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An analysis of variation of systematic characters in a laboratory population of *Tyrophagus putrescentiae* (SCHRANK, 1781) (*Acari*: *Astigmata*: *Acaridae*)

KRZYSZTOF SOLARZ[1], TADEUSZ SADOWSKI[2] & HALINA KORYCIAK-KOMARSKA[1]
[1] Department of Biology & Parasitology, [2] Department of Hygiene & Epidemiology, Silesian Medical Academy, 40-752 Katowice, Medyków 18, Poland

ABSTRACT. Variation of 40 morphological characters of 45 males of *Tyrophagus putrescentiae* (SCHR.) from a laboratory population was studied. All the characters display a small variability (6.80-16.79%). They can be used for diagnostic and systematic purposes. The observed differences in variability between characters are discussed. The least variable morphological characters are: length of genua of legs I and IV, length of setae "d4", maximal length of gnathosoma, length of solenidion "omega 1" on tarsus II and length of setae "d2".

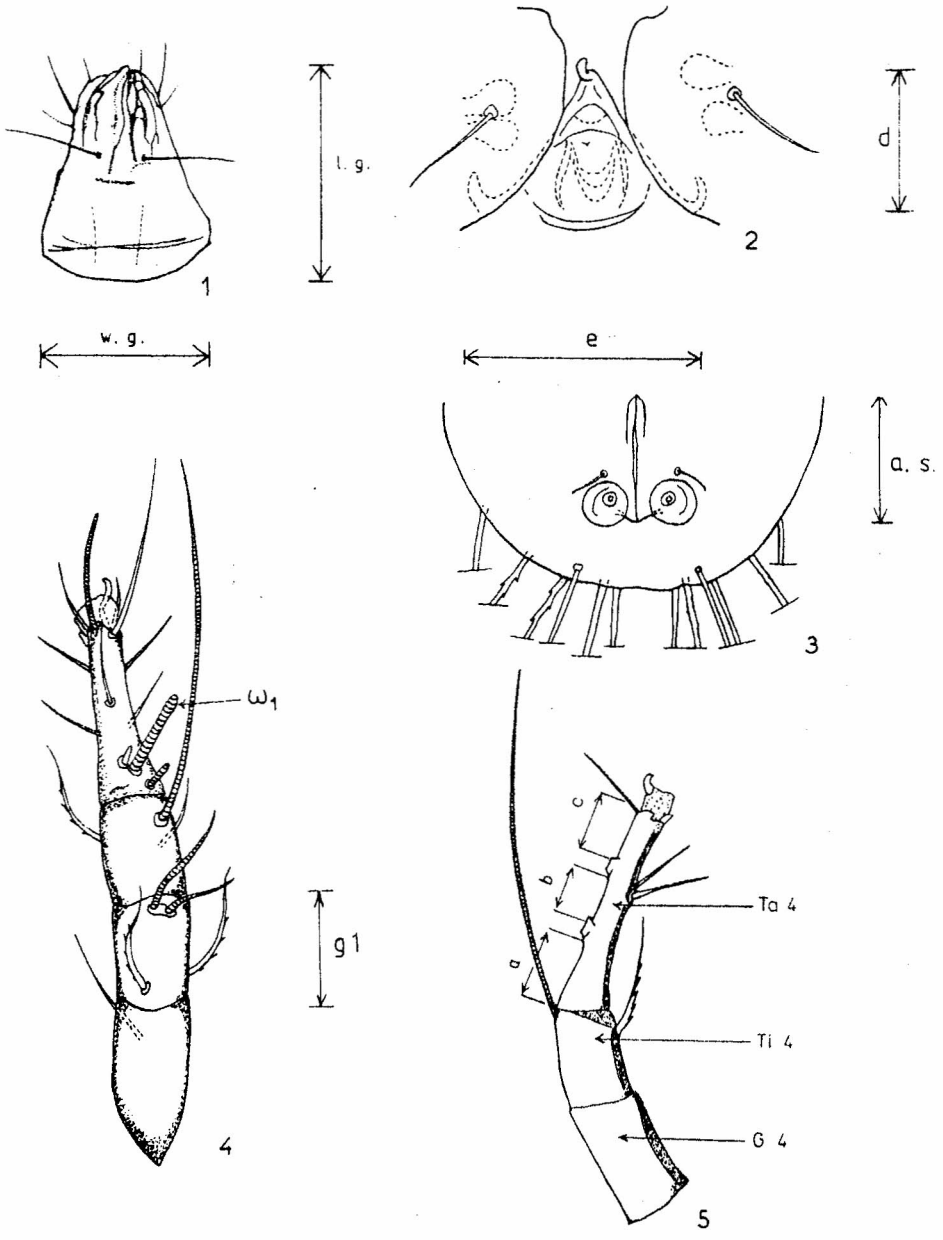
Keywords: acarology, *Tyrophagus putrescentiae*, variability, morphological characters, laboratory population, diagnostics, mites of medical concern, storage mite.

