

Article

Are distances between large setal pairs on dorsal shield in *Paraphytoseius* species (Acari: Phytoseiidae) of any taxonomic value?

Vikram Prasad¹ and Marie-Stéphane Tixier²

1. 7247 Village Square Drive, West Bloomfield, MI 48322, USA; E-mail: vikramprasad551@gmail.com

2. Montpellier SupAgro, UMR CBGP, INRA/IRD/CIRAD/ Montpellier SupAgro, Campus International de Baillarguet, CS 30016, 34988 Montferrier sur Lez cedex, France; E-mail: marie-stephane.tixier@supagro.fr

Abstract

This paper aims to determine whether distances between some setae can be helpful for differentiating two species of the genus *Paraphytoseius*: *P. cracentis* and *P. orientalis*. Specimens examined were collected in the 1970's in India by V. Prasad. Transverse ($j1-j1$, $j3-j3$, $s4-s4$, $Z4-Z4$, and $Z5-Z5$) and vertical distances ($j3-s4$, $s4-Z4$, and $z4-Z5$) were measured. It was observed that the transverse distances between the large setal pairs $j3-j3$, $s4-s4$, $Z4-Z4$, and $Z5-Z5$ and the vertical distances between the pairs $j3-s4$, $s4-Z4$, and $z4-Z5$ were significantly lower in *P. cracentis* (Corpuz and Rimando, 1966) than in *P. orientalis* (Narayanan *et al.*, 1960). The multifactorial analysis also showed a distinction between these two species based on the distances herein considered. Even if more specimens should be considered and more species studied, this work seems to show that in addition to setae measurements, distances between some setae could be helpful for diagnosis (i.e. distance between $s4-s4$ and vertical distance between $s4-Z4$). However, further studies should be conducted to better assess these taxonomic indicators.

Key words: Distance; large setae; *Paraphytoseius cracentis*; *P. orientalis*; setal pairs.

Introduction

Species of *Paraphytoseius* Swirski and Shechter, 1961, are unique in Phytoseiidae in having dorsal setal pattern of 10A:5D with 15 pairs of setae. Five pairs of large, heavy, and serrated setae (anterior to posterior), $j1$, $j3$, $s4$, $Z4$, and $Z5$, on the dorsal shield, called landmark setae by Prasad (2016), are located on tubercles. Remaining dorsal shield setae ($j4$, $j5$, $j6$, $J5$; $z2$, $z4$, $z5$, $Z1$; and $S5$ when present) are short to minute and not located on tubercles. Species of this genus with the seta $S5$ present have been classified in the *cracentis* species group (14 pairs of setae on the dorsal shield) and those with the seta $S5$ absent (13 pairs of setae on the dorsal shield) have been classified in the *orientalis* species group (Chant and McMurtry 2003b). Prasad (2016) recognized only two species (*P. cracentis* and *P. scleroticus*) in the former group and three species (*P. ghanaensis*, *P. hilli*, *P. orientalis*) in the latter one.

Within the genus *Paraphytoseius*, as for other Phytoseiidae species, the length of the dorsal setae has been used as one of the criteria to distinguish species (Chant and

McMurtry 1994, 2003a, b, 2004a, b, 2005a, b, c, 2006a, b; Tixier 2012, 2013). However, accurate length measurements are hindered because setae are not straight and have thin and pointed tips. Species of *Paraphytoseius* are characterized by five pairs of large setae on the dorsal shield. However, the problem is that, often, these setae are curved and difficult to measure accurately.

Considering the problem of the setal length measurements and because *P. cracentis* (Corpuz and Rimando, 1966) has seta *S5* present, and *P. orientalis* (Narayanan *et al.*, 1960) has seta *S5* absent, it was decided: (1) to measure the transverse and the vertical distances between the large setae in the latter two species; (2) observe if there were differences in these measurements in these two species; and (3) decide if all or some of these measurements were of any taxonomic value for discriminating between these two species.

