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STATISTICAL ANALYSIS OF VARIABILITY IN A POPULATION OF
PARAHADRONCHUS SHAKILI (NEMATODA)

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It is well established that morphological characters vary among the individuals of a species, though the extent of variation may differ. The variations may be geographical, ecophenotypic or host induced. Several workers have studied these variations in different species of nematodes (Goodey, 1952; Rhode and Jenkins, 1957; Bird and Mai, 1965; Fisher, 1965; De Grisse and Loof, 1970; Bajaj and Jairajpuri, 1977 a and b; Geraert, 1978 a and b; 1979; Loof and Sharma, 1979; Baqri and Ahmad, 1981).

Studies on *Parahadronchus shakili* (Jairajpuri, 1969) Mulvey, 1978 have shown that there are variations in the specimens, not only from different localities and habitats but also in a single population. In this paper, these variations in a single natural population in adults and juveniles of *P. shakili* collected from soil around roots of *Litchi chinensis* Sonn Company Gardens, Bareilly, Uttar Pradesh have been statistically analysed.

Morphometric and Allometric Variations

The morphometric and allometric characters analysed statistically for their variability in adults and juveniles are presented in Table I. With regard to the allometric characters it was found that length of the gonads was not proportional to body length, thus making ratios 'G1' and 'G2' highly variable. The position of the vulva showed a positive correlation with body length thereby making the value 'V'