INTRODUCTION

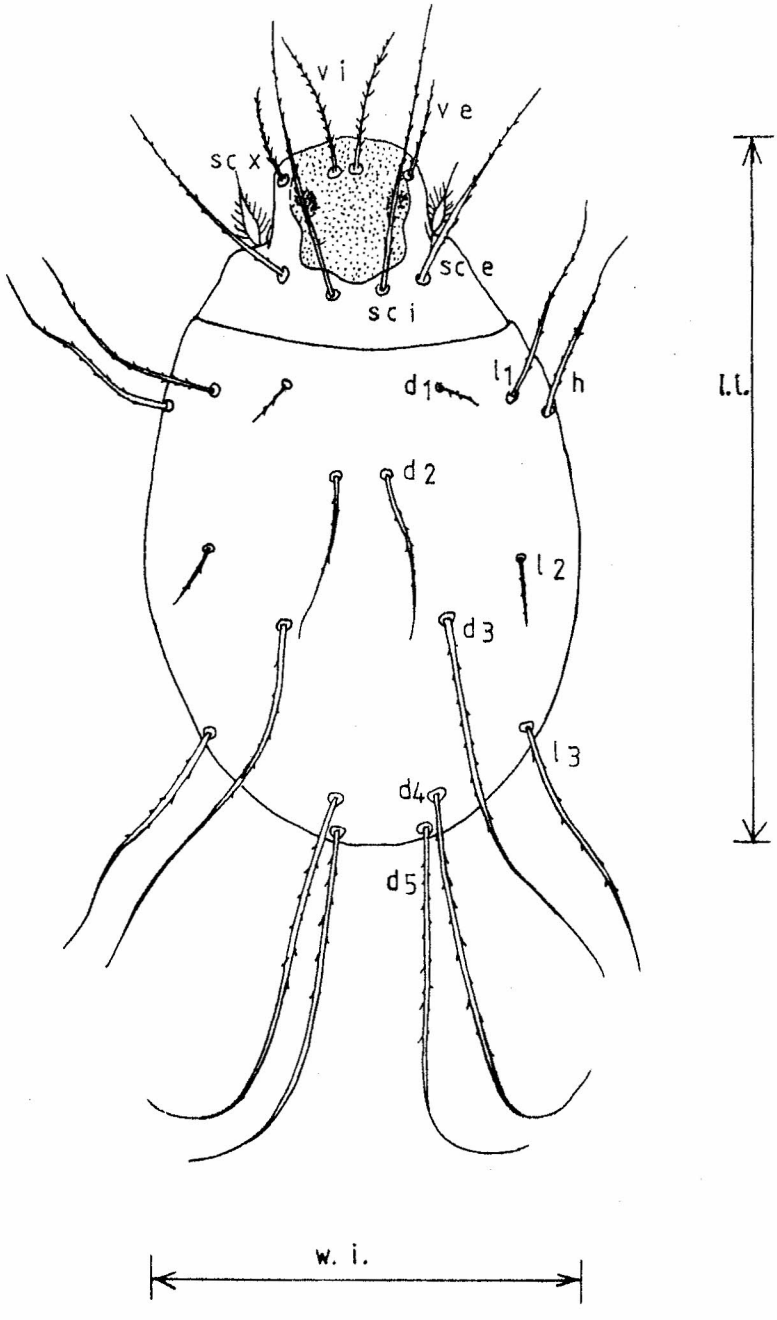
In order to assess the range of variability in males from a laboratory population of *Tyrophagus putrescentiae* (SCHRANK, 1781), we have examined 42 morphological characters most often used for systematic purposes in the genus *Tyrophagus* OUDEMANS, 1924 (Tab.1, figs 1-6).

We have restricted the analysis to males, since the variation in the shape and size of hysterosoma in most egg-laden mounted females is considerable (SINHA & VAN BRONSWIJK 1970).

The results make it possible not only to estimate the range of variation but also to assess their suitability for diagnostic and systematic purposes. Difficulties in identifying mites of the genus *Tyrophagus* - a number of very similar species differing in



1-5. *Tyrophagus putrescentiae*, male: 1 - gnathosoma in dorsal aspect; 2 - genital region and penis; 3 - anal region and anal slit; 4 - femur, genu, tibia and tarsus of the right leg I in latero-dorsal aspect; 5 - genu, tibia and tarsus of IV pair of legs in lateral aspect (modified from HUGHES 1976)



6. *Tyrophagus putrescentiae*: male, idiosoma in dorsal view (modified from FAIN et al. 1990). Idiosomal nomenclature after GRIFFITHS 1977, FAIN et al. 1990)

single, inconspicuous characters (ROBERTSON 1959, 1961, GRIFFITHS 1979, LYNCH 1989) may result in mistakes (SASA et al. 1967). It seemed thus advisable to apply biometrical analysis to this genus.

T. putrescentiae was chosen as the most common member of the genus *Tyrophagus*, frequently found in different kinds of stored products. Occasionally these mites are found in flats and also in nests of birds and rodents, in poultry houses, and in soil and litter. Moreover, it is found in hay-stacks and in mushroom growing cellars, in insect cultures and in entomological museum collections (BOCZEK 1966, 1980, BOCZEK & DUTKIEWICZ 1972, HUGHES 1976, ROSICKÝ et al. 1979, VAN BRONSWIJK 1981, DUBININA 1985, MUMCUOGLU & LUTSKY 1990). *T. putrescentiae* is also found in tropical and subtropical zones (HUGHES 1976).

