

Morphological variation in different populations of *Aceria anthocoptes* (Acari: Eriophyoidea) associated with the Canada thistle, *Cirsium arvense*, in Serbia

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Abstract The russet mite, *Aceria anthocoptes* (Nal.), is the only eriophyid that has been recorded on Canada thistle, *Cirsium arvense* (L.) Scop. It has been noted in several European countries and recently in the USA. With its apparent host specificity and because of the damage it causes to its host plant, *A. anthocoptes* is being studied as a potential candidate for classical biological control. The aim of the present study was to examine quantitative morphological traits in four populations of *A. anthocoptes* living on two infraspecific host plant taxa (*C. arvense* var. *arvense* and *C. arvense* var. *vestitum*) in two geographically separate areas of Serbia in order to test the hypothesis of absence of the possible host plant impact on mite morphology. MANOVA analysis revealed significant differences between populations from different localities in Serbia. Populations of *A. anthocoptes* inhabiting two thistle varieties in the vicinity of Belgrade differed significantly from mites inhabiting the same two host varieties in the vicinity of the town of Ivanjica. Canonical discriminant analysis showed that the trait which best discriminates the populations of *A. anthocoptes* is the number of dorsal annuli. It was not possible to ascribe morphological differences to the impact of the host plant.

Keywords *Aceria anthocoptes* · Eriophyoid mites · Creeping thistle mite · Host plant impact · Morphometry · Serbia

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Introduction

Eriophyoid mites are obligate plant feeders (Lindquist and Oldfield 1996). They are host-specific and mostly restricted to a narrow range of acceptable host plant species. The majority of eriophyoid species have been reported from a single host species or species within a single genus (Oldfield 1996). Studies on host specificity and plant–eriophyoid mite relationships are scarce and mostly concerned with species which can be used for biological control of weeds (Skoracka and Kucyznski 2006).

The genus *Aceria* includes over 900 species and is known to be taxonomically problematic, it may not be a natural assemblage of closely related species (Oldfield 1999; Amrine et al. 2003). Despite the description of so many species of *Aceria*, little has been published on relationships of intraspecific taxa (Oldfield 1999). Few papers have dealt with morphometric analysis of *Aceria* species inhabiting different hosts. The quantitative approach is available only for *Aceria tosichella* Keifer (Shevtchenko et al. 1970) and *Aceria tenuis* (Nalepa) (Sukhareva 1992), which live on monocots of the family Poaceae. Recently, 15 morphological features of 35 *Aceria* species living on Asteraceae were analyzed statistically to obtain information on the morphological variability of species (Sukhareva 2001).

The eriophyid mite *Aceria anthocoptes* (Nalepa) has been noted on *Cirsium arvense* (L.) Scop. (creeping, California, or Canada thistle) in several European countries (Davis et al. 1982). Discovered in Maryland in 1998, *A. anthocoptes* is now known to be present in 29 counties and seven states in the USA (Ochoa et al. 2001). *A. anthocoptes* is the only eriophyid mite that has been recorded on *C. arvense* (Petanović et al. 1997). Bull thistle, *Cirsium vulgare* (Savi) Tenore, has been mentioned as a host for *A. anthocoptes*; however no published data confirm this association (Ochoa et al. 2001). One immature *A. anthocoptes* found in spring on *Cirsium discolor* (Muhl. ex Willd.) Spreng from Maryland (USA) probably represents an ‘accidental’ occurrence (Ochoa et al. 2001). Recently, *A. anthocoptes* was found in Poland as accidental on *Lolium perenne* L. (Poaceae) (Skoracka 2004).

Cirsium. arvense is considered to be one of the most harmful weeds in the temperate world (Holm et al. 1977; Skinner et al. 2000). The species is highly variable; on the basis of hairiness and leaf shape, several infraspecific taxa, usually treated as varieties, are recognized. Four varieties—*horridum*, *mite*, *argenteum*, and *incanum*—are distributed in the flora of Central Europe (Hegi 1954). In Serbia, three varieties are found (Gajić 1975): *vestitum* (with hairy leaf undersurface and soft thistles), *arvense* (with both surfaces of leaves green and smooth, and weak thistles), and *horridum* (like *arvense*, but with hard thistles). The varieties *vestitum* and *arvense* both have two forms. Intraspecific taxa of *C. arvense* morphologically differ in the hairy cover of the leaf epidermis, leaf size, stem length, number of capitula, etc. They also exhibit different levels of resistance to herbicides (Zand et al. 2002).

