Principal Component Analysis in Shell Selection Behaviour of the Land Hermit Crab *Coenobita cavipes* Stimpson

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Shell variables which influence shell selection in the laboratory were studied by multivariate analyses. Three shell variables important for hermit crabs, viz. volume, weight and aperture width, were employed against carapace length of crabs in the analyses. Scaled 1st principal component appeared to be a reliable estimator of shell size for this crab and when it had a choice, the crab preferred a shell of suitable general dimension rather than a shell based on any one particular variable.

To protect itself from the environment and from its predators the hermit crab must enter a gastropod shell. It does not occupy a gastropod shell at random but prefers a shell because of its shape, ornamentation, dimension and weight[1]. The land hermit crab, *Coenobita cavipes*, occurring on the banks of Vellar estuary (lat. 11°29′ N and long. 79°46′ E), which has outgrown its domicile shells, seems under field conditions, to select shells based largely on shell volume[2]. When given a choice how do they select shells is investigated presently.

Procedures followed in previous studies[3-7] to find out shell factors important in shell selection have become increasingly unsatisfactory[8] and in the present study, therefore, principal component analysis has been used to find out the relative importance of the 3 shell factors, considered important for hermit crabs.

In the previous study[2] based on carapace length, the hermit crabs were divided into 6 size groups. Presently shell selection in the laboratory was studied employing the above 6 size groups following the method of Grant and Ulmer[1]. When the hermit crabs selected shells after a choice, the carapace length of the crabs and the 3 measures of gastropod shells were recorded. Data thus obtained were processed in 2 ways. In the first instance, raw data were used as such and denoted as unscaled, then all the 4 variables were transformed to logarithams and denoted as scaled.

Mean values of carapace length of crabs and 3 variables of gastropod shells selected in the laboratory experiments by the hermit crabs of various sizes are given in Table 1 along with selections made in field conditions. When given a choice, the hermit crabs selected shells of a larger volume and greater weight and aperture widths. The standard error of all variables was larger under selection conditions. So, a modified form of *t* test, the statistic *d*, was employed to find out whether the carapace lengths and shell parameters of the 2 categories were significantly different from each other. Carapace length of hermit crabs and shell weight in the above 2 situations were not significantly different from each other but shell volume and shell aperture width differed significantly in both laboratory and field experiments.

Zero order correlation coefficient values relating to the crab and shell parameters are given in Table 2. From *r* values under choice situation itself it could be inferred that all the 3 shell variables probably influenced the hermit crab equally in shell selection and this hermit crab selects a shell of general dimension. But the difficulty in putting forward the above inference, only by looking at the zero order was that shell variables are interrelated with each and simple correlation fails to reveal the individual influence of any one shell variable during selection. So multivariate analyses was used. Eventhough, the coefficient of multiple correlation (*R*), a measure of the closeness of fit of multiple regression plane, was highly significant in both unscaled and scaled situations (0.979 and 0.997 respectively), the 1st and 2nd order correlations, multiple regression equations and the analysis of

Table 1—Crab Carapace Lengths and Shell Variables of Gastropods Selected by *C. cavipes* in the Laboratory along with Those in Field

(Values are mean ± SE)

Variable	Shells selected	Shells occupied in field	*d*	*P*
Carapace length	20.145 ± 1.72	19.238 ± 0.479	0.488	> 0.1
Shell vol.	13.59 ± 2.103	9.552 ± 0.495	2.255	< 0.05
Shell wt	15.467 ± 2.178	13.558 ± 0.739	0.829	> 0.1
Shell aperture width	18.435 ± 1.574	14.583 ± 0.377	2.379	< 0.05

Table 2—Correlation Coefficient (*r*) Values and Their Significance Between the Crab and Shell parameters of Shells Occupied and Shells Selected by *C. cavipes*

(Number of samples 31)

Parameter	Unscaled		Scaled	
	r in field sample	*r* in lab. sample	*r* in field sample	*r* in lab. sample
A/B	0.648*	0.943*	0.726*	0.993*
A/C	0.187†	0.975*	0.237†	0.989*
A/D	0.369‡	0.878*	0.408‡	0.976*

A, carapace length; B, shell volume; C, shell weight; and D, shell aperture width.