The species is common in Poland, either in open field conditions or in stores and mushroom growing cellars. In open field conditions it is found in bird nests (*Passer domesticus, P. montanus*), rodent nests, bee-hives, on plants, in fertilizers. In store-houses it appears mainly on oil plant seeds and on herbs (KLIMASZEWSKA & KWIATKOWSKA 1959, WASYLIK 1959, 1963, 1964, BOCZEK et al. 1960, 1961, CHMIELEWSKI 1977, 1982, BANASZAK 1980, BOCZEK 1980, KARNKOWSKI 1990). It dominated in dust samples from freight trains transporting stored products (SOLARZ 1995). It was also found in great numbers in dust from wharf storehouses in Gdynia (WIĘCKO 1986), from kitchens of ocean-going ships (WEGNER 1980), in coal-mine dust samples (Upper Silesia, SOLARZ & SOLARZ 1996), and, sporadically, in house-dust samples (SOLARZ 1986, HORAK 1987, HORAK et al. 1996).

In medical literature the species is known as a cause of skin irritation known as "copra itch" (formerly as *Tyrophagus castellanii* HIRST, 1912), (CASTELLANI 1912, FAIN et al. 1990). Recently an opinion has appeared, that the disease is also caused by an other mite species - *Cosmoglyphus laarmani* SAMŠIŇÁK, 1966 (SAMŠIŇÁK 1966, ROSICKÝ et al., 1979, FAIN et al. 1990). *T. putrescentiae* is of great allergological importance (BOCZEK & DUTKIEWICZ 1972, GREEN & WOOLCOCK 1978, FAIN et al. 1990, ARLIAN 1991). It is the source of 20 antigens and five allergens (Arlian et al. 1984, 1993), and it is among the most abundant and most often studied storage mites of agricultural and medical importance (FAIN et al. 1990, ARLIAN 1991, VAN HAGE-HAMSTEN & JOHANSSON 1992, TEE 1994, HALLAS & IVERSEN 1996).

MATERIAL AND METHODS

In order to determine the degree of variation of the studied characters, we applied basic statistical methods (arithmetic mean, standard deviation, variability coefficient). All the individuals were from a laboratory population which for 5 years had been kept in optimal conditions, 75% relative humidity, temperature 25 °C. The culture medium consisted of wheat germ and flax seed.

Among the males mounted on microscopic slides in Faure's medium, we chose 45 placed in a position allowing exact measurements. The measured values are expressed in micrometers. The list of analysed characters is shown in Tab. 1.

Tab.1 List of the characters examined

	Characters	Character sign
1.	maximal length of idiosoma - fig.1	l.i.
2.	maximal width of idosoma - fig.1	w.i.
3.	maximal length of gnathosoma - fig.2	l.g.
4.	maximal width of gnathosoma - fig.2	w.g.
5.	setal length v i - fig.1	v i
6.	setal length ve - fig.1	v e
7.	setal length sc i - fig.1	sc i
8.	setal length sc e - fig.1	sc e
9.	setal length d_1 - fig.1	d_1
10.	setal length d_2 - fig.1	d_2
11.	setal length d_3 - fig.1	d_3
12.	setal length d_4 - fig.1	d_4
13.	setal length l_2 - fig.1	l_2
14.	setal length l_1 - fig.1	l_1
15.	setal length h - fig.1	h
16.	ratio of setal lengths d_2/d_1	d_2/d_1
17.	ratio of setal lengths d_1/l_2	d_1/l_2
18.	ratio of setal lengths d_2/l_2	d_2/l_2
19.	distance between both setae d_1-d_1	d_1-d_1
20.	distance between both setae d_2-d_2	d_2-d_2
21.	ratio d_1-d_1 / d_2-d_2	d_1-d_1 / d_2-d_2
22.	length of tarsus IV - fig.3d	Ta 4
23.	length of genu IV - fig.3d	G 4
24.	length of tibia IV - fig.3d	Ti 4
25.	ratio of lengths Ta 4 / G 4+Ti 4	Ta 4 / G 4+Ti
26.	length of solenidion omega 1 (ω1) on tarsus I	omega 1 - I
27.	length of solenidion omega 1 (ω1) on tarsus II	omega 1 - II
28.	height of lateral sclerites of aedeagus - fig.3a	d
29.	width of lateral sclerites of aedeagus - fig.3a	e
30.	lenght of supracoxal seta - fig.1	sc x
31.	ratio of lengths Ti 4 / d_1	Ti 4 / d_1
32.	ratio of length Ti 4 / d_2	Ti 4 / d_2
33.	ratio of length Ti 4 / la	Ti 4 / la
34.	setal length - fig.3b	pa_1
35.	length of anal slit - fig.3b	a.s.
36.	ratio of lengths pa_1 / a.s.	pa_1 / a.s.
37.	length of genu I - fig.3c	G 1
38.	ratio of lengths G1 / ve	G 1 / ve
39.	distance between apex of tarsus and tarsal sucker „e" - fig.3d	c
40.	distance between both tarsal suckers - fig.3d	b
41.	distance between tarsal sucker „d" and terminal margin of tarsus IV - fig.3d	a
42.	ratio a+b / c	a+b / c

The range of characters was estimated applying the estimation of arithmetic mean, with probability of 95% statement correctness (1-0.95). Some values in Tabs 2-4 were provided with correctness to second place after coma, due to measure correctness (in case of features of very small value - lenght of solenidia "omega 1 " or in case of characters expressed as length ratio).