Host specificity tests carried out with the *A. anthocoptes* population from the Belgrade area (Serbia) on five *Cirsium*, four *Carduus*, three *Centaurea*, two *Carlina* L., and one *Onopordum* L. species revealed that after 30 days the mite was found only on two varieties of *C. arvense* (Gassmann et al. 2004). It is widespread on *C. arvense* in Serbia (Rančić 2003). With its apparent host specificity and because of the damage it causes to its host plant, *A. anthocoptes* is being studied as a potential candidate for the biological control of *C. arvense* (Ochoa et al. 2001; Gassmann et al. 2004; Rančić et al. 2006).

Previous observations showed that *A. anthocoptes* lives and feeds between leaf hairs and that its population is more numerous on the infraspecific taxa of *C. arvensis* with hairy abaxial sides of leaves. A hairy undersurface can provide a protective microhabitat and may have an effect on mite morphology (Petanović et al. 1997). On the other hand, based on the conclusions of Sukhareva (2001), it seems probable that different asteraceous hosts do not affect phenotypic variation of the mite.

The aim of this study was to describe phenotypic variation quantitatively among populations of the Canada thistle eriophyid mite *A. anthocoptes* originating from two varieties of host plants with hairy and smooth abaxial leaf surface, respectively and from two geographically separate areas of Serbia in order to test the hypothesis that different host varieties and geographical position of the locality do not have an impact on the phenotype of *A. anthocoptes*.

Materials and methods

The main criteria for the selection of samples were hairiness of leaves of the host plants (*C. a. var. vestitum* and *arvensis*) and the presence of at least two varieties of the same locality. The samples of two varieties of *C. a.*—*vestitum* (hairy undersurface) and *arvensis* (smooth undersurface)—were found and checked for mite presence at two localities in Serbia: Loc. Bežanijska Kosa (UTM—DQ56), 116.75 m above sea level (a.s.l.), collected on June 15, 2004: population I BK (from *C. a. var. vestitum*) and population II BK (from *C. a. var. arvensis*), and Loc. Ivanjica (UTM—DP32), 468 m a.s.l., collected on September 25, 2003: population I IV (from *C. a. var. vestitum*) and population II IV (from *C. a. var. arvensis*).

The climate of Belgrade can be described as moderate-continental. Belgrade is located at the altitude of 132 m (latitude—44°48", longitude—20°28"). The average annual air temperature is 11.9°C. The average air temperature for the period April–October is 17.6°C. Average annual precipitation sums are 678 mm. The average precipitation sums for the period April–October are 429 mm. The average humidity for the period April–October is 65%.

The climate of Ivanjica can be described as moderate-continental. Ivanjica is an area with the altitude of 465 m (latitude—43°35", longitude—20°14"). The average annual air temperature is 9.3°C. The average air temperature for the period April–October is 14.7°C. The average annual precipitation sums are 845 mm. The average precipitation sums for the period April–October are 554 mm. Average humidity for the period April–October is 77%.

Mite specimens were collected by direct examination with a stereo microscope and/or extracted using the method described by De Lillo (2001). Twenty-four to 30 mites from each sample were mounted in a dorso-ventral position on slides in Kieffer's F medium and identified (Amrine and Manson 1996). Protogyne females randomly selected from each population were examined with a phase-contrast microscope (LEICA DMLS). Deutogyne females and males were excluded from the analysis. Twenty-three traits were measured on each individual with the IM 1000 (Leica, Wetzlar, Germany) software package (Fig. 1). The morphometric traits selected are important and were commonly used for eriophyid mite identification.

