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STATISTICAL ANALYSIS OF VARIABILITY IN A POPULATION OF *XIPHINEMA BASIRI* SIDDIQI, 1959

by

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The characters used in nematode taxonomy vary among and within populations of a single species. The variations may be host-determined or due to differences in the environment (ecophenotypic variations) or due to different geographical distribution of the populations. These have been studied by various authors. J. B. Goodey (1952) demonstrated host-induced variations in body length and dorsal or ventral positions of the oesophageal bulb in *Ditylenchus destructor*. Rhode and Jenkins (1957) found that body length and body width of *Trichodorus christiei* vary inversely with the temperature of soil. Taylor and Jenkins (1957) working with *Pratylenchus* spp. and Coomans (1962) with *Rotylenchus goodeyi* found that deviations from the mean were least for vulva position and greatest for tail shape. Sturhan (1963) found that body width, oesophageal and tail lengths of *Xiphinema* and *Longidorus* species exhibit negative allometric growth with body length. Tarjan (1964) noticed differences between north-western and south-eastern populations of *X. bakeri* in body length, values of a and b, posterior gonad length, and in c' ratio. Gysels (1964) observed that temperature influences allometric growth of *Panagrellus silusiae*. Fisher (1965) demonstrated variations due to host plant and temperature in the body and stylet lengths of *Pratylenchus nanus*. The host species and variety, host physiology and the geographical origin of a population was found to influence the variations in morphometric and allometric characters in *T. christiei* and the stylet length and the value of V were least variable characters

(Bird and Mai, 1967). Baqri and Jairajpuri (1967) studied the variations within 14 populations of *Thornenema mauritianum* from India. The variations among different populations of *X. americanum* from different parts of the world were possibly due to geographical latitude, temperature and other factors (Tarjan, 1969). Loof and Maas (1972) observed intraspecific variations among the populations of *Xiphinema* species found in Surinam and concluded that body dimensions alone are unsatisfactory for distinguishing species and qualitative characters should also be given at least equal weight. Heyns (1974a and 1974b) studied intraspecific variations in *X. brevicolle* and *X. elongatum* which may be correlated with the geographical distribution of the various populations. Bajaj and Jairajpuri (1977) studied variability within 23 populations of *X. insigne* from India and grouped them in two « forms », viz., *indicum*-form and *insigne*-form. Morphometric and allometric variations in a population of *Helicotylenchus indicus* have been studied by Azmi and Jairajpuri (1977).

Xiphinema basiri Siddiqi, 1959 is fairly well distributed in India, especially in the plains, and in Aligarh is of common occurrence. Specimens from different populations of *X. basiri* show variability in length of body, odontostyle and tail and in the shape of lip region and tail. However, not only do the specimens from different localities (geographical variations) and hosts (host-determined variations) show variability but also the specimens from a single population are variable. In this paper an attempt has been made to study the statistical significance of these variations in a single natural population of *X. basiri* collected from soil around roots of citrus plants from the gardens of Botany Department, Aligarh Muslim University, Aligarh. The variability was studied in the adults as well as in the juveniles. In addition, certain abnormal morphological variations were also noticed in the development of the gonads and in tail shape. These are described below.

MORPHOMETRIC AND ALLOMETRIC VARIATIONS

Morphometric and allometric variations were observed in almost every character in the population of *X. basiri* studied in the present work. These variations are basically different for each character.

MORPHOMETRIC VARIATIONS

Body length: Body length in adult ranged from 2.55-3.61 mm with S.D. ± 0.3 mm. The coefficient of variability of this character was 0.09 in adults showing that it is quite variable.

In juveniles, the body length measured 1.21 ± 0.14, 1.65 ± 0.2, 2.35 ± 0.2 mm in L_2, L_3 and L_4 respectively. The minimum variation was observed in L_4 where C.V. = 0.10. The value of C.V. in L_2 and L_3 = 0.12. This high value of C.V. shows that the total body length is also quite variable in the juveniles.

Body width: In the adults the body width ranged from 43-57 μm with S.D. ± 5.0 and C.V. = 0.10.