RESULTS AND DISCUSSION

The results of statistical analysis of the examined morphological characters are presented in Tabs 2-4. Since the most useful characters for systematic and diagnostic purposes are those of the smallest possible variation, the characters in the tables are arranged according to their increasing variation, and divided in 3 groups depending on the value of variability coefficient (V%).

The values of variability coefficient of the analysed characters ranged from 6.80 % (length of genu I) to 16.79% (lenght ratio of tibia IV and medial lateral setae "l 2"). This supports the initial selection of systematically useful characters - all the characters appear to be useful, although there exist certain differences among them, hence the division in 3 groups. The most useful are characters of variability coefficient lower than 10%. Eleven of 42 studied characters fall in this category (Tab. 2). Only 4 of them are used in identification keys of the genus *Tyrophagus* (e.g. SAMŠIŇÁK 1962, JOHNSTON & BRUCE 1965, GILYAROV & KRIVOLUTSKIJ 1975, HUGHES 1976, LYNCH 1989), but only combined with other useful features. These four characters are:

1. Length of genu leg I (G 1, V = 6.80% - the most constant character).
2. Length of setae "d 2" (d 2, V = 9.13%).
3. Length of tibia leg IV (Ti 4, V = 9.21%).
4. Length of "d 1" setae (d 1, V = 9.23%).

Tab. 2 Characters of variability coefficient (V%) less than 10%

	Character	$\bar{X}$	SD	V%	Range (μm.)
1.	G 1	29,5	2,01	6,80	29 - 31
2.	G 4	61,8	5,09	8,24	60 - 64
3.	d_4	256,5	21,77	8,49	250 - 264
4.	l.g.	72,3	6,19	8,56	70 - 74
5.	omega 1-II	14,61	1,33	9,08	14,21 - 15,01
6.	d_2	87,6	8,05	9,13	86 - 90
7.	Ti 4	28,4	2,62	9,21	27 - 29
8.	d_1	31,5	2,91	9,23	31 - 33
9.	d	40,3	3,78	9,39	39 - 41
10.	e	42,8	4,12	9,64	42 - 44
11.	sc i	145,8	14,54	9,97	142 - 150

The length of genu of leg I is used as a systematic character, as length ratio genu of leg I : external vetical setae ("v e"), as a characteristic feature of the genus *Tyrophagus*.

The "v e" setae in mites of this genus should always be longer than genu I (HUGHES 1976). In the measured males, "v e" setae were always considerably longer, and G 1/v e ratio ranged from 0.71 to 0.79. The rather high variability coefficient of the length ratio G 1/v e (V = 15.47%), is caused obviously by the variability of the length of setae "v e" (V = 16.34%). The ve and G 1/v e characters are among the most variable and are placed in Tab. 4. For certain "v e" setae variability coefficient of genu I length determines the usefulness of that generic feature (v e > G 1) for identification of *T. putrescentiae*.

The length of "d 2" setae is usually compared to that of "d 1" and "l 2" setae. It is characteristic of the discussed species that setae "d 1" and "l 2" are roughly equal in length, whereas "d 2" setae should be 2.5-3.5 (2.5-3.0) times longer than "d 1" (SAMŠIŇÁK 1962, GILYAROV & KRIVOLUTSKIJ 1975) . While "d 1" length turned out to be quite constant (V = 9.23%) and is included in the group of the least variable features (Tab. 2), the length of "l 2" setae is among the most variable - V exceeding 13% (Tab. 4). In all the examined individuals "l 2" setae were somewhat longer than "d 1" setae, and the length ratio d 1/l 2 ranged from 0.86 to 0.94, also being one of the most variable features (V = 14.17%). Due to a greater constancy of lenght of setae "d 1" and "d 2", the ratio d 2/d 1 should be applied for diagnostic or systematic purposes rather than d 2/l 2 (VOLGIN 1948, 1949, JOHNSTON & BRUCE 1965, GILYAROV & KRIVOLUTSKIJ 1975). The above ratio in the males analysed was fairly constant (V = 10.10%) and ranged from 2.67 to 2.83 (Tab. 3), i.e. its variation is narrower than mentioned in some keys (e.g. GILYAROV & KRIVOLUTSKIJ 1975 - from 2.5 to 3.5, and HUGHES 1976 - from 2.0 to 3.5) (Tab. 5), which is noteworthy.

