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MORPHOMETRIC AND ALLOMETRIC VARIATIONS OF A POPULATION OF *TRICHODORUS PAKISTANENSIS* SIDDIQI, 1962 FROM UTTAR PRADESH, INDIA

by

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Summary. Morphometric and allometric variations were studied on a population of *Trichodorus pakistanensis* Siddiqi, 1962, collected from the rhizosphere of litchi in the Doon Valley, India. In total, 25 characters were considered. Lip width, tail length and 'c' value in both sexes and cervical papillae, onchiostyle and ventromedian supplements in the males were stable according to CV% and can be used in species identification. Body length, mid-body width, body diameter at anus, 'c' value in females and guide ring position were moderately variable and correlation between characters were positive and significant at $P < 0.05$ level. However, 't' test ($P < 0.05$) has shown that these characters are not significant in males.

An abundant population of *Trichodorus pakistanensis* Siddiqi, 1962 was found in the rhizosphere of litchi (*Litchi chinensis* Sonner) trees in Doon Valley, Uttar Pradesh, India. The allometric variations of this population were studied to establish the relationship with the type population (Siddiqi, 1962) from Pakistan and a Chinese population (Xu and Decraemer, 1995) of *Trichodorus pakistanensis*.

Material and methods

Soil samples were collected in August, 1995. Nematodes were extracted by Cobb's wet sieving technique, killed and fixed in hot 5% formalin, processed by the slow method and mounted in anhydrous glycerine. Measurements were taken with an ocular micrometer. Characters considered on 50 specimens of either sex are indicated in Table I.

Results and discussion

Trichodorus pakistanensis Siddiqi, 1962 (Figs 1 and 2; Tables I-IV)

CV% Value of body length in both sexes showed a moderate range of variability. Correlations between body length and other characters were positive and significant, except for 'V' value in females (Table II); in males all correlations between body length and other characters were positive and significant, with the exception of spicule length and Ventr Median supplement 3 which showed a negative relation (Table III). The 't' test was significant for all characters with the exception of vulva, tail length, 'a' and 'b' ratios in females and with the exception of tail and spicule length and 'a', 'b' and 'c' values in males.

Body width at mid body was moderately variable (CV%) in both sexes.