All variables that entered the analyses presented normal distribution, as well as homogeneity of variance. The data were tested for normality using Kolmogorov–Smirnov and Shapiro–Wilk tests. When there are several dependent variables, there is a potential for inflated Type I errors (Zar 1999) due to multiple tests of (likely) correlated dependent

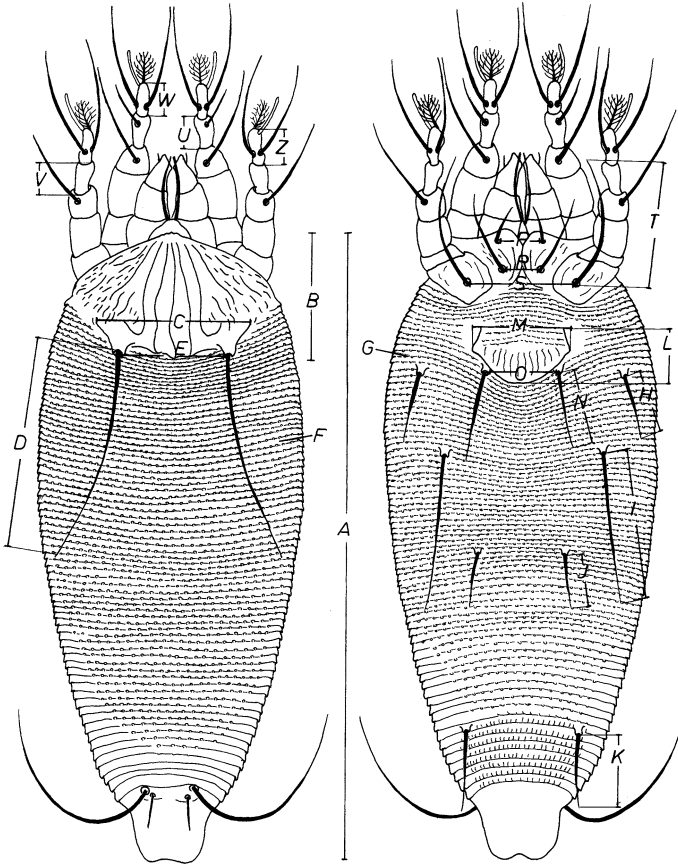


Fig. 1 Measurements of *A. anthocoptes* female morphology used in statistical analysis. Explanation of abbreviations: A—length of body, B—length of prodorsal shield, C—width of prodorsal shield, D—length of scapular setae *sc*, E—scapular tubercles apart from *sc*, F—no. of dorsal annuli, G—no. of ventral annuli, H—length of lateral setae *c2*, I—length of I ventral setae *d*, J—length of II ventral setae *e*, K—length of III ventral setae *f*, L—length of genitalia, M—width of genitalia, N—length of setae *3a*, O—spacing of tubercles *3a*, P—spacing of tubercles *1b* of coxa I, R—spacing of tubercles *1a* of coxa I, S—spacing of tubercles *2a* of coxa I, T—length of setae *2a*, U—length of tibia I, W—length of tarsus I, Y—length of tibia II, Z—length of tarsus II

variables (Tabachnik and Fidell 1996). A multivariate analysis of variance (MANOVA) allows for the comparison of the population means of all variables of interest at the same time (multivariate response), rather than considering multiple responses as a suite of univariate responses (Zar 1999). This reduces the magnitude of Type I errors. The statistical significance of the MANOVA can be determined in a variety of ways. The most often used statistic test Wilks' Lambda was applied (Zar 1999). A two-way MANOVA was used to examine the effects of host-plant and locality on Canada thistle eriophyid mite *A. anthocoptes* morphological variation. The fixed factors were the variety of *C. arvensis* (hairy versus smooth leaf undersurface) and two localities. When the MANOVA were statistically significant, subsequent univariate ANOVAs were performed to elucidate which responses contributed to the significant multivariate response. For this purpose Unequal N

HSD post-hoc test was used. Additionally, to describe and interpret effects from MANOVA, a multivariate discriminant analysis (DA) was used as a useful post method to employ following a MANOVA. Discriminant analysis was employed on all data, in order to determine the relative importance of characters as discriminators between a priori groups and the relative positions of the centroids of those groups (Manly 1986). In addition, canonical variables were computed. All statistical analyses were conducted using the Statistica 6 software package (StatSoft 2001).