Tab. 3 Characters of variability coefficient (V%) ranging from 10% to 13%

	Character	$\bar{X}$	SD	V%	Range (μm.)
1.	d_2/d_1	2,7	0,28	10,10	2,67 - 2,83
2.	d_3	234,4	24,32	10,37	227 - 241
3.	sc e	92,3	9,58	10,38	89 - 95
4.	a.s.	55,0	5,84	10,60	53 - 57
5.	h	131,7	14,25	10,82	128 - 136
6.	i.i.	322,8	35,33	10,82	312 - 334
7.	v i	75,3	8,24	10,95	72 - 78
8.	$d_1 - d_1$	79,9	8,89	11,13	77 - 83
9.	b	14,5	1,62	11,14	14 - 16
10.	Ta 4	63,1	7,13	11,29	61 - 65
11.	Ti 4 / d_2	0,33	0,04	11,52	0,32 - 0,34
12.	Ti 4 / d_1	0,91	0,11	11,54	0,88 - 0,94
13.	h_1	156,5	18,10	11,57	152 - 162
14.	omega 1-l	12,70	1,53	12,03	12,24 - 13,16
15.	a	18,2	2,20	12,09	17 - 19

Tab. 4 Characters of variability coefficient (V%) above 13%

	Character	$\bar{X}$	SD	V%	Range (μm.)
1.	l_2	35,8	4,67	13,13	35 - 37
2.	d_1-d_1 / d_2-d_2	2,69	0,36	13,19	2,58 - 2,80
3.	w.i.	200,4	26,86	13,26	192 - 208
4.	w.g.	54,8	7,25	13,40	53 - 57
5.	d_1/l_2	0,90	0,13	14,17	0,86 - 0,94
6.	sc x	24,4	3,51	14,38	23 - 25
7.	Ta 4 / G 4 + Ti 4	1,01	0,15	14,65	0,97 - 1,05
8.	c	20,3	3,02	14,87	19 - 21
9.	pa_1	120,1	18,14	15,10	115 - 125
10.	G 1 / ve	0,75	0,12	15,47	0,71 - 0,79
11.	pa_1 / s.a.	2,20	0,34	15,57	210 - 2,30
12.	d_2-d_2	30,2	4,89	16,17	28 - 32
13.	ve	40,6	6,64	16,34	39 - 43
14.	Ti 4 / l_2	0,81	0,14	16,79	0,77 - 0,85
15.	d_2/l_2	2,48	0,38	15,08	2,37 - 2,59
16.	a+b / c	1,65	0,24	14,29	1,58 - 1,72

It is also advisable to compare the length of tibia IV to the length of "d 1" and "d 2" setae (and not e.g. to "l 2") since the character is of low variability (Tab. 2). The ratios Ti 4/d 2 and Ti 4/d 1 are considerably more constant (V = 11.52% and 11.54%, respectively) than the ratio Ti 4/l 2 (V = 16.79%), which displays the greatest variability (Tabs 3, 4).

The remaining features ranked among the most constant (Tab. 2) are not commonly used for diagnostic and systematic purposes. Since no comparable study has been made on males of related species, it is difficult to discuss the importance of such characters, except for drawing attention to their low variability.

Tab. 3 contains characters of variability coefficient ranging from 10% to 13%. There are 15 such characters, 5 of which are used for identification of mites of the genus *Tyrophagus*. These are:

1. Length ratio of setae "d 2" and "d 1" (d 2/d 1, V = 10.10%).
2. Distance between setal bases of "d 1" (d 1 - d 1, V = 11.13%).
3. Length of tarsus IV (Ta 4, V = 11.29%).
4. Length ratio of tibia IV and "d 2" setae (Ti 4/d 2, V = 11.52%).
5. Length ratio of tibia IV and "d 1" setae (Ti 4/d 1, V = 11.54%).

The length ratio of setae "d 2" and "d 1" was discussed above.

The distance between bases of setae "d1" is less often used for diagnostic and systematic purposes than the distance between bases of setae "d 2". The latter feature (d 2 - d 2) is a good diagnostic character of members of the genus *Tyrophagus*, and is compared to the former (d 1 - d 1). In *Tyrophagus putrescentiae* the bases of setae "d 2" are located close to each other - so close that the distance between them is

approximately 3 times shorter than that between the bases of "d 1". In this respect the most similar species is *Tyrophagus palmarum* OUDEMANS, 1924, where the ratio is 2.3 - 2.9. Also the length ratio of the setae d 2/d 1 is of the same range in both species (GILYAROV & KRIVOLUTSKIJ 1975, Tab. 5). Tab. 5 shows values of the discussed character (d 1 - d 1/d 2 - d 2) in selected species of *Tyrophagus*, closely related to *T. putrescentiae*. In the examined males the value of this ratio ranged from 2.58 to 2.80 (V = 13.19%) placing it in the group of the most variable characters (Tab. 4). Therefore, the values mentioned in the keys, i.e. the distance between bases of setae "d 2" is over 3 times shorter than that between bases of "d 1", are misleading. This actual range is wider i.e. from 2.5 to 2.8 (3.0), which makes the studied species more similar to *T. palmarum*, the commonly accepted difference (ratio d 1 - d 2/d 2 - d 2) being of little diagnostic value. These two species differ in some other characters - for example in the shape of solenidion "omega 1", in the form of supracoxal setae ("sc x"), the penis shape and the location of copulatory suckers on tarsus IV. Based exclusively on the length ratio of setae "d 1" and "d 2", and on the distance between bases of these setae, one can easily confuse the two species.

