Body characters reflecting the body size of spider mites in flattened specimens (Acari, Tetranychidae)

Yutaka Saito, Kotaro Mori and Anthony R. Chittenden

Laboratory of Animal Ecology, Graduate School of Agriculture, Hokkaido University, Sapporo 060–8589, Japan

(Received 2 December 1998; Accepted 16 April 1999)

Abstract

We examined the morphological characters of two spider mite species, in order to identify characters that accurately reflect mite body size regardless of mounting method. Several body characteristics of flattened and non-flattened specimens of *Schizotetranychus longus* Saito and *S. miscanthi* Saito were investigated. There were several characters which were not influenced by mounting conditions regardless of sex and species, and which reflected body length and width well. The distance (DL1) between the bases of P1 (dorsal propodosomal seta) and CL (clunal seta) was a relatively stable character reflecting body size under both mounting conditions, i.e. flattened and non-flattened, and appears to be the best character to estimate body length. Body width was reflected by DW1 alone, the distance between the bases of paired P3 setae (dorsal propodosomal seta). It is, however, a stable enough character, under both mounting conditions, to be suitable for estimating body width.

Key words: Morphology, *Schizotetranychus longus*, *Schizotetranychus miscanthi*, specimen condition, slide preparation

INTRODUCTION

Because of the very soft nature of their bodies, measuring the body size of flattened mite specimens that have been prepared on glass slides using mounting media (e.g. Hoyer's medium) has been very difficult. It is also very difficult to measure leg and seta lengths on non-flattened (ordinary) specimens, because their abdomens are relatively thick in comparison with their size. Researchers who intend to study individual morphology have, thus, been plagued with this dilemma. For example, Potter et al. (1976) and Saito (1990) adopted fore leg lengths as representative of body size in their morpho-behavioral studies on male-to-male aggression. However, this assumption is not always reliable if we try to conduct studies on intra-specific variation of allometric characters.

Saito (1995) reported that there is variation in the relative length of leg of *Schizotetranychus miscanthi* Saito, which might result from intra-sexual selection in males. In the study, he used the length of the 4th leg as a denominator reflecting the body length of this species. There is, however, no objective reason to consider this

so, though behavioral observations did not reveal the 4th leg to have any function in sexual selection.

The lack of characters which accurately reflect the body length and width of spider mites in flattened specimens has thus made it difficult for us to conduct studies on individual variation in morphs from behavioral and genetic perspectives.

In this report, we first attempted to discover body characters which reflect the body size of non-flattened specimens. Next we tried to determine which of these characters are unchangeable between ordinary (non-pressed) specimens and flattened (pressed) ones.

MATERIALS AND METHODS

Two species of tetranychid mites, *Schizotetranychus longus* Saito and *S. miscanthi* were used for morphological measurements. Fifteen females and 15 males of each species were taken from rearings which had been maintained in our laboratory for more than one year after collection, and individually mounted in Hoyer's medium with stocks of silk threads (thickness ca. 100 μm) on slide glasses. They were then covered by cover glasses and heated with a soldering iron

(Saito and Osakabe, 1992). One to two weeks after the slide preparations, we inputted video-photographs of the specimens into a computer using an optical microscope (phase-contrast, Olympus Co.), a video camera (S-VHS, Victor Co.) and a Macintosh computer (Apple Co.). Using NIHImage (provided by NIH through Internet) software, measurements of 17 characters for females and 12 for males (Fig. 1) were taken from the digital pictures on the computer. Characters in pairs, such as DL1, DL2 and so on, were both measured and averaged.

After measuring, all specimens were removed from the mounting media with steam and re-mounted on new slide glasses without padding (silk threads). Then they were heated using a soldering iron and flattened by individually placing 10 g weights on the cover glasses for one week. After preparation, the same characters which had been measured on the non-flattened specimens were re-measured using the same method. In the process of remounting, several individuals were discarded because of severe damage to their

bodies. Thus, the number of specimens analyzed decreased to the numbers shown in Tables 1 and 2.