Materials and methods

Four females of *P. cracentis* collected in India were studied (Table 1): (1) Collection # VP72-185, female #1, Vellayani, Thiruvananthapuram District, Kerala state, *Euphorbia pulcherrima* (Poinsettia, Euphorbiaceae), 22 September 1972, coll. V. Prasad. (2) Collection # VP72-189, female #2, Vellayani, Thiruvananthapuram District, Kerala state, *Morinda tinctoria* (Indian mulberry, Rubiaceae), 22 September 1972, coll. V. Prasad. (3) Collection # VP72-237, females #3 and 4, Vellayani, near lake, Thiruvananthapuram District, Kerala state, mixed vegetation, 22 September 1972, coll. V. Prasad.

Ten females of *P. orientalis* collected in India were studied (Table 2): (1) Collection # VP72-330, female #1; Goa, *Datura alba* (Solanaceae), 29 November 1972, coll. V. Prasad. (2) Collection # VP73-18, females #2, 3, and 4, campus of Bihar Agriculture College, Sabour, Bhagalpur District, Bihar state; *Solanum melongena* (Solanaceae), 24 January 1973, coll. V. Prasad. (3) Collection # VP73-27, females #5 and 6, campus of Bihar Agriculture College, Sabour, Bhagalpur District, Bihar state; *Ocimum tenuiflorum* (Lamiaceae), 24 January 1973, coll. V. Prasad. (4) Collection # VP73-50; female #7, campus of Agriculture College, Deoria City, Deoria District, Uttar Pradesh state; *Phaseolus vulgaris* (Fabaceae), 27 January 1973, coll. V. Prasad. (5) Collection # VP73-56, female #8, campus of Agriculture College, Deoria City, Deoria District, Uttar Pradesh state; *Solanum melongena* (Solanaceae), 27 January 1973, coll. V. Prasad. (6) Collection # VP73-93, females #9 and 10, campus of Agriculture College, Bhubaneswar (or Bhubaneshwar), Odisha state (formerly known as Orissa state when mites were collected); *Solanum melongena* (Solanaceae), 18 January 1973, coll. V. Prasad.

The females were examined using an Acc-Scope 3000 trinocular phase-contrast microscope (Acc-Scope, New York, NY, USA) under 200–400x. The distance measurements (Tables 1 & 2) were taken from the middle of one setal socket to the middle of next setal socket. The setal nomenclature is based on the system proposed by Lindquist and Evans (1965) as adapted for the family Phytoseiidae by Rowell *et al.* (1978); the dorsal setal patterns of Chant and Yoshida-Shaul (1989); and the idiosomal setal patterns of Chant and Yoshida-Shaul (1992), who also provided the designations for these setae. The measurements are given in micrometers, the distance expressed is the mean and within brackets, the minimum and the maximum values.

To determine whether these measurements were significantly different between specimens of the two species, a non-parametric test was carried out (Mann and Whitney

1947). In addition, a multifactorial analysis was performed to determine how the combination of these measurements allows a separation between specimens of these two species. All statistical analyses were carried out with Statistica (StatSoft France 2010).

Results and discussion

Paraphytoseius cracentis

The Table 1 shows the following measurements of transverse distances for the females of *P. cracentis*: $j1-j1 = 20$ (18–21), $j3-j3 = 26$ (24–28), $s4-s4 = 94$ (91–97), $Z4-Z4 = 73$ (69–75), and $Z5-Z5 = 55$ (53–56).

The Table 1 shows the following measurements of vertical distances for the females of *P. cracentis*: $j1-j3 = 14$ (11–16), $j3-s4 = 66$ (63–68), $s4-Z4 = 174$ (169–179), and $Z4-Z5 = 15$ (13–17).

Table 1. Measurements of distance between large setal pairs (from middle of socket to middle of socket) on dorsal shield in 4 females of *Paraphytoseius cracentis* from India (x = not clear to measure).