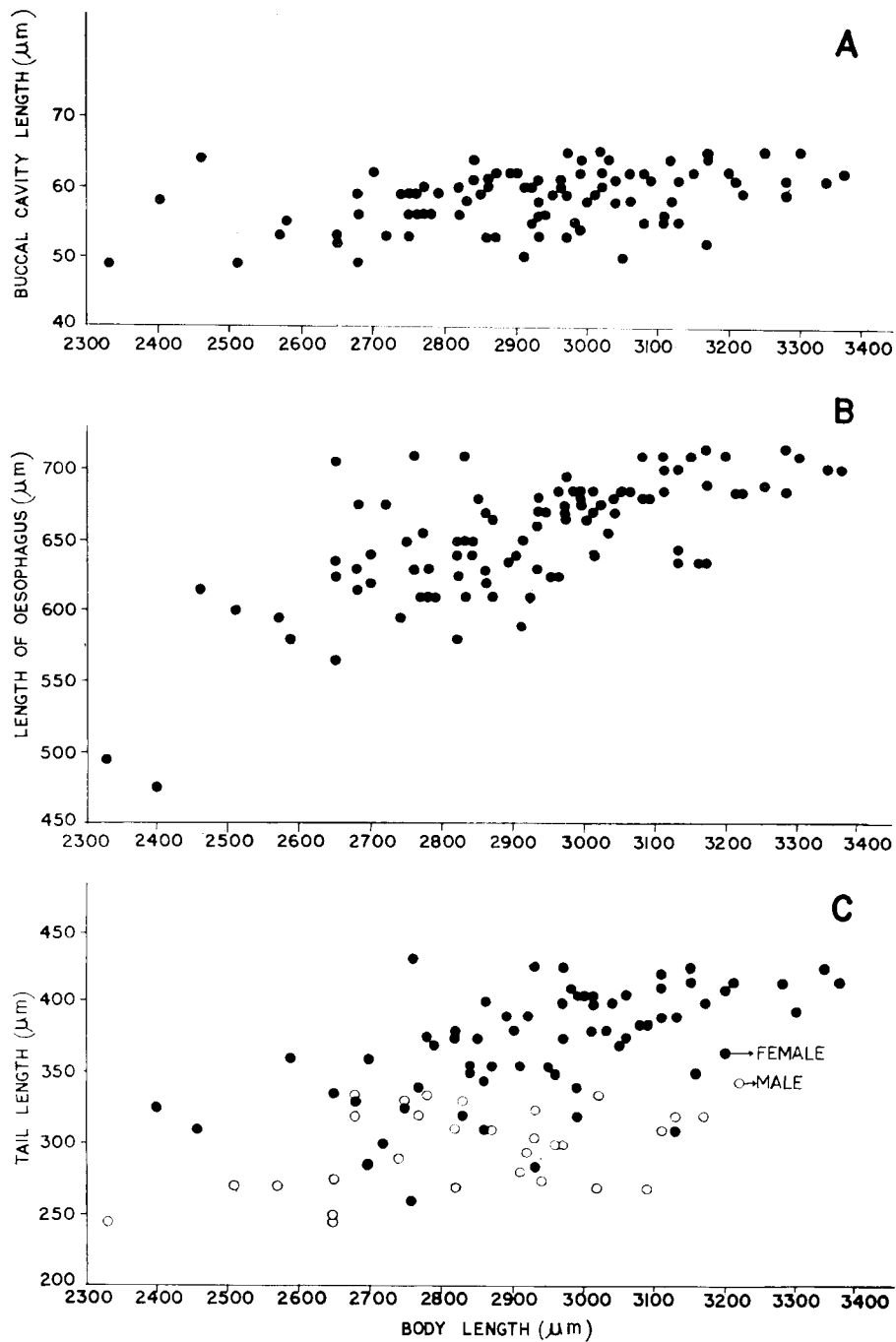


Fig. 1 - The body length in relation to buccal cavity length A; oesophageal length B; tail length in adults C of *Parahadronchus shakili*.

a reliable taxonomic character (Fig. 2). It was also evident that the length of the buccal cavity, oesophagus and tail did not depend upon the body length in adults as well as in juveniles (Fig. 1 and 3).

Adults:

Among all the morphometric and allometric characters evaluated in adults, the less variable characters (C.V. \leq 3%) were the length of buccal cavity (C.V. = 2.2-3%) and value of 'V' (C.V. = 2.7%). The highly variable characters (C.V. \geq 10%) were position of the amphid apertures (C.V. = 14-16%); length of the gonads (C.V. = 12-16%); rectum (C.V. = 13%); tail (C.V. = 13-14%); Values 'G1' and 'G2' (C.V. = 12-17%); the number of ventromedian supplements (C.V. = 14%) and the length of lateral accessory pieces (C.V. = 12%). The characters which showed a moderate degree of variation, ranging from 4-6%, were width of the buccal cavity (C.V. = 3.6-4.4%), position of the nerve ring (C.V. = 4.7-6%), anal body-width (C.V. 4.6-6.3%) and length of the spicules (C.V. = 5%). Other characters were markedly variable, C.V. ranging from 7-10%.

Juveniles:

The variability of total body length was high in the first (C.V. = 14%) and second (C.V. = 9.5%) stage juveniles and moderate in the third and fourth stages (C.V. = 5.9-6%). Lip-height in all the developmental stages was highly variable (C.V. = 12-14%), except in the third stage juveniles where it was markedly variable. The variability of lip width was moderate in the second and fourth stage juveniles and somewhat higher in the first and third stages. The width of the amphid apertures was as markedly variable as the females (C.V. = 6.9-10%). The variations in length and width of the buccal cavity of various juvenile stages were moderate, C.V. = 3.5-5.0% and 5.4-6.2% respectively, except in the first stage juveniles where the length of buccal cavity was less variable (C.V. = 2.7%). The position of the dorsal tooth was moderately variable in the fourth stage (C.V. = 4.9%), more variable in the third stage (C.V. = 8.4%) and highly variable in the first and second stage juveniles (C.V. = 15% and 11% respec-

Table I - *Morphometric and allometric variations in adults and juveniles of Parahadronchus shakili.*