Among the juveniles the body width measured 26 ± 3.0, 31 ± 3.0, and 39 ± 4.0 μm in L_2, L_3, and L_4 respectively and have C.V. = 0.12, 0.09 and 0.10.

This high value of C.V. in adults and the juveniles clearly shows that body width is a greatly variable character. Similar values of C.V. (0.09-0.12) also show that this character is variable to the same extent in each stage of the life cycle.

Odontostyle lengths:

Functional odontostyle length: The functional odontostyle length was the least variable of all the morphometric characters that were studied. In adults of *X. basiri* the variability was only 3% of its length and measured 119 ± 3.4 μm.

Among juveniles, the C.V. of functional odontostyle length was 0.04, 0.03 and 0.03 in L_2, L_3 and L_4 respectively and was least variable of all the characters measured. The odontostyle length measured 62 ± 2.4 μm in L_2, 80 ± 2.9 μm in L_3 and 99 ± 3.4 μm in L_4.

The C.V. 0.03 – 0.04 clearly shows that odontostyle length is variable to almost the same extent in each stage of the life cycle.

Replacement odontostyle length: This varied 3.2% – 5.2% of its length in juveniles. In L_2, L_3 and L_4, it measured 80 ± 4.2, 98 ± 3.1 and 120 ± 5.3 μm respectively with C.V. = 0.05 in L_2, 0.03 in L_3 and 0.04 in L_4. This shows that the replacement odontostyle length is also a less variable character.

Odontophore length: This character was quite constant having C.V. 0.04 in adults, 0.05 in L_2, 0.05 in L_3, 0.06 in L_4. This shows that odontophore length varies to a limited extent in each stage of the life cycle.

Guiding ring: The position of guiding ring from the anterior end was also a constant character with C.V. 0.06 in adults (distance 101 $\pm$ 6.9 μm). Among the juveniles 54 $\pm$ 3.52, 90 $\pm$ 4.10 μm in L_2 and L_4 with C.V. 0.06 and 0.05 respectively.

Oesophageal length: A few specimens had abnormal oesophageal lengths measuring 518 μm against 402 μm which is the average length in normal adults. In adults this character was variable with C.V.=0.07.

The variations of oesophageal length were similar for each of the juvenile stages, the C.V. being equal to 0.07, 0.08, 0.08 in L_2, L_3 and L_4 respectively and measuring 249 $\pm$ 16.1, 305 $\pm$ 24.2 and 375 $\pm$ 28.4 μm respectively.

Basal oesophageal bulb: It was comparatively less variable in adults (C.V. = 0.06), and measured 101 $\pm$ 6.1 μm, although its length was affected by the position of the odontostyle. In juveniles, the L_3 stage exhibited more variation than in any other juvenile stage with C.V. = 0.12 (length 73 $\pm$ 9.2 μm) as compared to C.V. = 0.06 and 0.07 in L_2 and L_4 respectively.

Gonad length: The lengths of anterior and posterior gonads were quite variable having C.V. = 0.13 and 0.17 respectively. These variations were due to unequal coiling of the muscular part of uterus.

Vaginal length: The length of vagina varied 3.6 of its length and measured 27 $\pm$ 2.4 μm.

Anal body-width: The C.V. of anal body-width was 0.08, 0.13, 0.09, 0.09 and measured 17 $\pm$ 1.4, 21 $\pm$ 3.7, 26 $\pm$ 2.5 and 27 $\pm$ 2.4 μm in L_2, L_3 and L_4 and the adults respectively. This indicates that the anal body-width shows more variations in L_3 than in any other juvenile stage or adults.

Tail length: It varied 7.1% of its length and measured 42 $\pm$ 3.0 μm in adults. In juveniles the maximum variations observed were in L_2 where C.V. = 0.10 against 0.06 and 0.07 in L_3 and L_4.

ALLOMETRIC VARIATIONS

Body length/body width: The ratio ' a ' varied from 54-75 with S.D. = ± 5.3 and C.V. = 0.08 in adults. Although the body width had a tendency to increase with the increase in the body length it did not increase in the same proportion. Further, C.V. of ' a ' = 0.08, which is only a little less than C.V. of body width.