Results

Descriptive statistics of the quantitative traits of *A. anthocoptes* are given in Table 1. The two-way MANOVA of *A. anthocoptes* from two varieties of *C. arvense* at Bežanijska Kosa (I BK and II BK) and Ivanjica (I IV and II IV) revealed significant effects of host-plant, locality and host-plant \times locality interaction on *A. anthocoptes* morphological variation ($P < 0.001$ in all cases, Table 2).

Table 1 Basic statistical data for 23 morphological traits of nine *Aceria anthocoptes* populations from two varieties of *Cirsium arvense* at Bežanijska Kosa (I and II BK) and Ivanjica (I and II IV). n = number of specimens, SD = standard deviation

Populations	I BK (n = 30)		II BK (n = 28)		I IV (n = 29)		II IV (n = 24)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A—body length	181.06	19.59	186.49	18.32	215.81	16.31	199.74	17.07
B—prodorsal shield length	30.53	1.77	30.66	3.23	35.97	3.19	35.45	4.07
C—prodorsal shield width	29.08	2.19	33.32	3.08	37.27	2.91	35.56	3.20
D—setae sc length	51.37	7.05	47.62	7.39	63.00	6.50	61.07	7.29
E—tubercles sc apart	23.35	1.79	23.83	1.59	22.66	1.72	22.17	1.28
F—no. of dorsal annuli	73.53	4.94	79.43	7.83	43.34	2.86	43.21	4.25
G—no. of ventral annuli	89.00	11.05	92.61	11.81	68.93	7.97	61.71	9.99
H—setae c2 length	22.29	2.44	21.51	4.03	26.30	3.24	26.22	2.76
I—setae d length	58.97	8.60	54.81	10.17	67.99	6.17	65.56	7.21
J—setae e length	20.03	2.10	18.80	2.64	24.93	2.00	24.65	1.67
K—setae f length	25.10	2.49	23.50	4.09	24.83	2.58	26.32	1.74
L—genitalia length	11.84	1.27	12.30	1.88	13.99	1.84	14.09	2.79
M—genitalia width	20.89	1.48	20.74	1.93	22.24	1.56	21.60	1.70
N—setae 3a length	17.55	2.41	17.70	4.93	22.80	2.73	22.11	2.08
O—tubercles 3a apart	16.83	1.42	17.06	1.94	17.04	1.06	17.03	1.35
P—tubercles 1b apart	10.33	0.94	10.63	1.47	11.59	0.86	10.93	1.07
R—tubercles 1a apart	7.80	0.64	8.20	1.81	7.78	0.86	7.85	1.05
S—tubercles 2a apart	22.12	1.08	21.74	1.96	23.20	2.04	21.76	2.54
T—setae 2a length	41.31	8.67	43.13	6.07	49.30	8.01	47.52	7.82
U—tibia I length	7.57	0.57	7.22	0.94	9.19	0.61	8.92	0.87
W—tarsus I length	6.22	1.01	6.89	0.88	7.11	0.96	7.00	0.71
V—tibia II length	5.87	0.59	6.60	0.81	7.26	0.71	7.21	0.81
Z—tarsus II length	6.22	0.58	6.33	0.54	7.41	0.80	7.02	0.61

Table 2 Results of two-way MANOVA on the considered traits of *Aceria anthocoptes* from two varieties of *Cirsium arvense* (hairy and smooth undersurface) (Host-plant as factor) at Bežanijska Kosa and Ivanjica (Locality as factor)