Particulars	Female 1 (72-185)	Female 2 (72-189)	Female 3 (72-237)	Female 4 (72-237)	Average (Mean)	Range	SD
Transversers:							
<i>j1-j1</i>	21	20	18	x	20	18–21	1.53
<i>j3-j3</i>	28	27	24	x	26	24–28	2.08
<i>s4-s4</i>	91	93	97	x	94	91–97	3.06
<i>Z4-Z4</i>	69	75	74	x	73	69–75	3.21
<i>Z5-Z5</i>	53	55	56	x	55	53–56	1.53
Vertical:							
<i>j1-j3</i>	11	16	14	14	14	11–16	2.06
<i>j3-s4</i>	63	68	68	64	66	63–68	2.63
<i>s4-Z4</i>	169	179	170	177	174	169–179	4.99
<i>Z4-Z5</i>	16	17	14	13	15	13–17	1.83

SD = standard deviation

Paraphytoseius orientalis

The Table 2 shows the following measurements of transverse distances for females of *P. orientalis*: $j1-j1 = 23$ (19–27), $j3-j3 = 34$ (31–38), $s4-s4 = 115$ (107–132), $Z4-Z4 = 84$ (77–96), and $Z5-Z5 = 64$ (57–78).

The Table 2 shows the following measurements of vertical distances for the females of *P. orientalis*: $j1-j3 = 14$ (12–16), $j3-s4 = 76$ (70–85), $s4-Z4 = 192$ (185–208), and $Z4-Z5 = 19$ (16–24).

Comparison of measurements data of *P. cracentis* and *P. orientalis*

On the five transverse distances considered, four were significantly lower in *P. cracentis* than in *P. orientalis*: $j3-j3$, $s4-s4$, $Z4-Z4$, and $Z5-Z5$ (Table 3). On the four vertical distances considered, three were significantly lower in *P. cracentis* than in *P. orientalis* ($s4-Z4$, $Z4-Z5$, and $j3-s4$). However, even if significant, the differences between means are quite low and lower than the decision threshold proposed by Tixier (2013) in using seta lengths for Phytoseiidae diagnostic. It seems that the most informative characters would be distances between $s4-s4$ and $s4-Z4$ because differences between means are important. However these measurements correspond to the highest distances, and this can explain such large gaps between the measurements of the two species.

Table 2. Measurements of distance between large setal pairs (from middle of socket to middle of socket) on dorsal shield in 10 females of *Paraphytoseius orientalis* from India (x = not clear to measure).

Particulars	Female 1 (72-330)	Female 2 (73-18)	Female 3 (73-18)	Female 4 (73-18)	Female 5 (73-27)	Female 6 (73-27)	Female 7 (73-50)	Female 8 (73-56)	Female 9 (73-93)	Female 10 (73-93)	Average (Mean)	Range	SD
Transversers:													
<i>j1-j1</i>	27	22	21	23	19	24	22	20	27	x	23	19-27	2.82
<i>j3-j3</i>	32	36	38	34	32	31	33	35	34	31	34	31-38	2.27
<i>s4-s4</i>	110	115	117	115	111	107	114	132	112	x	115	107-132	7.14
<i>Z4-Z4</i>	77	88	85	84	84	83	81	96	79	78	84	77-96	5.56
<i>Z5-Z5</i>	64	63	78	67	60	58	59	70	59	57	64	57-78	6.59
Vertical:													
<i>j1-j3</i>	14	16	13	16	14	15	12	12	15	12	14	12-16	1.6
<i>j3-s4</i>	72	80	76	79	73	73	78	85	74	70	76	70-85	4.52
<i>s4-Z4</i>	185	197	193	195	188	193	193	208	185	187	192	185-208	6.92
<i>Z4-Z5</i>	17	18	23	19	22	18	17	24	16	16	19	16-24	2.94

SD = standard deviation

The multifactorial analysis is shown in Figure 1. On the two axes of the multifactorial analysis explaining 77 % of the variation, specimens of *P. cracentis* are quite separated from those of *P. orientalis*. However, some specimens of *P. orientalis* are much more closer to specimens of *P. cracentis* than to their conspecifics. Thus, even some trends are observed, it would be interesting to measure more specimens to better characterize intra and interspecific variations of the characters herein considered.