In *T. putrescentiae*, the distance between "d 2" setae is more variable than the distance between the bases of setae "d 1", and the character is included in the third group i.e. the most variable characters (V = 16.17%, Tab. 4).

The length of tarsus IV (Ta 4) is used for diagnostic purposes in comparison to the length of genu and tibia of these legs. In *T. putrescentiae* tarsus IV is not longer than the sum of genu and tibia lengths, as is the case in *Tyrophagus zachvatkini* VOLGIN, 1948. In the males, this ratio (Ta 4/G 4 + Ti 4) ranged from 0.97 to 1.05. It thus shows a greater variability than the length of tarsus IV (Tab. 3 and 4), and, with its high variability coefficient 14.65%, it is placed in the third group of characters

Tab. 5 Ratios of lengths and distances between bases of the setae d_1 and d_2

Species	CHARACTERS					
	d_1-d_1 / d_2-d_2		d_2/d_1			
	Gilyarov and Krivolutskij, 1975	own results ♂♂	Gilyarov and Krivolutskij, 1975	Hughes 1976	Samšiňák 1962	own results ♂♂
T. zachvatkini	1,4 - 1,5		1,9 - 2,1		2	
T. formicetorum	2		3,5 - 4,5		3 - 4,5	
T. perniciosus	2		d_2 d_1	2,5 - 4,5	3 - 4,5	
T. palmarum	2,3 - 2,9		2,5 - 3,5	3 - 4	2,5 - 3	
T. longior	2		1,3 - 2,0	1 - 1,3	1,3 - 2,0	
T. putrescentiae	3	2,58 - 2,80	2 - 3,5	2,5 - 3	2,5 - 3	2,63 -2,83

(Tab. 4). This character is useful - as we have never noted a tarsus IV longer than combined tibia and genu IV.

T. putrescentiae belongs to a group of species whose "d 2" setae are longer than "d 1" and tibia IV. The other group of species of this genus is characterized by approximately equal lengths of setae "d 1" and "d 2", which both are shorter than tibia IV (e.g. *Tyrophagus molitor* ZACHVATKIN, 1941, *Tyrophagus mixtus* VOLGIN 1948, *Tyrophagus similis* VOLGIN, 1949 and *Tyrophagus silvester* ZACHVATKIN, 1941).

In our studies on *T. putrescentiae*, we observed, that the length ratios, either Ti 4/d 2 or Ti 4/d 1, are rather little variable (V = 11.52% and 11.54%, respectively), and both are useful, especially the ratio Ti 4/d 2 , which is commonly applied to identify this species (Tab. 3).

Some of the remaining features from Tab. 3 will be discussed further on.

Tab. 4 shows 14 most variable characters, of variability coefficient above 13%. Of these, up to 11 characters are used for diagnostic and systematic purposes. One should stress, that though these are the most variable characters, the range of their variability (13.13%-16.79%) in fact does not render their suitability doubtful. The mentioned characters are:

1. Length of lateral setae "l 2" (l 2, V = 13.13%).
2. Ratio of the distance between setae "d 1" to the distance between setae "d 2" (d 1 - d 1/d 2 - d 2, V = 13.19%).
3. Length ratio of setae "d 1" and "l 2" (d 1/l 2, V = 14.17%).
4. Length ratio of tarsus IV to combined genu and tibia IV (Ta4/G4 + Ti 4, V = 14.65%).
5. Length of postanal seta "pa 1" (pa 1, V = 15.10%).
6. Length ratio of genu I and external vertical setae "v e" (G 1/v e, V = 15.47%).
7. Length ratio of postanal seta ("pa 1") and anal slit (pa 1/a.s., V = 15.57%).
8. Distance between the bases of setae "d 2" (d 2 - d 2, V = 16.17%).
9. Length of setae "v e" (v e, V = 16.34%).

Tab. 6 Ratios of setal lengths $d_2 : l_2$ in males of *T. putrescentiae* and of several other sibling species from this genus

Mites species	$\bar{X} \pm SD$	Range (μm.)	V%	N° of observatioins	Data source
T. putrescentiae	2,48 ± 0,38	2,37 - 2,59	15,08	45	own results
T. neiswanderi	1,44 ± 0,03 1,58 ± 0,04	1,2 - 1,7 1,4 - 2,0	8,5 10,9	18 16	Johnston & Bruce,1965 Johnston & Bruce,1965
T. savasi	3,00 ± 0,06	2,47 - 3,83	-	29	Lynch, 1989
T. robertsonae	2,08 ± 0,03	1,70 - 2,28	-	30	Lynch, 1989

10. Length ratio of setae "d 2" and "l 2" (d 2/l 2, V = 15.08%).
11. Ratio a+b/c (a+b/c, V = 14.29%).

The above mentioned characters and most of the remaining characters of this group (V% > 13%) have already been discussed, except for the length ratio of postanal setae "pa 1" and anal slit (a.s.), and the ratio a+b/c. According to GILYAROV & KRIVOLUTSKIJ (1975), in the males of *T. putrescentiae* the postanal seta "pa 1" is 1.8 - 2.1 times longer than the anal slit. In the examined males the ratio pa 1 /a.s. ranged from 2.10 to 2.30 ($\underline{X}$ = 2.20), thus exceeding the range mentioned by these authors.