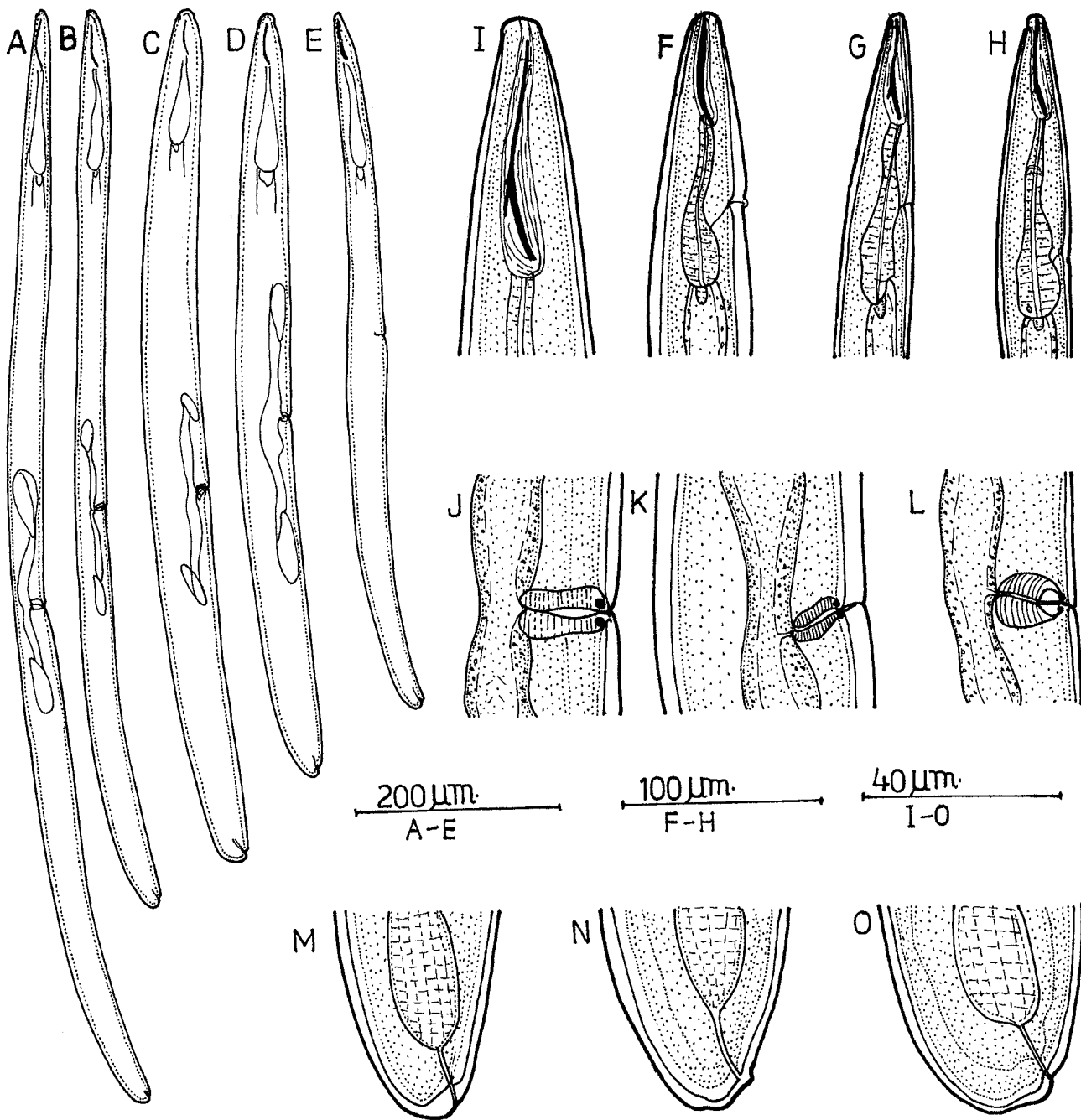


Fig. 1 - Morphological variations of *Trichodorus pakistanensis* females: A-E, entire body; F-I, anterior region; J-L vulval region; M-O, tail.

TABLE I - *Morphometric and allometric variations of Trichodorus pakistanensis* (n = 50).

| Character | | Female | Male | Character | | Female | Male |
|-----------------------|-------|--------------|--------------|---------------|--------------|--------------|------|
| Length (L) | range | 675-1200 | 675-1125 | Lip | 5-10 | 5.16-10.36 | |
| | X±Sd | (983±109.6) | (898±99.17) | height | (6.81±1.13) | (8.22±1.77) | |
| | CV% | 11.14% | 11.05% | | 16.72% | 21.47% | |
| a | | 21.8-37 | 21-39 | | 41.2-55 | 41-61.8 | |
| | | (29.8±3.72) | (25.9±4.66) | Onchiostyle | (46.57±3.43) | (49±4.37) | |
| b | CV% | 12.46% | 18.05% | length | 7.37% | 8.94% | |
| | | 7-11.3 | 4.55-11.46 | Guiding ring | 13.8-24.1 | 13.8-27.5 | |
| c | | (9.3±1.5) | (8.57±1.16) | from anterior | (16.7±2.28) | (18.23±3.01) | |
| | CV% | 11.32% | 13.57% | end | 13.7% | 16.6% | |
| c' | | 60-204 | 39-77 | Nerve ring | 17.2-51.6 | 27.5-44.7 | |
| | | (107.4±28.4) | (55.5±7.88) | from anterior | (33.64±8.0) | (37.2±4.75) | |
| V/T | CV% | 26.43% | 14.20% | end | 23.78% | 12.8% | |
| | | 0.33-0.76 | 0.4-0.83 | Cardia length | 3.44-6.88 | 3.44-10 | |
| Width at mid body | | (0.53±0.12) | (0.64±0.1) | | (7.10±1.83) | (4.40±1.24) | |
| | CV% | 22.96% | 15.7% | | 28.3% | 25.79% | |
| Oesophagus length | | 34.4-66.6 | 44-62 | Spicule | – | 48.2-58.5 | |