Characters	Females n = 69	Males n = 32	L ₁ n = 19	L ₂ n = 20	L ₃ n = 11	L ₄ n = 13
Length (mm)	Range (Mean) C.V.	2.40-3.35(2.96) 8.5 ⁰ / ₀	0.61-0.99(0.84)*** 14 ⁰ / ₀	1.06-1.45(1.26)*** 9.5 ⁰ / ₀	1.49-1.80(1.71)** 5.9 ⁰ / ₀	1.81-2.31(2.01) 6 ⁰ / ₀
a	Range (Mean) C.V.	35-52(45) 9 ⁰ / ₀	21-31(26)*** 11 ⁰ / ₀	29-35(34) N.S. 5.7 ⁰ / ₀	33-38(35) N.S. 5.3 ⁰ / ₀	34-43(37) 6 ⁰ / ₀
b	Range (Mean) C.V.	3.8-6.2(4.5) 8.2 ⁰ / ₀	3.1-3.7(3.4)*** 7.7 ⁰ / ₀	3.4-4.5(3.9) N.S. 7.7 ⁰ / ₀	3.9-4.2(4.0) N.S. 5.9 ⁰ / ₀	4.0-4.5(4.1) 5.9 ⁰ / ₀
c	Range (Mean) C.V.	7.3-11.8(9.2) 8.7 ⁰ / ₀	5.5-7.9(6.9) N.S. 9.1 ⁰ / ₀	6.3-7.7(7.1)*** 6.9 ⁰ / ₀	7.4-8.6(8.0) N.S. 5.4 ⁰ / ₀	6.6-9.0(8.0) 9.4 ⁰ / ₀
V/T	Range (Mean) C.V.	60-66(61) 2.7 ⁰ / ₀	—	—	—	—
G ₁	Range (Mean) C.V.	9-15(12) 17 ⁰ / ₀	—	—	—	—
G ₂	Range (Mean) C.V.	9-15(12) 12 ⁰ / ₀	—	—	—	—
Spicules (µm)	Range (Mean) C.V.	—	—	—	—	—
Gubernaculum (µm)	Range (Mean) C.V.	91-106(96) 5 ⁰ / ₀	—	—	—	—
Lateral accessory pieces (µm)	Range (Mean) C.V.	18-24(21) 9.7 ⁰ / ₀	—	—	—	—
Ventromedian supplements	Range (Mean) C.V.	12-18(13) 12 ⁰ / ₀	—	—	—	—
Lip-height (µm)	Range (Mean) C.V.	11-16(13) 14 ⁰ / ₀	—	—	—	—
Lip-width (µm)	Range (Mean) C.V.	15-25(18) 7.6 ⁰ / ₀	7-11(8)*** 14 ⁰ / ₀	9-11(10)*** 12 ⁰ / ₀	11-15(13)*** 9.7 ⁰ / ₀	12-18(16) 14 ⁰ / ₀
Width of amphid apertures (µm)	Range (Mean) C.V.	45-60(53) 9.2 ⁰ / ₀	18-24(21)*** 8.2 ⁰ / ₀	24-27(26)*** 3.9 ⁰ / ₀	29-33(31)*** 6.5 ⁰ / ₀	35-41(38) 6 ⁰ / ₀
	Range (Mean) C.V.	5-8(7) 7.1 ⁰ / ₀	3-4(3.8) N.S. 9.6 ⁰ / ₀	3-4(3.9)*** 10 ⁰ / ₀	5-6(5.6) N.S. 7.1 ⁰ / ₀	5-6(5.8) 6.9 ⁰ / ₀