All effects	Wilks' λ	F(23, 85)	
Host-plant	0.549	3.039***	
Locality	0.043	82.644***	
Host-plant \times locality	0.507	3.594***	
Specific effects	Host-plant	Locality	Host-plant \times locality
Traits	F(1,107)	F(1,107)	F(1,107)
A	2.435	49.440***	9.923**
B	0.101	74.174***	0.297
C	5.460*	92.086***	30.031***
D	4.469*	87.044***	0.458
E	0.000	14.459***	2.456
F	8.122**	1080.136***	8.911**
G	0.847	168.226***	7.595**
H	0.508	51.896***	0.342
I	4.449*	40.018***	0.308
J	3.399	172.443***	1.314
K	0.009	5.378*	7.893**
L	0.561	27.425***	0.227
M	1.523	11.965**	0.597
N	0.186	60.721***	0.460
O	0.158	0.104	0.181
P	0.736	13.449***	5.202*
R	1.161	0.670	0.567
S	5.996*	2.194	2.057
T	0.000	17.700***	1.503
U	4.445*	132.254***	0.065
W	2.634	8.466**	5.145*
V	6.037*	52.020***	7.816**
Z	1.277	58.873***	4.047*

P-level: * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$. Traits are illustrated in Fig. 1

Some of the most significant results from Unequal N HSD post-hoc test are shown in Table 3.

The result of the discriminant analysis showed the most important and distinct discrimination to be between the populations from Ivanjica (I IV and II IV) and Bežanijska Kosa (I BK and II BK) based on the first canonical axis (function) (Fig. 2). The total correct percent of Classification matrix of all four groups was high (89.189%).

From the standardized canonical discriminant function coefficients (Table 4) it is evident that the first canonical function describes 93.34% of the total variability; the first and second together, 98.63%; and all three roots with 100% of the total variability. It should be stressed that the first and the second canonical functions describe most of the variability. The number of dorsal annuli (F) contributes most to this discrimination. The following two

Table 3 Results of Unequal N HSD post-hoc test for the most significant traits (C, F, U, V) of *Aceria anthoceptes* from 2 × 2 host plants and localities: 1—I BK; 2—I IV; 3—II BK; 4—II IV

Trait C				Trait U			
{1}	{2}	{3}	{4}	{1}	{2}	{3}	{4}
1	***	***	***	1	***	NS	***
2		***	NS	2		***	NS
3			*	3			***
4				4			

Trait F				Trait V			
{1}	{2}	{3}	{4}	{1}	{2}	{3}	{4}
1	***	***	***	1	***	**	***
2		***	NS	2		**	NS
3			***	3			*
4				4			

NS—not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. Traits are illustrated in Fig. 1

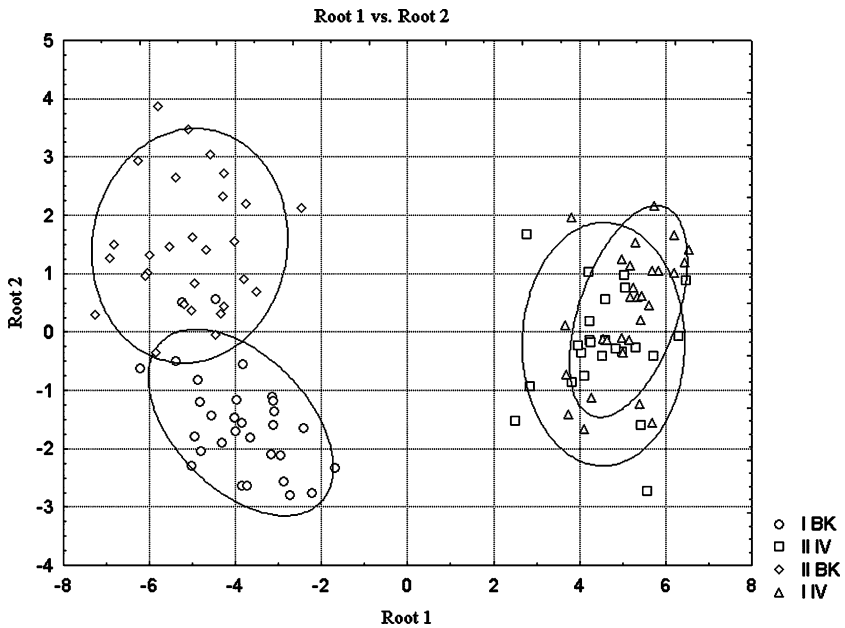


Fig. 2 Plots of scores of the first two canonical axes (Root 1 and Root 2) of four populations of *Aceria anthoceptes* from two host-plants and two geographically distant areas in Serbia. Abbreviations of populations are described in “Materials and methods” Section

characters contribute, but to a lesser extent: E—the distance between tubercles (*sc*) and U—length of tibia of the first legs based on the first canonical function (Table 2). Width of prodorsal shield (C), length of the tibia of the second leg (V), and length of the third ventral (*f*) setae (K), has the most distinct discriminative power based on the second canonical

