 0·3977 |
| Difference between regressions .. .. .. | 2 | 1·5766 ($S_2$) | 0·7883 |
| Deviation from average within group regression ($b_a$) .. .. | 116 | 46·9122 ($S_1+S_2$) | 0·4044 |
| Deviation from regression through group means ($b_m$) .. .. | 1 | 1·2988 ($S_3$) | 1·2988 |
| Deviation between $b_a$ and $b_m$ .. .. .. | 1 | 1·4272 ($S_4$) | 1·4272 |
| Deviation from common (Total) regression ($b_c$) .. .. | 118 | 49·6382 ($S_5$) | |

D.F. = Degrees of Freedom. S.S. = Sum of Squares. M.S. = Mean Square.

APPENDIX II (*d*)

*Analysis of Covariance—Dimension D*

| Source of variation | D.F. | S.S. | M.S. |
|---|---|---|---|
| Deviation from individual within group regressions .. .. | 114 | 44·2332 ($S_1$) | 0·3880 |
| Difference between regressions .. .. .. | 2 | 0·5409 ($S_2$) | 0·27045 |
| Deviation from average within group regressions ($b_a$) .. | 116 | 44·7741 ($S_1+S_2$) | 0·3860 |
| Deviation from regression through group means ($b_m$) .. | 1 | 8·3662 ($S_3$) | 8·3662 |
| Deviation between $b_a$ and $b_m$ .. .. .. | 1 | 10·7842 ($S_4$) | 10·7842 |
| Deviation from common (Total) regression ($b_c$) .. .. | 118 | 63·9245 ($S_5$) | |

D.F. = Degrees of Freedom. S.S. = Sum of Squares. M.S. = Mean Square.