RESULTS

Characters reflecting body size

In the characters which were *a priori* regarded as candidates reflecting body length (symbols with L), correlation analyses for non-flattened specimens showed that several characters reflected the body length (L) of *S. miscanthi* and *S. longus* (Table 1) well. Among these, the coefficients between L vs. DL1 and L vs. VL3 were significantly high in both sexes of the two species. Some other characters such as VL1, VL2, VL5 and VL7 were significantly correlated with L in females, though these characters were not useful for measuring males. On the other hand, there were several characters which reflect body length of either sex or species (e.g. DL3, VL4 and VL5), suggesting variation in body surface structure between sexes and between species.

Fig. 1. Characters of females measured in the present study. 1: ventral view, 2: dorsal view. Characters italicized were only measured for females. MV1, 2 and 3, PRG and G in 1 are symbols of ventral setae used by Gutierrez (1985). P1-P3, C1-C4 and CL in 2 are symbols of setae used by Ehara and Tho (1988). In order to avoid unnecessary cluttering of the diagram, VL4 and VL7 are shown outside of the bases of setae in 1, but their land-marks are actually the centers of the respective setal bases.

Table 1. Correlation coefficients (*r*) between body length (L) vs. other body characters of non-flattened specimens. Character symbols appear in Fig. 1.

	Female						Male					
	<i>S. miscanthi</i>			<i>S. longus</i>			<i>S. miscanthi</i>			<i>S. longus</i>		
	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>
L, DL1	12	0.646	0.021	13	0.778	0.001	13	0.956	<0.001	12	0.660	0.017
L, DL2	12	0.553	0.062	13	0.779	0.001	13	0.870	<0.001	12	0.790	0.001
L, DL3	12	0.525	0.080	13	0.542	0.055	13	0.877	<0.001	12	0.804	<0.001
L, VL1	12	0.756	0.003	14	0.743	0.002	—	—	—	—	—	—
L, VL2	12	0.767	0.002	14	0.642	0.011	—	—	—	—	—	—
L, VL3	12	0.799	0.001	14	0.692	0.005	13	0.941	<0.001	12	0.834	<0.001
L, VL4	12	0.531	0.076	14	0.291	0.320	13	0.814	<0.001	12	−0.174	0.603
L, VL5	12	0.825	<0.001	14	0.803	<0.001	13	0.659	0.012	12	−0.040	0.905
L, VL6	12	0.430	0.167	14	0.228	0.441	—	—	—	—	—	—
L, VL7	12	0.705	0.009	14	0.837	<0.001	—	—	—	—	—	—

^aNo. of individuals measured.Table 2. Correlation coefficients (*r*) between body width (W) vs. other body characters of non-flattened specimens. Character symbols appear in Fig. 1.

	Female						Male					
	<i>S. miscanthi</i>			<i>S. longus</i>			<i>S. miscanthi</i>			<i>S. longus</i>		
	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>	<i>n</i> ^a	<i>r</i>	<i>p</i>
W, DW1	12	0.742	0.004	12	0.717	0.007	9	0.761	0.015	12	0.762	0.003
W, DW2	12	−0.244	0.455	14	0.401	0.159	13	0.701	0.014	12	−0.056	0.695
W, VW1	11	0.173	0.620	14	0.229	0.439	11	0.465	0.154	12	0.250	0.444
W, VW2	12	0.384	0.224	13	0.063	0.842	12	0.770	0.002	11	0.242	0.485
W, VW3	12	0.318	0.323	14	−0.238	0.421	—	—	—	—	—	—

^aNo. of individuals measured.

Among the characters concerning body width (W) of mites, DW1 was significantly correlated with body width (W) in all kinds of non-flattened specimens, but the other 4 characters showed no consistent correlation with W (Table 2).