Table 4 Standardized coefficients for canonical variables on first (Root 1) and second (Root 2) canonical axes in discriminant function analysis (DA)

Traits	Root 1	Root 2
A—body length	0.249	0.123
B—prodorsal shield length	0.313	0.092
C—prodorsal shield width	0.235	0.784
D—setae sc length	0.167	-0.074
E—tubercles sc apart	-0.390	-0.337
F—no. of dorsal annuli	-0.951	0.303
G—no. of ventral annuli	-0.061	-0.011
H—setae c2 length	0.204	0.090
I—setae d length	0.131	-0.253
J—setae e length	0.183	-0.111
K—setae f length	-0.160	-0.380
L—genitalia length	-0.215	0.107
M—genitalia width	-0.181	-0.062
N—setae 3a length	0.046	0.097
O—tubercles 3a apart	0.111	0.057
P—tubercles 1b apart	-0.168	0.417
R—tubercles 1a apart	-0.021	0.210
S—tubercles 2a apart	0.184	-0.358
T—setae 2a length	0.035	0.190
U—tibia I length	0.325	-0.287
W—tarsus I length	0.033	0.278
V—tibia II length	-0.004	0.488
Z—tarsus II length	0.065	0.015
Eigenvalues	22.738	1.291
Cumulative proportions (%)	93.336	98.634

Traits are illustrated in Fig. 1

function. Bearing in mind that the second canonical function describes only 5.29% of the total variability, it could be inferred that its discriminative power is significantly lower in comparison with the first canonical function.

Aceria anthocoptes mites from two host plants (*C. a.* var. *vestitum* and *arvense*) and the same geographical location (Ivanjica, Southwest Serbia) are characterized by the smallest number of dorsal annuli, the smallest distance between scapular setae and the longest first leg tibia. The results obtained in this work indicate that the *A. anthocoptes* populations from Ivanjica differ from those originating from Bežanijska Kosa (Belgrade region, Central Serbia).

A host-plant-dependent morphological difference exists among Bežanijska Kosa populations, but does not in case of the Ivanjica populations (Fig. 2). The Bežanijska Kosa population of *A. anthocoptes* from hairy undersurface host-plant is characterized by narrower prodorsal shield, longer second leg tibia, and shorter length of the third ventral (*f*) setae, compared with the population inhabiting smooth undersurface host-plant on the same locality.

Discussion

Results of our study done at two widely separated localities revealed non-significant differences of certain morphological traits between *A. anthocoptes* populations inhabiting two different varieties of the host-plant. However, mites from two different varieties of the host-plant at Bežanijska Kosa had significant differences in width of prodorsal shield, length of the tibia of the second leg, and length of the third ventral (*f*) setae (K). Differences in these traits can be explained to some extent as adaptation *sensu lato* to protected microhabitat.

According to Kozłowski (1998) and Skoracka et al. (2002), free-living eriophyoids inhabiting protected microhabitats (narrow and deep grooves or a more hirsute surface) are elongated in body shape and have short setae and legs as a result of adaptation to such conditions. Absence of significant differences between *A. anthocoptes* inhabiting two varieties of the host plant at Ivanjica locality is possible to ascribe to higher average relative humidity which can neutralize the more exposed microhabitat such as variety of the host plant with smooth undersurface of leaves.

It has been reported that morphology of eriophyoid mites may be closely related to the structure of their habitat. Boczek et al. (1984) found certain differences of many morphometric features in females of *Aculus fockeui* (Nalepa & Trouessart) collected from various species of *Prunus*. According to Kozłowski (1998), protogyne females of *Aculus schlehtendali* (Nalepa) living on several varieties of apple trees display differences in body size and length of the ventral setae. Skoracka et al. (2002) found host-dependent morphological variation in three populations of the cereal rust mite *Abacarus histrix* (Nalepa). The authors interpreted the morphological variation as being on adaptation to specific environmental conditions created by the host.