| | | (51.89±6.75) | (53.21±4.52) | length | | (53.23±3.38) | |
| Tail length | CV% | 13.02% | | | | 6.36% | |
| | | 28-41 | 28-44 | Gubernaculum | – | 13.8-27.5 | |
| Body diameter at anus | | (33±3.35) | (35.4±5.17) | length | | (19.81±2.96) | |
| | CV% | 10.18% | 14.6% | | | 14.96% | |
| Vulva/ Testes | | 86-127 | 93-162 | V.M. Supl.-1 | – | 27.5-48.2 | |
| | | (105±9.71) | (108.2±12.9) | from anus | | (36.9±4.11) | |
| Ant. Gonad length | CV% | 9.21% | 11.93% | | | 11.14% | |
| | | 7-17 | 14-21 | V.M. Supl.-2 | – | 34.4-65.4 | |
| Post. Gonad length | | (10±2.27) | (8.56±1.16) | from anus | | (44.5±6.68) | |
| | CV% | 23.57% | 13.57% | | | 15.07% | |
| Lip width | | 14-31 | 21-34 | V.M. Supl.-3 | – | 44.7-7.5 | |
| | | (18.06±3.64) | (27.2±3.37) | from anus | | (54.84±8.39) | |
| Lip height | CV% | 20.18% | 12.2% | | | 15.3% | |
| | | 353-675 | 375-645 | CP-1 from | – | 92.9-127 | |
| Ant. Gonad length | | (15.8±28.2) | (47.72±58.3) | anterior end | | (103.8±13.5) | |
| | CV% | 5.46% | 12.21% | | | 13% | |
| Post. Gonad length | | 103-240 | | CP-2 from | – | 96.3-135 | |
| | | (193±15.05) | | anterior end | | (115±132.7) | |
| Lip width | CV% | 7.78% | | | | 11.95% | |
| | | 93-240 | | CP-3 from | – | 120-127.3 | |
| Lip height | | (187±36.01) | | anterior end | | (123.8±4.86) | |
| | CV% | 19.24% | | | | 3.92% | |
| Lip width | | 7-10 | 6.88-1.76 | – | – | | |
| | | (7.43±1.16) | (9.49±2.56) | | | | |
| Lip height | CV% | 15.6% | 24.9% | | | | |