In the juveniles, the ratio ' a ' was quite variable in each stage. The maximum variations were observed in L_4 where C.V. = 0.10 and minimum in L_3 where it was only 0.07. The value of ' a ' in L_2, L_3 and L_4 was 48 ± 4.0, 54 ± 4.0 and 61 ± 6.3 respectively.

Body length/oesophageal length: This ratio was found to be 7.6 ± 0.57 with C.V. = 0.07. Since C.V. of b is 0.075 while that of total oesophageal length is 0.07 and of the oesophageal bulb is 0.06, it is clear that ratio b is more variable than the oesophageal length or the length of oesophageal bulb in adults.

In the juveniles too, the value of b was quite different for developmental stages showing that oesophageal length does not increase in the same proportion as does the body length. The value of b in L_2, L_3 and L_4 was found to be 4.8 ± 0.7, 5.4 ± 0.7 and 6.3 ± 0.5 respectively.

Body length/tail length: The increase in the body length was independent of tail length in adults. The c value correlated with total body length showing that this ratio is not good taxonomic character as was reported by Clark (1962). The C.V. of c = 0.10 (mean = 75.2 ± 7.3) while that of tail length itself is only 0.07 showing that the tail length is more constant than ratio c in adults.

In juveniles, the c value was more variable than the tail length with maximum C.V. = 0.11 in L_2 and 0.09 in L_3 and L_4. The c value in L_2, L_3 and L_4 was found to be 26.1 ± 3.0, 32.9 ± 3.0 and 49 ± 4.6 respectively. As in adults, c had a tendency to increase with the total body length.

Body length/functional odontostyle length: No relation was found between the body length and the length of functional odontostyle. The odontostyle length was independent of body length in adults as well as in juveniles.