On the other hand, Lamb (1953) did not observe differences between measurements of *Aculops lycopersici* (Masse) from *Lycopersicum esculentum* Miller and *Physalis peruviana* L. (Solanaceae). Morphometric analysis of 40 traits in four widely separated *Aculops euphorbiae* (Petanović) populations inhabiting *Euphorbia seguierana* Neck. subsp. *seguierana* and *E. seguierana* Neck. subsp. *niciciana* (Borbás ex Novák) Rech.f. (Euphorbiaceae) showed variation in measurable characteristics. The four populations exhibited a significant difference in only one trait, width of the dorsal shield. No impact of the different host plant subspecies was proven (Petanović and Dimitrijević 1995).

So far, one possible explanation of the results on morphological variation in different populations of *A. anthocoptes* obtained in the present study agrees with the hypothesis of Sukhareva (2001). In her paper dealing with mites of the genus *Aceria* on asteraceous plants, it was inferred that no distinct groups of species connected with phylogenetic groups of hosts can be singled out. The *Aceria* group of species from plants of the tribe Carduae is homogeneous with respect to quantitative features. This may be explained in the high degree of variability of the host plants themselves and in rapid evolution of this group of plants, accompanied by development of new forms. According to this author, one of the special features of evolution of the Asteraceae is its biochemical direction, which is associated with the synthesis of sesquiterpenes. It results in the development of physiologically specific new forms of plants. Among species of the genus *Aceria* inhabiting phylogenetically remote hosts that are sometimes different ecologically, there are similar, almost identical species of mites.

The results of our study support the hypothesis that varieties of plants within the family Asteraceae do not affect the phenotype of mite species.

At the other hand the most important and distinct discrimination was shown between the two distant geographical populations from Ivanjica and Bežanijska Kosa. The number of dorsal annuli (F) contributes most to this discrimination. Considering that samples of mites from two localities were taken in June and September respectively, it is also possible to ascribe these differences to season influences of mite morphology. The obtained results to be confirmed needed in further experimental work. In studying morphologically similar species (or subspecific taxa) of mites, we should consider their biochemical and genomic features.