N.B.: All measurements in µm.

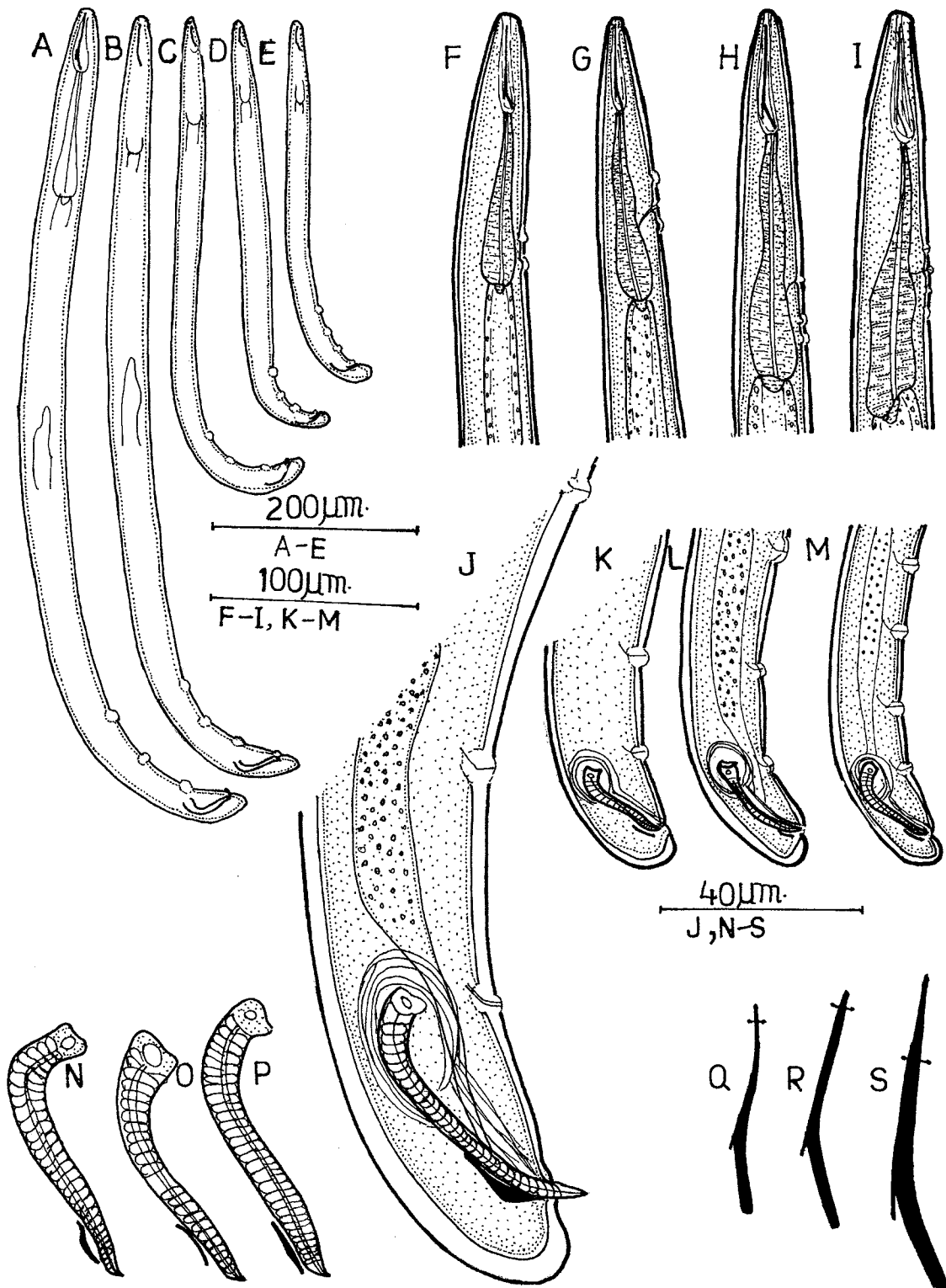


Fig. 2 - Morphological variations of *T. pakistanensis* males: A-E, entire body; F-I, oesophageal region; J-M, posterior region; N-P, spicules; Q-S, onchiostyle.

TABLE II - Correlation matrix of different characters pair of female *T. pakistanensis*.

| Character | Length | Oesoph. len. | Tail len. | Vulva f.a.e. | Onchio. len. | a | b | c | V |
|-----------------------|------------|--------------|------------|--------------|--------------|-------------|-------------|-------------|-------------|
| Length | $r_1=1.00$ | $r_2=0.45$ | $r_3=0.21$ | $r_4=0.55$ | $r_5=0.38$ | $r_6=0.66$ | $r_7=0.70$ | $r_8=0.29$ | $r_9=-0.11$ |
| | $t_1=1.00$ | $t_2=3.51$ | $t_3=1.48$ | $t_4=4.56$ | $t_5=2.80$ | $t_6=4.68$ | $t_7=6.79$ | $t_8=2.09$ | $t_9=-0.77$ |
| Oesophagus len. | | | $r_3=0.22$ | $r_4=0.36$ | $r_5=0.18$ | $r_6=0.27$ | $r_7=-0.37$ | $r_8=-0.03$ | $r_9=-0.09$ |
| | | | $t_3=0.03$ | $t_4=4.08$ | $t_5=1.26$ | $t_6=1.94$ | $t_7=6.79$ | $t_8=-0.20$ | $t_9=-0.64$ |
| Tail length | | | | $r_4=0.62$ | $r_5=0.03$ | $r_6=-0.02$ | $r_7=-0.37$ | $r_8=-0.77$ | $r_9=0.05$ |
| | | | | $t_4=5.47$ | $t_5=0.92$ | $t_6=0.13$ | $t_7=-2.75$ | $t_8=-8.30$ | $t_9=2.40$ |
| Onchiostyle len. | | | | | $r_5=0.92$ | $r_6=1.0$ | $r_7=-0.08$ | $r_8=-0.99$ | $r_9=0.72$ |
| | | | | | $t_5=16.2$ | $t_6=1.0$ | $t_7=-0.05$ | $t_8=0.17$ | $t_9=7.18$ |
| Vulva from ant. extr. | | | | | | $r_6=0.10$ | $r_7=0.92$ | $r_8=1.19$ | $r_9=0.02$ |
| | | | | | | $t_6=0.69$ | $t_7=16.2$ | $t_8=0.28$ | $t_9=6.38$ |
| a | | | | | | | $r_7=0.30$ | $r_8=2.02$ | $r_9=-0.24$ |
| | | | | | | | $t_7=2.17$ | $t_8=0.08$ | $t_9=1.71$ |
| b | | | | | | | | $r_8=1.87$ | $r_9=-0.22$ |
| | | | | | | | | $t_8=0.08$ | $t_9=-1.56$ |
| c | | | | | | | | | $r_9=-0.19$ |
| | | | | | | | | | $t_9=-1.35$ |
| V | | | | | | | | | |

TABLE III - Correlation matrix of different characters pair of male *T. pakistanensis*.