Body length/replacement odontostyle length: There was no corre-

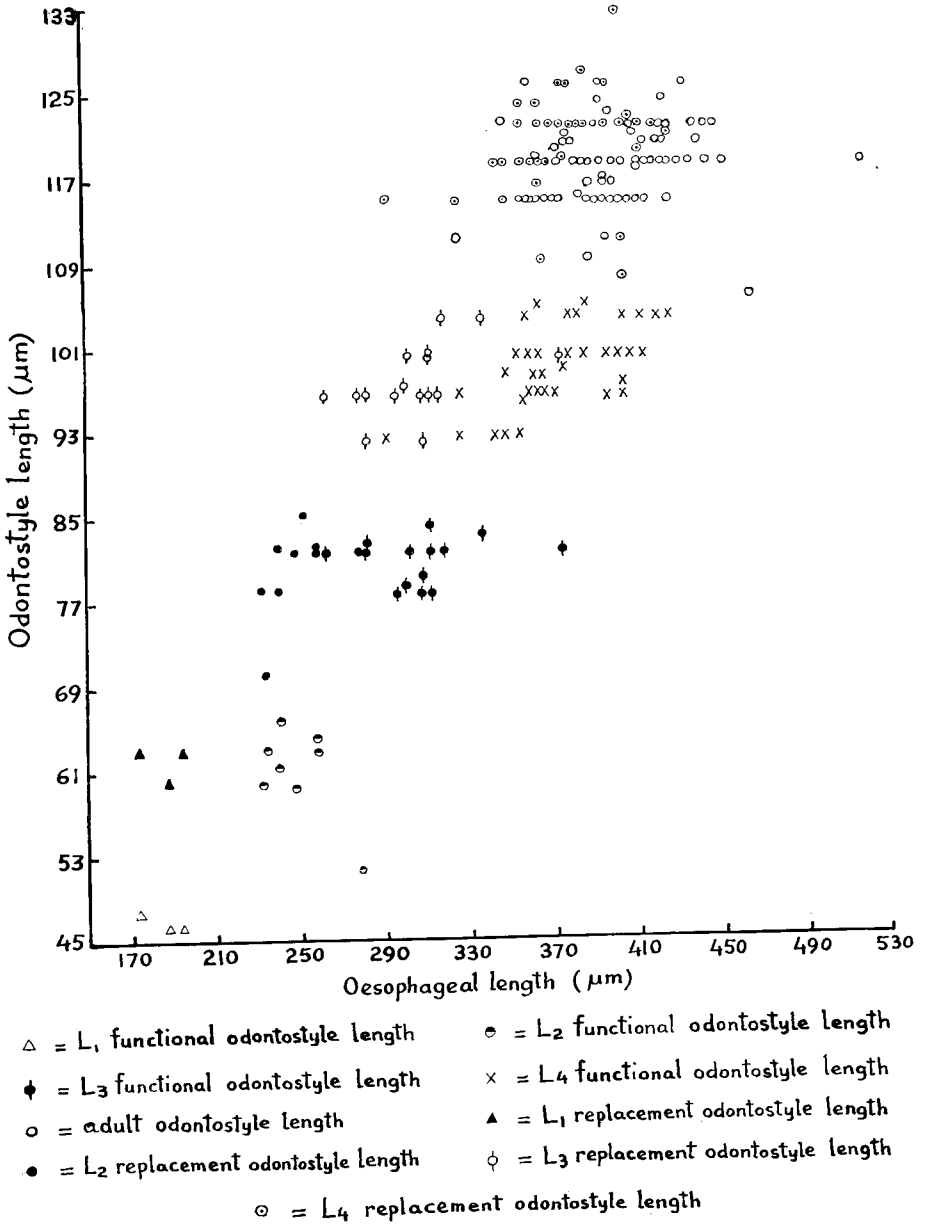

Fig. 1 - Relationship between oesophageal and odontostyle lengths in adults and juveniles of *Xiphinema basiri.*

lation between these two structures, both being quite independent of each other in the juveniles.

Oesophageal length/functional odontostyle length: The functional odontostyle length was independent of oesophageal length as seen in Fig. 1. This also shows that the functional odontostyle is consistent in length in adults and juveniles.

Oesophageal length/replacement odontostyle length: The growth of replacement odontostyle correlated with the growth of the oesophagus (Fig. 1). Also coefficient of rank correlation between these two characters was found to be significant at 5% level of probability in each juvenile stage.

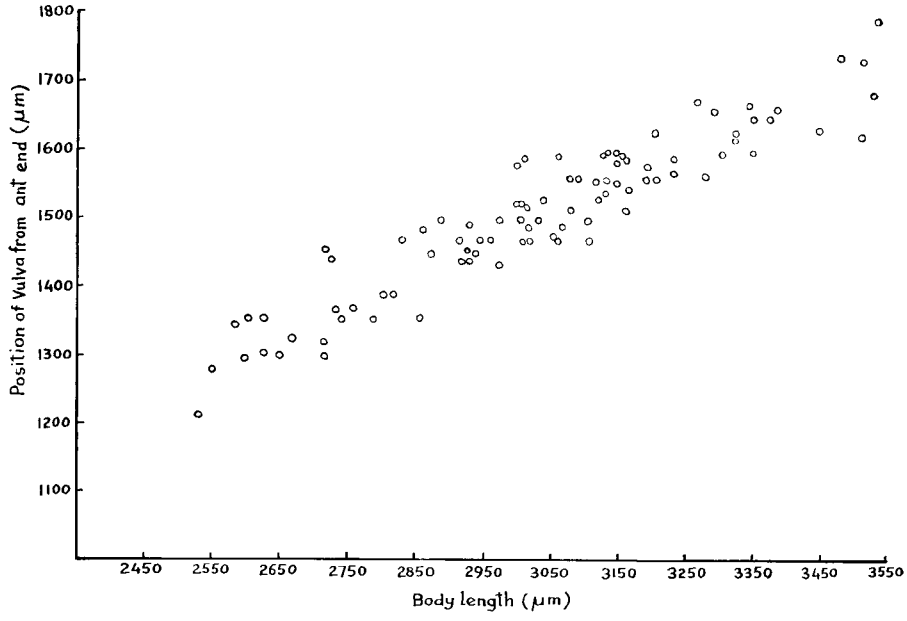

Fig. 2 - Relationship between body length and position of vulva from anterior end in *X. basiri*.