Unchangeable characters

Figure 2 shows the magnitude of change between non-flattened and flattened specimens by the index (FC). This index was calculated as follows: $FC (\%) = 100 \times |(\text{measurement of a flattened specimen}) - (\text{measurement of a non-flattened specimen})| / (\text{measurement of a non-flattened specimen})$. Namely, this index indicates the relative change rate of flattened specimens to non-flattened ones. If the FC is smaller, the character is more stable towards the difference in mounting conditions.

Several body characters varied greatly between the different treatments of specimens (Fig. 2). For example, when compared with non-flattened specimens, the body length and body width of flattened specimens showed 4.5–8% and 13–18% variance respectively. VL3, reflecting body size in the non-flattened specimens well, was also a very changeable character. In contrast, there were many characters which did not show differences between the treatments: From Fig. 2, it was apparent that DL1, DL2, DL3, DW1, DW2, VL5, VW2 and VW3 were very consistent characters between the two different treatments in all sexes and species examined.

DISCUSSION

There were several characters which reflected body length and width well. Furthermore, some

Fig. 2. Changeability (FC) of characters between non-flattened and flattened specimens. FC was calculated as: (absolute deviation between measurement of non-flattened specimen and that of flattened specimen)/(measurement of non-flattened specimen). Symbols are the same as in Fig. 1.

of these were not influenced by mounting conditions, i.e. flattened or non-flattened. Regardless of sex and species, the distance (DL1) between the bases of P1 (dorsal propodosomal seta) and CL (clunal seta) was a relatively stable character reflecting body size under different specimen conditions. Therefore, DL1 appeared to be the best character to estimate the body length of *S. longus* and *S. miscanthi*. The land-marks (bases of the setae CL), however, sometimes become difficult to determine in flattened specimens, because the bases are often distorted during the mounting process (e.g. puncturing the end of body). In such cases, the distance (DL2) between P1 and C4 (inner sacral seta) may be an alternative character representing body length, though it was not significantly ($p=0.062$) corre-

lated with the body length of *S. miscanthi* females.

The body width was reflected in DW1 alone, the distance between the bases of paired P3 setae (dorsal propodosomal seta). Fortunately, as shown in Fig. 2, DW1 was a stable character under different mounting conditions, therefore, it appeared to be the best character to estimate the body width of *S. longus* and *S. miscanthi*.

The present results suggest that there is much variation in body surface conditions between species and sexes, probably because of differences in the structure or hardness of the body surfaces. Therefore, we have to conduct examinations similar to the present study for each mite species, before we can analyze morphological traits.

ACKNOWLEDGEMENTS

We thank Dr. S. Akimoto for valuable suggestions. This work was supported by Grants-in-Aid for Scientific Research (11640626 & 09460022) from the Ministry of Education, Science, Sports and Culture of Japan (Monbushou).

REFERENCES

- Ehara, S. and Y. P. Tho (1988) Spider mites of the Malay Peninsula (Acarina: Tetranychidae). *J. Fac. Educ. Tottori Univ.* 37: 1–24.
- Gutierrez, J. (1985) Systematics. In *Spider Mites. Their Biology, Natural Enemies and Control*. Vol. 1A (W. Helle and M. W. Sabelis eds.). Elsevier, Amsterdam, pp. 75–90.
- Potter, D. A., D. L. Wrensch and D. E. Johnston (1976) Guarding, aggressive behavior, and mating success in male two-spotted spider mites. *Ann. Entomol. Soc. Am.* 69: 707–711.
- Saito, Y. (1990) Factors determining harem ownership in a subsocial spider mite (Acari, Tetranychidae). *J. Ethol.* 8: 37–43.
- Saito, Y. (1995) Clinal variation in male-to-male antagonism and weaponry in a subsocial mite. *Evolution* 49: 413–417.
- Saito, Y. and Mh. Osakabe (1992) A new fixation method for preparing mite specimens for optical and SEM microscopic observations. *Appl. Entomol. Zool.* 27: 427–436.