P value: * < .001; † > 0.05; ‡ < 0.05.

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variance for testing the regressional fit did not give a true picture. The 1st component $0.972666\ X_1 + 1\ X_2 + 0.966276\ X_3$ in unscaled analysis accounted for 93.93% of the total variability of the shell parameters. In scaled analysis the results were still more significant and the percentage contributions of the 1st component $1\ X_1 + 0.995575\ X_2 + 0.983723\ X_3$ to total variability of shell parameters was 97.93%. Since the 1st component itself accounted for more than 90% of total variability, further components were not worked out. Both in unscaled and scaled conditions, the values for the 3 variables were similar and it was more so in scaled situation. This indicates that all 3 shell variables may exert their influence in selection of a shell by this crab, when given a choice.

The 1st principal component seems to be a more reliable estimator of shell size for hermit crabs than selection by multiple regression of the best pair of shell and crab size correlates[8]. In the present study also both in unscaled and scaled analyses the variability of the shell parameters could adequately be explained by the 1st principal component[8,9]. The variability explained was greater for scaled analysis than for unscaled analysis. It therefore seems to be advisable to look at the scaled analysis and interpret the 1st principal component as the main guideline which influences *C. cavipes* to select its shell. The 1st principal component can easily be interpreted as in all cases the length attached to each of the 3 shell variables are very near to each other. In terms of relative importance all shell variables, viz. volume, weight and aperture width, seem to exert an equal influence in the selection of a shell by *C. cavipes* when it is offered a choice of shells.

When empty gastropod shells are available in abundance, this crab always selects a shell of a general dimension that suits its body. Smaller shells were found to be available in plenty and larger shells were found to be in short supply in the field[2]. Accordingly smaller crabs occupy adequate shells while the bigger sized crabs have outgrown their domicile shells. The 1st principal component of the shells occupied by the smaller sized animals was $1\ X_1 + 0.955587\ X_2 + 0.939725\ X_3$ and the total variability of shell parameters explained was 94.6%. The values for 1st principal component analysis in bigger sized crabs which were occupying inadequate shells was $0.416996\ X_1 + 0.966897\ X_2 + 1\ X_3$ and the total variability of shell variables explained only amounted to 67.47%. In nature shell volume influenced more in the shell selection behaviour of the bigger crabs[2] and it is clearly reflected in the 1st principal component analysis where the value attached to shell volume (X_1) was only 0.416996. The inadequate occupation of shells leads to aggressive behaviour among them leading also to a fight for shells as observed commonly in the field.

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Maturity Size of the Female Population of Certain Commercial Prawns from Bombay*

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Size at which 50% of female prawn population attains maturity is determined in 8 species of commercial prawns, commonly available in the bag net catches of Bombay waters. The sizes (in mm) for different species determined were *Metapenaeus brevicornis* - 112.5, *Parapenaeopsis stylifera* - 105.5, *P. hardwickii* - 85.5, *P. sculptilis* - 122.0, *Solenocera indica* - 88.5, *Atypopenaeus stenodactylus* - 38.3, *Palaemon tenuipes* - 50.5 and *Hippolysmata ensirostris* - 60.5.

Determination of size at maturity is an important aspect of reproductive biology. However, most of the available literature[1-6] on the subject refer only to the minimum size at 1st maturity attained by stray individual prawns. What is more important is the maturation size of the population as such which can be the size at which at least 50% of the individuals from the population are matured. Such an information about all the commercially important species would prove very useful in throwing light on their fluctuations, breeding migrations and status of their fisheries. Therefore, an attempt has been made to determine the maturity size of the population by constructing maturity curves of 8 commercially important prawns, available around Bombay region.

Penaeid prawns *Metapenaeus brevicornis* (H.M. Edw.), *Parapenaeopsis stylifera* (H.M.Ewd), *P. hardwickii* (Miers), *P. sculptilis* (Heller), *Solenocera indica* Nataraj and *Atypopenaeus stenodactylus* (Stimpson) and non-penaeid prawns *Palaemon*

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