Position of (1) amphid apertures (μm)	Range (Mean) C.V.	15-23(18) 14 ^{0/0}	14-22(18) 16 ^{0/0}	11-12(11.6) N.S. 4.3 ^{0/0}	11-13(11.8)*** 5.9 ^{0/0}	12-15(14)*** 6.4 ^{0/0}	16-18(17) 5.4 ^{0/0}
Buccal cavity-length (μm)	Range (Mean) C.V.	50-65(60) 2.2 ^{0/0}	49-60(55) 3 ^{0/0}	22-24(23)*** 2.7 ^{0/0}	29-31(30)*** 3.5 ^{0/0}	35-39(37)*** 4.8 ^{0/0}	41-48(45) 5 ^{0/0}
Buccal cavity-width (μm)	Range (Mean) C.V.	32-40(36) 3.6 ^{0/0}	29-35(31) 4.4 ^{0/0}	9-11(10)*** 6.2 ^{0/0}	14-16(14.2)*** 5.4 ^{0/0}	17-20(19)*** 6.2 ^{0/0}	22-26(25) 6.2 ^{0/0}
Dorsal tooth (μm)	Range (Mean) C.V.	21-30(26) 8.5 ^{0/0}	19-27(23) 10 ^{0/0}	5-8(7)*** 15 ^{0/0}	9-12(10)*** 11 ^{0/0}	13-17(15)*** 8.4 ^{0/0}	17-20(18) 4.9 ^{0/0}
Oesophagus (1) (μm)	Range (Mean) C.V.	476-716(662) 6.3 ^{0/0}	500-685(629) 7.7 ^{0/0}	188-280(249)*** 11 ^{0/0}	294-362(328)*** 6.7 ^{0/0}	378-430(409)*** 4.1 ^{0/0}	452-512(479) 2.7 ^{0/0}
Nerve (1) ring (μm)	Range (Mean) C.V.	150-198(176) 6 ^{0/0}	145-178(171) 4.7 ^{0/0}	83-88(85)*** 2.3 ^{0/0}	88-110(102)*** 3.2 ^{0/0}	113-126(124)*** 2 ^{0/0}	120-145(133) 4 ^{0/0}
Vulva (1) (μm)	Range (Mean) C.V.	1490-2140 (1821) 7.9 ^{0/0}	—	—	—	—	—
Anterior gonad (μm)	Range (Mean) C.V.	272-488(366) 16 ^{0/0}	—	—	—	—	—
Posterior gonad (μm)	Range (Mean) C.V.	260-450(360) 12 ^{0/0}	—	—	—	—	—
Vagina (μm)	Range (Mean) C.V.	19-25(23) 8.7 ^{0/0}	—	—	—	—	—
Vulva body-width (μm)	Range (Mean) C.V.	61-71(66) 4.3 ^{0/0}	56-62(60) 3.2 ^{0/0}	28-39(34)*** 12 ^{0/0}	35-42(40)*** 6.6 ^{0/0}	44-53(48)*** 7 ^{0/0}	50-59(54) 5 ^{0/0}
Anal body width (μm)	Range (Mean) C.V.	41-53(47) 6.3 ^{0/0}	47-55(53) 4.6 ^{0/0}	18-24(21)*** 13 ^{0/0}	24-30(28)*** 7 ^{0/0}	33-36(34)* 5.7 ^{0/0}	34-39(36) 4.8 ^{0/0}
Rectum (μm)	Range (Mean) C.V.	31-52(41) 13 ^{0/0}	—	14-21(17)*** 8 ^{0/0}	18-24(21)*** 5.8 ^{0/0}	23-28(26) N.S. 5.7 ^{0/0}	25-33(27) 5.7 ^{0/0}
Tail (μm)	Range (Mean) C.V.	262-430(372) 13 ^{0/0}	245-355(297) 14 ^{0/0}	83-147(123)*** 22 ^{0/0}	141-221(195) + 10 ^{0/0}	174-262(213) N.S. 8.6 ^{0/0}	203-314(230) 12 ^{0/0}

(1) Distance from anterior extremity.
C.V. = Coefficient of variability.

*** Significant at > 0.1% level.
** Significant at > 1% level.
* Significant at > 2% level.
+ Significant at > 5% level.
N.S. = Not Significant.

tively). The position of the nerve ring was also a less variable character, except in the fourth stage juvenile where it was moderate (C.V. = 4%). As with the position of dorsal tooth, the coefficient of variation for oesophageal length also decreased from the first to the fourth stage juvenile, C.V. being 11% in L1, 6.7% in L2, 4.1% in L3 and 2.7% in L4. The variation for rectum length was moderate in the second, third and fourth stage juveniles (C.V. = 5.7-5.8%), and markedly higher in the first (C.V. = 8%). The anal body-width was found highly variable in the first stage juvenile, somewhat less in the second, and moderate in the third and fourth. The tail length was found to be highly variable in the first and fourth stage juveniles, and slightly less in the second and third. Among all the morphometric and allometric characters, the maximum variability was noted in tail length of the first stage juveniles (C.V. = 22%).