| Character | Length | Oesophagus len. | Tail length | Onchiostyle len. | Spicule len. | a | b | c | VMS I | VMS II | VMS III |
|------------------|------------|-----------------|-------------|------------------|--------------|-------------|-------------|-------------|-------------|----------------|----------------|
| Length | $r_1=1.00$ | $r_2=0.25$ | $r_3=0.08$ | $r_4=0.06$ | $r_5=-0.02$ | $r_6=0.50$ | $r_7=0.45$ | $r_8=0.25$ | $r_9=0.07$ | $r_{10}=0.20$ | $r_{11}=-0.81$ |
| | $t_1=1.00$ | $t_2=1.50$ | $t_3=6.98$ | $t_4=2.66$ | $t_5=4.31$ | $t_6=8.28$ | $t_7=7.50$ | $t_8=7.34$ | $t_9=0.49$ | $t_{10}=0.08$ | $t_{11}=-1.26$ |
| Oesophagus len. | | | $r_3=0.025$ | $r_4=0.05$ | $r_5=0.37$ | $r_6=-0.10$ | $r_7=0.45$ | $r_8=0.51$ | $r_9=-0.14$ | $r_{10}=-0.36$ | $r_{11}=0.16$ |
| | | | $t_3=9.67$ | $t_4=4.51$ | $t_5=1.11$ | $t_6=-0.69$ | $t_7=1.86$ | $t_8=1.65$ | $t_9=-0.98$ | $t_{10}=2.66$ | $t_{11}=1.12$ |
| Tail length | | | | $r_4=0.60$ | $r_5=-0.09$ | $r_6=-0.25$ | $r_7=0.03$ | $r_8=0.05$ | $r_9=0.03$ | $r_{10}=0.10$ | $r_{11}=0.11$ |
| | | | | $t_4=1.27$ | $t_5=2.56$ | $t_6=1.79$ | $t_7=0.55$ | $t_8=7.27$ | $t_9=0.21$ | $t_{10}=0.69$ | $t_{11}=0.77$ |
| Onchiostyle len. | | | | | $r_5=-0.87$ | $r_6=-0.36$ | $r_7=-0.08$ | $r_8=0.23$ | $r_9=0.33$ | $r_{10}=0.34$ | $r_{11}=0.16$ |
| | | | | | $t_5=0.92$ | $t_6=-2.66$ | $t_7=0.50$ | $t_8=5.24$ | $t_9=2.42$ | $t_{10}=2.50$ | $t_{11}=1.12$ |
| Spicule | | | | | | $r_6=0.013$ | $r_7=-0.28$ | $r_8=-0.09$ | $r_9=0.26$ | $r_{10}=0.24$ | $r_{11}=-0.07$ |
| | | | | | | $t_6=0.09$ | $t_7=0.45$ | $t_8=1.80$ | $t_9=1.86$ | $t_{10}=1.71$ | $t_{11}=-0.49$ |
| a | | | | | | | $r_7=0.72$ | $r_8=0.22$ | $r_9=-0.04$ | $r_{10}=0.54$ | $r_{11}=-0.11$ |
| | | | | | | | $t_7=0.08$ | $t_8=4.86$ | $t_9=0.27$ | $t_{10}=4.44$ | $t_{11}=-0.77$ |
| b | | | | | | | | $r_8=0.11$ | $r_9=-0.07$ | $r_{10}=-0.10$ | $r_{11}=0.11$ |
| | | | | | | | | $t_8=1.84$ | $t_9=-0.49$ | $t_{10}=-0.69$ | $t_{11}=0.77$ |
| c | | | | | | | | | $r_9=0.04$ | $r_{10}=0.06$ | $r_{11}=0.11$ |
| | | | | | | | | | $t_9=0.28$ | $t_{10}=0.42$ | $t_{11}=0.77$ |
| VMS I | | | | | | | | | | $r_{10}=0.26$ | $r_{11}=0.03$ |
| VMS II | | | | | | | | | | $t_{10}=1.87$ | $t_{11}=0.21$ |
| | | | | | | | | | | | $r_{11}=-0.18$ |
| VMS III | | | | | | | | | | | $t_{11}=-1.26$ |