Body length/vulva position: The vulva position was found to be correlated with total body length (Fig. 2). This character is the least variable of all the morphometric and allometric characters that were measured, having C.V. = 0.024.

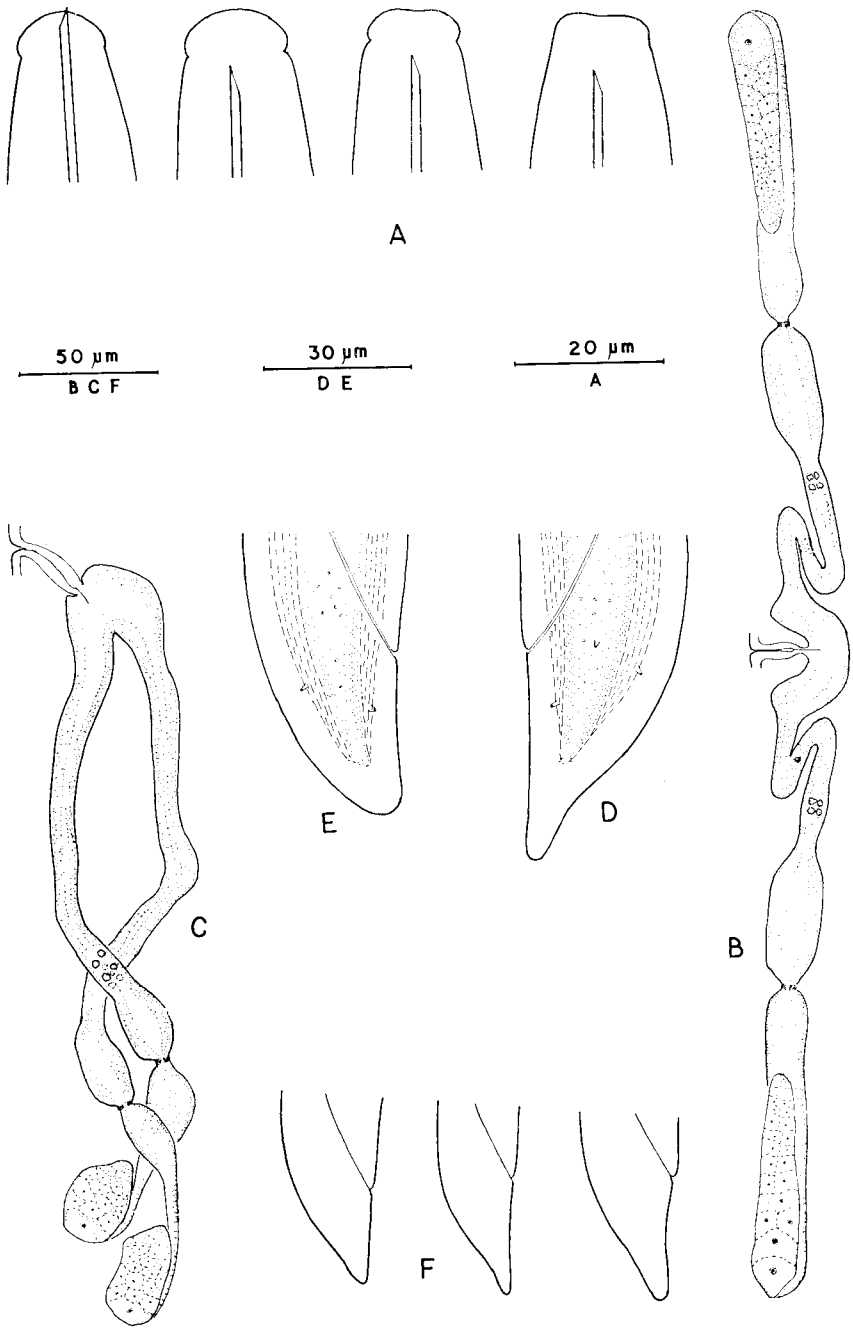

Fig. 3 - *X. basiri*: A = lip regions; B = didelphic, amphidelphic (typical) female genital tract; C = didelphic, opisthodelphic (abnormal) female genital tract; D = conoid-digitate (typical) female tail; E = convex-conoid (abnormal) female tail; F = female tails.