Table 3. Mean and standard deviation of the transverse and the vertical distances of *Paraphytoseius cracentis* and *P. orientalis* along with *P* value associated to statistical analyses.

	Transverse distances					Vertical distances			
	<i>j1-j1</i>	<i>j3-j3</i>	<i>s4-s4</i>	<i>Z4-Z4</i>	<i>Z5-Z5</i>	<i>j1-j3</i>	<i>j3-s4</i>	<i>s4-Z4</i>	<i>Z4-Z5</i>
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
<i>P. cracentis</i>	19.7 (2.8)	26.3 (2.1)	93.7 (3.1)	72.7 (1.5)	54.7 (1.5)	13.8 (2.1)	65.8 (2.6)	173.8 (5.0)	15.0 (1.8)
<i>P. orientalis</i>	22.7 (2.8)	33.6 (2.2)	114.7 (7.13)	83.5 (5.6)	63.5 (6.6)	13.9 (1.6)	76.0 (4.5)	192.4 (6.9)	19.0 (2.94)
<i>P</i> value	0.10	0.00045	0.00067	0.0091	0.0468	0.88	0.001	0.0004	0.028000

Conclusion

Main distinguishing characters of P. cracentis and P. orientalis – Only two main features distinguish these two closely related species: (1) seta *S5* present in *P. cracentis* but absent in *P. orientalis*; and (2) Heavy, clavate, modified seta *MgeI* absent on genu of leg I in *P. cracentis* but present in *P. orientalis*.

Axis 2 (15%)

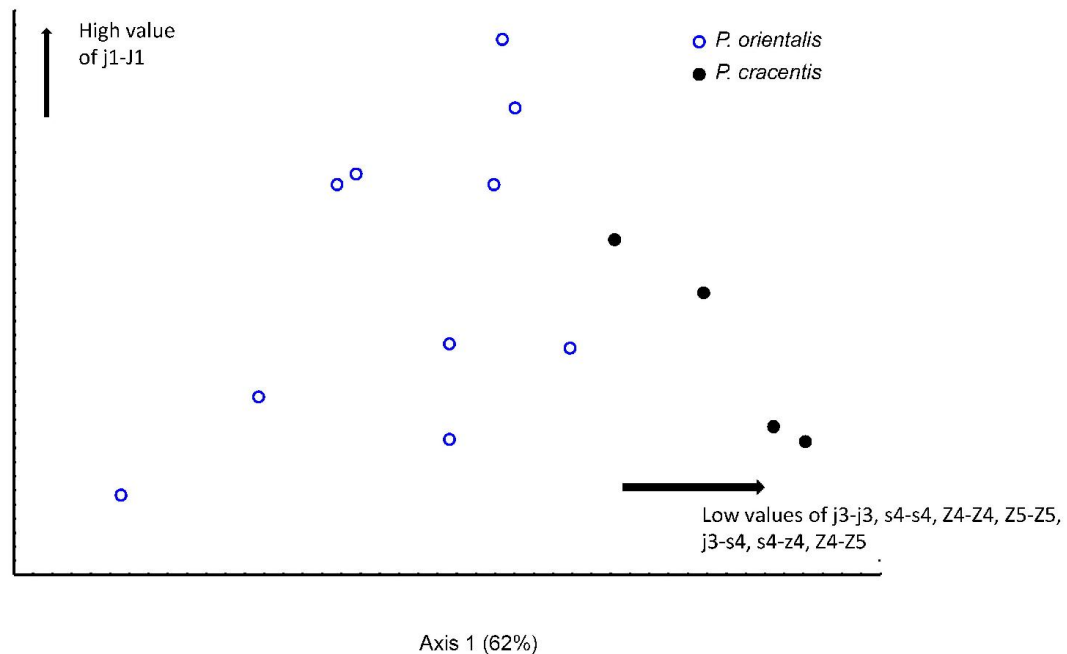


Figure 1. Scatter plots (multifactorial analysis) of the first two multifactorial axes for nine morphological characters (transverse and vertical distances between dorsal setae) of specimens of *Paraphytoseius cracentis* and *P. orientalis*.