A characteristic diagnostic feature of males of some species of *Tyrophagus* is the location of copulatory suckers on tarsus IV (e.g. SAMŠIŇÁK 1962, JOHNSTON & BRUCE 1965, LYNCH 1989). Because of this we have studied the variability of the following features (Fig. 3 d):

- distance between the begining of tarsus IV and the first tarsal sucker (c),
- distance between both tarsal suckers (b),
- distance between the second tarsal sucker and the end of tarsus (a).

The three mentioned characters differ in their variability, character b being the most constant (V = 11.14%, Tab. 3), character a slightly less so (V = 12.09%, Tab. 3) and the distance c being the most variable (V = 14.87%, Tab. 4). They are classified as characters of medium (b, a) or great (c) variability. According to GILYAROV & KRIVOLUTSKIJ (1975) in *T. putrescentiae* is all these distances are more or less equal. In the examined males they differed considerably, namely: c = 19 - 21 µm ($\underline{X}$ = 20.µ3 m), b = 14 - 16 µm ($\underline{X}$ = 14.5 m) and a = 17 - 19 µm ($\underline{X}$ = 18.2 m)(Tabs 3, 4). The ratio a+b/c (taken into account in some papers, e.g. SAMŠIŇÁK 1962, JOHNSTON & BRUCE 1965, LYNCH 1989) varied slightly between 1.6 and 1.7 ($\underline{X}$ = 1.65±0.24) (Tab. 4).

Tab. 7 Ratios a+b / c in males of *T. putrescentiae* and several sibling species of the genus Tyrophagus

Mite species	$\overline{X} \pm SD$	Range (µm.)	V%	N° of observations	Data source
T. putrescentiae	1,65 ± 0,24	1,58 - 1,72	14,29	45	own results
T. neiswanderi	1,86 ± 0,51	1,5 - 2,6	13,1	23	Johnston & Bruce, 1965
	1,92 ± 0,80	1,5 - 4,8	27,3	43	Johnston & Bruce, 1965
T. savasi	1,83 ± 0,03	1,44 - 2,13	-	30	Lynch, 1989
T. robertsonae	3,02 ± 0,11	2,07 - 4,80	-	30	Lynch, 1989

Tyrophagus savasi LYNCH, 1989 can be distinguished from *T. putrescentiae* by the form of solenidion "omega 1", form of seta "sc x", shape of aedeagus (males) and shape of receptaculum seminis (females) (LYNCH 1989). We have found two other differences - the ratios a+b/c and d 2/l 2 (see Tabs 6 and 7), although they are among the characters of the variability coefficient above 13% (Tab. 4). These characters may also be useful in distinguishing between *T. putrescentiae* and *Tyrophagus neiswanderi* JOHNSTON et BRUCE, 1965 or *Tyrophagus robertsonae* LYNCH, 1989.

The length of idiosoma in the measured males was less variable than its width (V = 10.82% and 13.26%, respectively, Tabs 3 and 4). According to HUGHES (1976) the idiosoma length in males of *T. putrescentiae* ranges from 280 to 350 μm. In the examined males, this character ranged from 312 to 334 μm, but the width of idiosoma varied from 192 to 208 μm. The observed range of idiosoma length variability is within the range mentioned by HUGHES (1976).

External scapular setae ("sc e") are somewhat more variable in length than the internal scapular setae ("sc i") (V = 10.38% and 9.97%, respectively) (Tabs 3 and 2, respectively). In members of *Tyrophagus* the "sc i" setae are longer than setae "sc e" (like in mites of the genera *Tyroborus* OUDEMANS, 1924, *Tyrolichus* OUDEMANS, 1924 and *Mycetoglyphus* OUDEMANS, 1932), and in the studied males the length of "sc i" setae ranged from 142 μm to 150 μm ($\underline{X}$ = 145.8 μm), of "sc e" setae - from 89 μm to 95 μm ($\underline{X}$ = 92.3 μm). The length of external vertical setae "v i" is more constant than the length of external scapular setae "v e" (V = 10.95% and 16.34%, respectively, Tabs 3 and 4).

Humeral setae ("h") are much less variable (V = 10.82%) than the anterior lateral setae "l 1" (V = 11.57%). Both these features are included in the group of medium variability characters (10% < V% < 13%) (Tab. 3).