TABLE IV - *Morphometric and allometric variations of three populations of T. pakistanensis.*

| Character | Pakistani Population (Siddiqi, 1962) | | Chinese Population (Xu and Decraemer 1995) | | Indian Population original | |
|------------------------|---|-----------------------|---|------------------------|-------------------------------|------------------------|
| | Females | Males | Females | Males | Females | Males |
| L | 0.82-1.22 (0.98) mm | 0.84-1.2 (0.97) mm | 0.93-1.05 (0.98) mm | 0.80-0.90 (0.85) mm | 0.84-1.2 (0.97) mm | 0.68-1.12 (0.89) mm |
| a | 24-31 (27) | 25-34 (29) | 25-28 (26) | 22-25 (24) | 22-37 (30) | 21-39 (26) |
| b | 5.6-6.8 (6.4) | 5-7.4 (6.1) | 6.4-6.7 (6.5) | 4.3-6.0 (5.3) | 7-11.3 (9.3) | 6-11 (8.5) |
| V/T | 51.5-8.5 (54) | 52-70 (61) | 55-57 (56) | 56-67 (62) | 34.4-66.6 (52) | 44-62 (53) |
| Width at mid body | 30-38 (34) | 29-33 (30) | 34-40 (38) | 33-37 (36) | 28-41 (33) | 28-44 (35.4) |
| Oesophagus length | 95-130 (105) | 90-128 (112) | 146-164 (152) | 134-187 (164) | 86-127 (105) | 93-163 (108) |
| Onchiostyle length | 39-46 (41.5) | 39-48 (42) | 40-41 (41) | 40-43 (42) | 41-55 (47) | 41-62 (49) |
| Excretory pore | 106-118 (110) | 96-110 (105) | 106-118 (110) | 102-104 (103) | 105-115 (110) | 100-109 (105) |
| CP I from anterior end | — | 89-120 (103) | — | 87-89 (88) | — | 92.9-127 (104) |
| CPI-CP II | — | 8-13 (10) | — | 8-10 (10) | — | 4-8 (6) |
| CP II-III | — | 20-26 (23) | — | 14-16 (15) | — | 26-33 (30) |
| Spicule length | — | 49-58 (52.6) | — | 47-52 (51) | — | 48-58.5 (53) |
| Gubernacul length | — | 12-16 (13.5) | — | 23-25 (24) | — | 14-27 (37) |
| Cloaca to SP I | — | 37-42 (39) | — | 30-36 (33) | — | 28-48 (37) |
| SP I-SP II | — | 48-59 (52.6) | — | 41-42 (45) | — | 34-65 (45) |
| SP II-SP III | — | 53-64 (58) | — | 43-47 (51) | — | 45-75 (55) |

All measurements in μm except L in mm.

The allometric characters 'a' and 'b' were highly variable according to (CV%) with a positive relation. The 't' test was significant for all characters and the correlation between 'a' and 'b' ratios were significant in both sexes. Ratio 'c' was moderately variable in males and highly

variable in females and 'c' highly variable in both sexes and therefore are not useful for species characterization.

CV% of 'T' was significant and CV% of 'V' moderately variable, and thus useful for species identification. Correlation of 'V' with body

length was negative and not significant at the 't' test. Oesophagus length, vulva-anterior extremity distance and ratios 'a', 'b' and 'c' showed positive relation and the relation between 'V' and either tail length and onchiostyle length was not significant.

CV% for oesophagus length was variable in males and significant in females. Correlation regressions between oesophagus length and all the other characters were positive and significant at the 't' test.

CV% tail length and diameter of anus were significant in males and highly variable in females. Showing positive correlation with vulva-anterior extremity distance, onchiostyle length and 'V' value and positive relation with all other characters. Body diameter at anus was moderately variable in males and highly variable in females.

Vulva-anterior extremity distance and spicule length were stable and significant characters, whereas gubernaculum length was moderately variable.

All three ventromedian supplements and the cervical papillae, which are useful diagnostic characters in species identification in *Trichodorus* were moderately variable according to CV%.

CV% for anterior gonad length was significant and variable for positive gonad length. Correlation with G₁ and G₂ were highly variable and not significant.

Lip width and height were very variable and not significant in both sexes while the onchiostyle length was significant in both sexes.

Guide ring anterior extremity distance was moderately variable only in males and highly variable in females.

The morphometrics of the Indian population of *T. pakistanensis* agree more or less with those of the type population from Pakistan from which it differs only in having a narrower body, shorter oesophagus and longer onchiostyle in females, and shorter body, shorter oesophagus and longer onchiostyle in males. The Indian population of *T. pakistanensis* differs from the Chinese population in having a shorter oesophagus, lower 'T' value, longer onchiostyle and posterior location of cervical papillae in males. It is regarded here as a geographical variant of *T. pakistanensis* Siddiqi, 1962.

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