The value 'a' was highly variable in the first stage (C.V. = 11%), and moderate in remaining stages (C.V. = 5.3-6.0%). The value 'b' was markedly variable in the first and second stage juveniles (C.V. = 7.7%) and moderate in the third and fourth (C.V. 5.3-5.9%), while 'c' value was markedly variable in all the developmental stages except in the third stage where it was moderately variable (C.V. = 5.4%).

The Distinguishing Features of the Juveniles:

Among the various morphometric and allometric characters listed in the Table I, the various juvenile stages differed significantly from its successive stage in the body length, lip-width and lip-height, length and width of buccal cavity, position of dorsal tooth and nerve ring, length of oesophagus and anal body-width. The values 'a', 'b' and 'c' were found to be unreliable because 'a' and 'b' differed significantly only between L1 and L2 and 'c' between L2 and L3. The other characters were also found to be unreliable in the differentiation of various juvenile stages.

Besides the above cited characters, the first stage juveniles differed from rest of the stages in the absence of denticles in the buccal cavity. These denticles were 1-2 in the second stage juvenile, 3-4 in the third stage and 3-6 in the fourth stage. In the fourth stage juvenile, a rectangular hyalin area usually appeared which indicated the place of formation of the future vulva. The presence of the

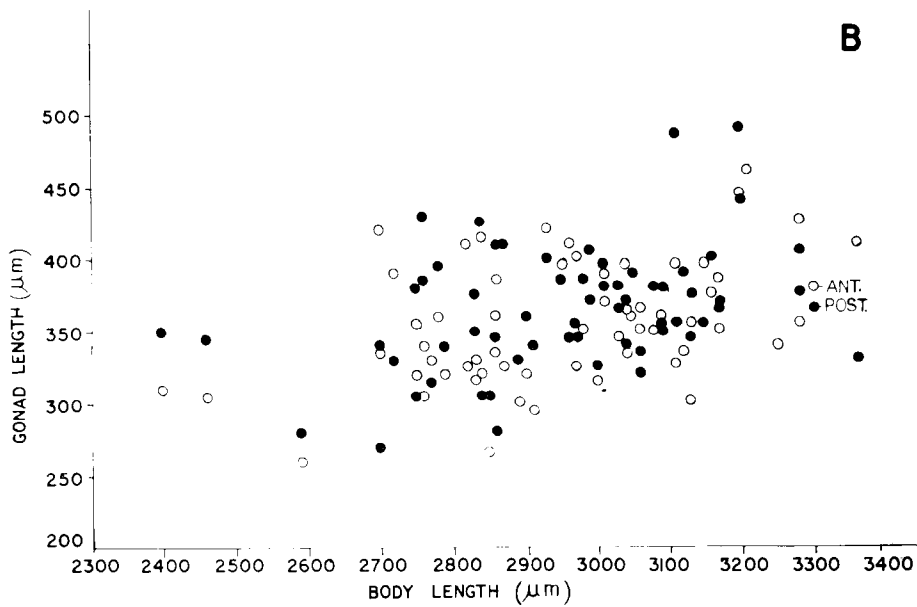
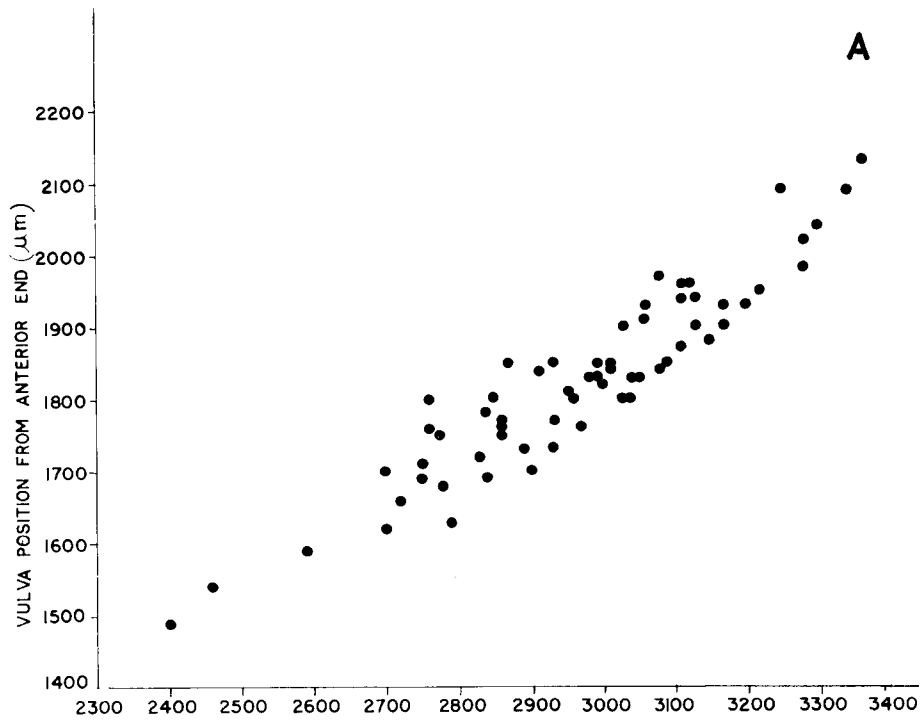