Length and width of dorsal shield – The average body length (L) and width (W) in four females of *P. cracentis* and ten females of *P. orientalis* are as follows – *P. cracentis*: L = 288, W = 142, ratio of L:W = 2.0:1.0; *P. orientalis*: L = 309, W = 160, ratio of L:W = 1.9:1.0 (Prasad 2016). Thus, the ratio of length to width in these two species almost the same (2:1), and not discriminant for distinguishing these two closely related species. Chant and McMurtry (2003b) have reported length to width ratio of 1.7–2.0:1.0 in different species of *Paraphytoseius*. Thus, the results of Prasad (2016) confirm the ratio given by Chant and McMurtry (2003b).

Length of setae on dorsal shield – Dorsal seta lengths have been reported to be highly variable in different species of *Paraphytoseius* (Chant and McMurtry 2003b) and even between populations of a same species (Prasad 2016). As mentioned before, often, the large setae are bent and difficult to measure accurately.

Measurements of distances between setal pairs of setae – The present results show some significant differences in such distances between the two species considered. These are lower in *P. cracentis* than in *P. orientalis*. Measurements of *s4-s4* and *s4-Z4* showed the higher differences. However, more studies considering a higher number of specimens and species are needed to clearly define the interest of using such characters for helping diagnostic of Phytoseiidae species.

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آیا فاصله بین جفت موهای بزرگ روی صفحه پشتی گونه‌های جنس *Paraphytoseius* (Acari: Phytoseiidae) ارزش تاکسونومیک دارند؟

ویکرام پراساد^۱ و ماری-استفن تیکسیر^۲

۱. ۷۲۴۷ ویلیج اسکوار درایو، وست بلومفیلد، ام-آی ۴۸۳۲۲، امریکا؛ رایانامه:

v.prasad@ix.netcom.com

۲. مونت پلیه سوپ‌آگرو، یو ام آر سی بی جی پی، اینرا/آی ار دی/سیراد/مونت پلیه سوپ‌آگرو، پردیس

بین‌المللی بیلا رگو، سی ای ۳۰۰۱۶، ۳۴۹۸۸ مونت‌تیپیه سولز سدکس، فرانسه؛ رایانامه:

mariestephane.tixier@supagro.fr

چکیده

هدف این مقاله تعیین مفید بودن فاصله بین برخی از موها در تشخیص بین دو گونه در جنس *Paraphytoseius* است: گونه‌های *P. cracentis* و *P. orientalis*. نمونه‌های بررسی شده را ویکرام پراساد در دهه ۱۹۷۰ جمع‌آوری کرد. فاصله ردیف‌های عرضی ($j1-j1$ ، $j3-j3$ ، $s4-s4$ ، $Z4-Z4$) و ردیف‌های طولی ($j3-s4$ ، $s4-Z4$ ، $Z5-Z5$) و ردیف‌های بزرگ ($j3-j3$ ، $s4-s4$ ، $Z4-Z4$ ، $Z5-Z5$) و فاصله طولی بین جفت موهای $s4-Z4$ ، $j3-s4$ و $Z4-Z5$ به طور معنی‌داری در *P. cracentis* (Corpuz and Rimando, 1966) کمتر از *P. orientalis* (Narayanan et al., 1960) بود. تجزیه چند عاملی نیز نشان داد می‌توان این دو گونه را با فواصل در نظر گرفته شده در این مقاله تشخیص داد. در صورتی که نمونه‌های بیشتری در نظر گرفته و گونه‌های بیشتری مطالعه شود، به نظر می‌رسد این کار نشان می‌دهد افزون بر اندازه موها، فاصله بین برخی از موها برای تمایز مفید است (یعنی فاصله بین $s4-s4$ و فاصله طولی بین $s4-Z4$). اما مطالعات بیشتری برای ارزیابی این شاخص‌های تاکسونومیک باید صورت گیرد.

واژگان کلیدی: فاصله؛ موهای بزرگ؛ *Paraphytoseius cracentis*؛ *Paraphytoseius orientalis*؛

جفت موها.

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