Anterior gonad length/posterior gonad length: Anterior gonad length was found to be quite independent of posterior gonad length. This may have been due to unequal coiling of the uteri of two gonads.

ABNORMALITIES

Genital tract: The nature of genital tract is of prime importance in the taxonomy of *Xiphinema*. The reproductive organs are typically didelphic, amphidelphic in this species. In one specimen the anterior sexual branch was completely reflexed and both the sexual branches were postvulval attaining a didelphic, opisthodelphic condition (Fig. 3, C). This seems to be an abnormality similar to that described by Khan *et al.* (in press) in *Mononchus tunbridgensis* and *X. americanum*.

Tail: The females of this species possess conoid-digitate tails which showed very little variation. In one specimen, however, the tail was convex-conoid without a trace of the digitate portion (Fig. 3, E). Had this specimen been collected from another locality, it would have caused much confusion regarding its identity as *X. basiri* since much importance has been given to tail shape in the taxonomy of *Xiphinema*.

DISCUSSION

Various morphometric and allometric characters varied to different degrees in a population of *X. basiri*. The length of the odontostyle and V were the least variable characters in this species and so they can safely be used to differentiate this species from other closely related species. These results are similar to those of Bird and Mai (1967) for *T. christiei*, Tarjan (1969) for *X. americanum*, Wu (1960) for *D. destructor* and Azmi and Jairajpuri (1977) for *H. indicus*. The position of the fixed guiding ring from anterior end, odontophore length, length of oesophageal bulb and tail vary to moderate degrees. All other characters were very variable and should be used with caution. The body width, length of the oesophagus and tail exhibited negative allometric growth with the body length

which agrees with the observations of Sturhan (1963). All the morphometric and allometric characters varied to almost the same extent in the juvenile stages as well as in the adults. This shows that the variability of a character is determined from the first juvenile stage.

X. basiri comes close to *X. coxi* Tarjan, 1964 and *X. ifacolum* Luc, 1961, Cohn and Sher (1972) synonymized *X. ifacolum* with *X. basiri* owing to the overlapping values of L, a, b, c, V, length of odontostyle and tail shape and in the presence of ' Z ' organ. Luc and Dalmasso (1975) rejected this synonymy on the basis of differences in the ' Z ' organs (*X. ifacolum* has a typical ' Z ' organ while *X. basiri* a pseudo ' Z ' organ) and the structure of tail tip (in *X. ifacolum* the inner surface of the cuticle of the tail tip forms a thin and regular blind canal surrounded apically by a thin muff but in *X. basiri* the tail tip has a large conical blind canal without any apical muff). The views of Luc and Dalmasso on this synonymy appear to be quite correct. *X. basiri* and *X. coxi* differ only in the position of vulva (V = 40 — 46 in *X. coxi*) but as was made clear above the position of the vulva is least variable in *X. basiri*, and consequently the two species are clearly different from each other.

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SUMMARY

The morphometric and allometric variations of adults and juveniles of a local population of *Xiphinema basiri* Siddiqi (from the gardens of Botany Department, University campus, Aligarh) were studied and the relationships of these variations among juvenile stages and adults were analysed. Odontostyle length and value of V were shown to be the least variable characters in this species. Each character was found to vary to almost same extent in all the life stages. Abnormal females having didelphic opistodelphic genital tract and convex-conoid tail are reported.

RIASSUNTO

Analisi statistica della variabilità in una popolazione di Xiphinema basiri *Siddiqi, 1959.*

È stata analizzata statisticamente la variabilità biometrica ed allometrica di adulti e stadi giovanili di una popolazione di *Xiphinema basiri* Siddiqi, 1959, raccolta nell'Orto botanico dell'Università di Aligarh, India. La lunghezza dell'odontostile ed il valore di V sono apparsi essere i caratteri meno variabili. Tutti i caratteri considerati hanno mostrato un campo di variabilità analogo in stadi adulti e giovanili. Sono state osservate femmine aberranti con gonadi didelfiche ospitodelfiche e coda convesso-conoide.

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