Fig. 2 - The body length in relation to vulva position (A); and gonad length (B) in *P. shakili*.

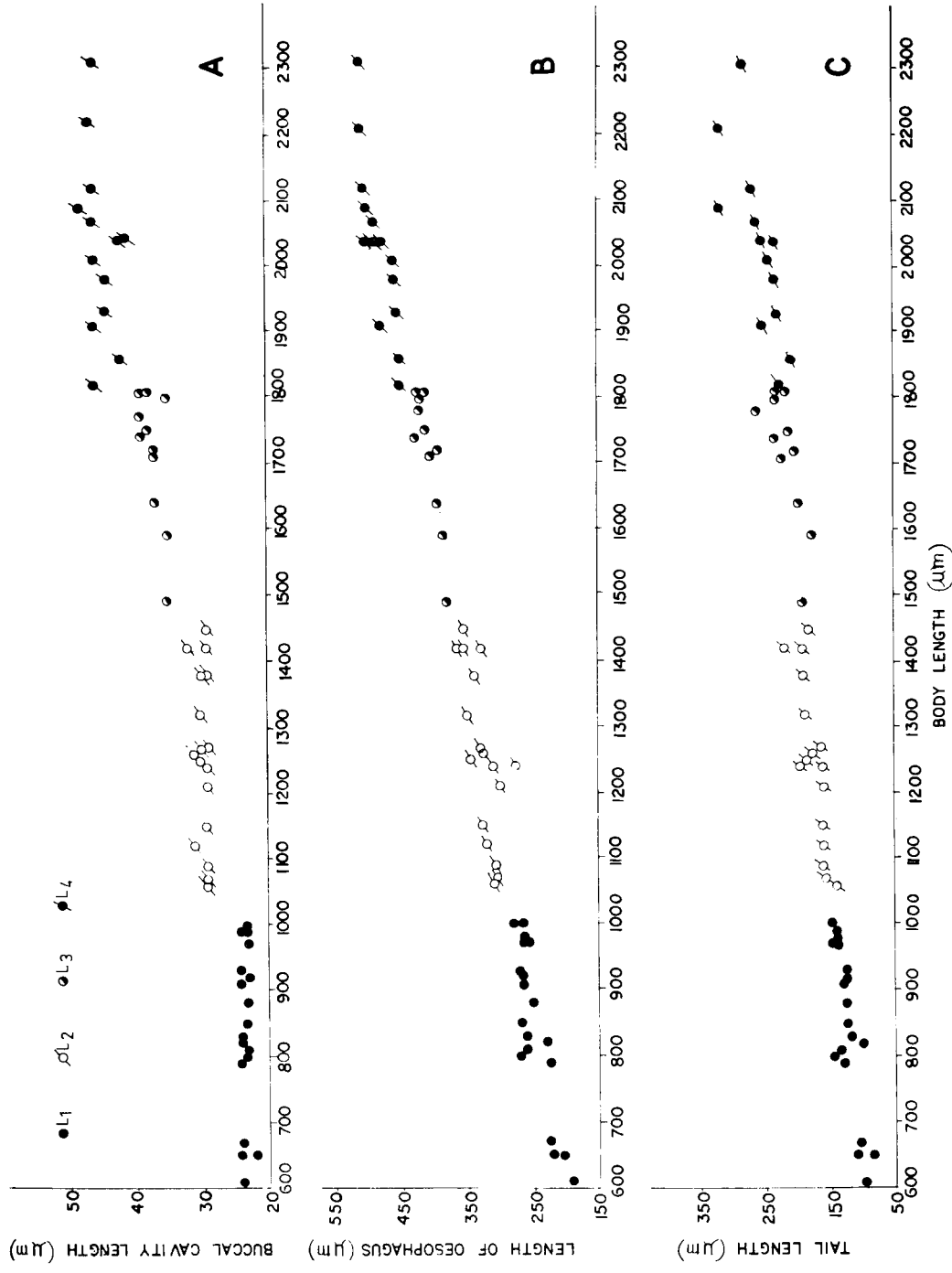


Fig. 3 - The body length in relation to buccal cavity length (A); oesophageal length (B); and tail length in juveniles (C) of *P. shakili*.

replacement tooth clearly differentiated the juveniles from their adults.

Discussion

The present morphometric studies on adults and juveniles of *Parahadronchus shakili* indicate that there is variation in all the morphological characters to a certain degree. The morphometric characters evaluated in the adults show that the length and width of the buccal cavity are least variable and can be regarded as good diagnostic characters at species level. There is considerable variation in total body length, lip-width and lip-height, width of amphid apertures, position of dorsal tooth, length of oesophagus and length of gubernaculum. The position of nerve ring, anal body-width and the length of spicules also showed little variation but all the other characters are highly variable. In the allometric characters the value of V is least variable. This agrees with the observations made by Bird and Mai (1967) on *Trichodorus christiei*; Wu (1960) on *Ditylenchus destructor*; Rashid and Khan (1976) on *Pratylenchus coffeae*; and Bajaj and Jairajpuri (1976) on *Xiphinema basiri*. The G_1 and G_2 values showed highest coefficient of variability which partly agrees with Azmi and Jairajpuri (1978). The body width, oesophageal length, tail length and length of gonads are independent of body length. These findings are in conformity with those of Sturhan (1963) and Geraert (1968).