Particular pairs of dorsal setae ("d 1" - "d 4") also slightly differ in their length variability. The length of setae "d 4" (V = 8.49%) and the length of already discussed setae "d 2" (V = 9.13%) and "d 1" (V = 9.23%) are in the group of the least variable features (Tab. 2). The "d 3" setae are ranked among features of medium variability (V = 10.37%), thus belonging to the most constant characters in this group (Tab. 3). The length of the "d 4" setae (mainly), and also the length of the "d 3" setae may be used for systematic purposes due to their low variability.

The lengths of genua I and IV are characters showing the lowest variability among all the features studied by us (G 1 - V = 6.80%, G 4 - V = 8.24%). The group of the least variable characters (V% < 10%) includes also the length of tibia IV (V = 9.21%)(Tab. 2). The length of tarsus IV turned out to be more variable (V = 11.29%) and is included in the group of characters of medium variability (Tab. 3).

Solenidion "omega 1" on tarsus II is slightly longer ($\underline{X}$ = 14.61 μm) than the respective solenidion on tarsus I ($\underline{X}$ = 12.70 μm), and its length varies much less (V = 9.08% and 12.03%, respectively) (Tabs 2 and 3).

The height (d) and width (e) of lateral sclerites suspending the penis (fig. 3 a), belong to the least variable characters and differ in this respect only slightly (Tab. 2). These characters, except for the shape of these sclerites, have not been used for diagnostic and systematic purposes so far.

CONCLUSIONS

1. All the studied morphological characters vary rather little (V = 6.80 % - 16.79 %), and all can be used for diagnostic purposes, though the features differ in their variability, which allowed their division into three groups according to the variability coefficient (Tabs 2, 3 and 4).
2. Some features commonly used for diagnostic purposes are actually the most variable of the studied characters (Tab. 4):
   - length of setae "v e " (V = 16.34%),
   - distance between setal bases d 2 - d 2 (V = 16.17%),
   - length ratio of setae "pa 1" and anal slit (a.s.) (V = 15.57%),
   - length ratio of genu I and setae "v e" (V = 15.47%),
   - length of setae "pa 1" (V = 15.10%),
   - length ratio of tarsus IV and combined genu and tibia IV (V = 14.65%),
   - length ratio of setae d 1 / 1 2 (V = 14.17%),
   - ratio of distance between bases of setae d 1 - d 1 / d 2 - d 2 (V = 13.19%),
   - length of setae "l 2" (V = 13.13%).

   Most of the constant characters are not used for diagnostic purposes (Tab. 2 and 3):

   - length of genu IV (V = 8.24%),
   - length of setae d 4 (V = 8.49%),
   - maximal length of gnathosoma (V = 8.56%),
   - length of solenidion "omega 1" on tarsus II (V = 9.08%),
   - height and width of lateral penis sclerites (V = 9.39% and 9.64%, respectively),
   - length of setae "sc i" (V = 9.97%),
   - length of setae "d 3" (V = 10.37%),
   - length of setae "sc e" (V = 10.38%),
   - anal slit length (V = 10.60%),
   - length of setae "h" (V = 10.82%),
   - maximal length of idiosoma (V = 10.82%),
   - length of setae "v i" (V = 10.95%),
   - length of setae "l 1" (V = 10.57%),
   - length of "omega 1" solenidion on tarsus I (V = 12.03%).

3. Some of the characters show similar variability (e.g. height and width of lateral penis sclerites; length of genua I and IV; length of setae "d 2" and "d 1"; length ratios of tibia IV and setae "d 1" and "d 2"; width of idiosoma and width of gnathosoma). Some characters differ slightly in their variability (length of setae "sc i" and "sc e"; length of setae "l 1" and "h"; gnathosoma length and idiosoma length; lenght of solenidion "omega 1" on tarsus I, and length of solenidion "omega 1" on tarsus II), while others differ markedly (length of setae "v i" and "v e"; length ratio of tibia IV and setae "d 1" or "d 2", length ratio of tibia IV and setae "l 2").

4. The following morphological characters in males of *T. putrescentiae* are the least variable and thus most useful for diagnostic purposes:

   - length of genua I and IV,
   - length of setae "d 4",
   - length of gnathosoma,
   - length of solenidion "omega 1" on the tarsus II,
   - length of setae "d 2",
   - length of tibia IV,
   - length of setae "d 1",
   - height and width of lateral sclerites of the aedeagus,
   - length of setae "sc i".

   The most variable and the least useful of the studied characters include:

   - length of setae "pa 1",
   - length ratio of genu I and setae "v e",
   - length ratio of setae "pa 1" and anal slit,
   - distance between setal bases "d 2",
   - length of setae "v e",
   - length ratio of tibiae IV and setae "l 2".

5. The difference between *T. putrescentiae* and *T. palmarum* i.e. the ratio d 1 - d 1/d 2 - d 2, mentioned by GILYAROV & KRIVOLUTSKIJ (1975), is probably not as distinct as it was supposed (Tab. 5).

Apart from pointing to the variability ranges the diagnostic suitability of the examined morphological characters can not be defined univocally, without comparing our results with studies on other species of *Tyrophagus*.

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