The length of the buccal cavity is also independent of body length. The extent of variability for values of 'a' and 'L' is almost the same while the value 'c' shows more variability than the anal body-width. The length of the oesophagus is less variable than 'b'. This is in accordance with the findings of Geraert (1968). The value 'c' is more constant than the tail length.

In juveniles, the first stage exhibits the maximum variability in almost all the morphometric and allometric characters. In third and fourth stages the degree of variation for each character shows consistency. The results further show that in the juvenile stages and the adults the extent of variation for a particular character is almost same. This indicates that variability of a character is determined from the very first stage (Bajaj and Jairajpuri, 1977 b).

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S U M M A R Y

The analysis of variability of some important morphological characters of the adults and the juveniles of *Parahadronchus shakili* (Jairajpuri, 1969) Mulvey, 1978 (Nematoda: Mononchida) revealed that almost all the characters are variable to some extent. The length and the width of the buccal cavity however, are least variable. The position of nerve ring, anal-body-width and the length of the spicules also show little variation. The highly variable characters include the position of amphid apertures, length of female sexual branches, tail, rectum etc. The vulva position is positively correlated with the total body-length while the length of the genital branches are not correlated. Of all the allometric characters, the value of 'V' is least variable and 'G₁' and 'G₂' exhibit maximum variability. The length of buccal cavity, oesophagus and tail are independent of body length. The characters in juveniles vary almost to the same extent as in the adults.

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