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References

- Amrine JW, Manson DCM (1996) Preparation, mounting and descriptive study of eriophyoid mites. In: Lindquist EE, Sabelis MW, Bruin J (eds) Eriophyoid mites. their biology, natural enemies and control. Elsevier Science BV, Amsterdam, pp 383–396
- Amrine JW Jr, Stasny TAH, Flechtmann CHW (2003) Revised keys to world genera of Eriophyoidea (Acari: Prostigmata). Indira Publishing House, West Bloomfield, MI
- Boczek J, Zawadzki W, Davis R (1984) Studies on the morphological and biological differences in *Aculus fockeui* (Nalepa et Trouessart) (Acari: Eriophyidae) on various host plants. Internat J Acarol 10:81–87
- Davis R, Flechtmann CHW, Boczek JH, Barke HF (1982) Catalogue of eriophyid mites (Acari: Eriophyoidea). Warsaw Agricultural University Press, Warsaw
- De Lillo E (2001) A modified method for eriophyoid mite extraction (Acari: Eriophyoidea). Internat J Acarol 27(1):67–70
- Hegi G (1954) Illustrierte flora von Mitteln-Europa, Band VI 2 Teil. Carl hanser Verlag-Munchen. *C. arvense*, pp 903–916
- Holm LG, Plucknett DL, Pancho LV, Herberger JP (1977) *Cirsium arvense* (L.) Scop. The worlds worst weeds. Distribution and biology. University Press of Hawaii for the East-West food Institute, Honolulu, pp 217–224
- Gajić M (1975) Asteraceae Dum. In: Josifović M (ed) Flora of the Republic of Serbia VII, p 465
- Gassmann A, Petanović R, Rančić D, Magud B, Toševski I (2004) Biological control of Canada thistle (*Cirsium arvense*). Annual report 2003. Unpublished report, CABI Bioscience Switzerland Centre, Delemont
- Kozłowski J (1998) Czynniki warunkujące odmain jabloni i rekacja odmain na porzewiacza jabloniwego-*Aculus schlechtendali* (Nalepa) (Factors determining susceptibility and response of apple cultivars to the apple rust mite: *Aculus schlechtendali* (Nalepa). Rozprawy Naukowe Instytutu Ochrony Roslin w Poznaniu 2, p 119
- Lamb KP (1953) A revision of the gall-mites (Acarina, Eriophyoidea) occurring on tomato (*Lycopersicon esculentum* Mill.), with a key to Eriophyidae recorded from solanaceous plants. Bull Ent Res 44(2):343–350
- Lindquist EE, Oldfield GN (1996) Evolution of eriophyoid mites in relation to their host plants. In: Lindquist EE, Sabelis MW, Bruin J (eds) Eriophyoid mites. Their biology, natural enemies and control. Elsevier Science BV, Amsterdam, pp 277–300
- Manly FJB (1986) Multivariate statistical methods—A primer. Chapman and Hall, New York
- Ochoa R, Erbe EF, Wergin WP, Frye C, Lydon J (2001) The presence of *Aceria anthocoptes* (Nalepa) (Acari: Eriophyidae) on *Cirsium* species in the United States. Internat J Acarol 27:179–187
- Oldfield GN (1996) Diversity and host plant specificity. In: Lindquist EE, Sabelis MW, Bruin J (eds) Eriophyoid mites. Their biology, natural enemies and control. Elsevier Science BV, Amsterdam, pp 195–216
- Oldfield GN (1999) Distribution of asymmetrical and symmetrical sperm storage in the Eriophyoidea and its phylogenetic implications. In: Bruin J, van der Geest LPS, Sabelis MW (eds) Ecology and evolution of Acari. Kluwer Academic Publishers, Nederlands, pp 157–161
- Petanović R, Dimitrijević J (1995) Intraspecific variability of *Vasates euphorbiae* Pet. (Acari: Eriophyoidea) on different subspecies of the host plant. Zaštita bilja 46(1), 211:17–28

- Petanović R, Boczek J, Stojnić B (1997) Taxonomy and bioecology (Acari: Eriophyoidea) associated with Canada thistle, *Cirsium arvense* (L.) Scop. *Acarologia* 38:181–191
- Rančić D (2003) Morpho-anatomical alterations of vegetative and reproductive organs of plant species *Cirsium arvense* (L.) Scop. caused by eriophyid mite *Aceria anthocoptes* (Nal.). MSc thesis, University of Belgrade
- Rančić D, Stevanović B, Petanović R, Magud B, Toševski I, Gassmann A (2006) Anatomical injury induced by the eriophyid mite *Aceria anthocoptes* on the leaves of *Cirsium arvense*. *Exp Appl Acarol* 38:243–253
- Shevtchenko VG, De Millo AP, Razvyazkina GM, Kapkova EA (1970) Taksonomicheskoe razgranichenie blizkih vidov klschej *Aceria tulipae* Keif. i *Aceria tritici* sp.n. (Acarina: Eriophyioidea) perenoschikov virusov luka i pšenici. (Taxonomic separation of similar species of eriophyid mites, *Aceria tulipae* Keif. and *A. tritici* sp.n. (Acarina, Eriophyoidea)—vectors of the viruses of onions and wheat) *Zoologicheskij zhurnal* 49(2):224–235
- Skinner K, Smith L, Rice P (2000) Using noxious weed lists to prioritize targets for developing weed managements strategies. *Weed Sci* 48:640–644
- Skoracka A (2004) Eriophyoid mites from grasses in Poland (Acari: Eriophyoidea), Genus—supplement 13, BS, Wrocław, p 205
- Skoracka A, Kuczynski L (2006) Is the cereal rust mite, *Abacarus hystrix* really a generalist?—Testing colonization performance on novel hosts. *Exp Appl Acarol* 38:1–13
- Skoracka A, Kuczynski L, Magowski W (2002) Morphological variation in different host populations of *Abacarus hystrix* (Acari: Prostigmata: Eriophyoidea). *Exp Appl Acarol* 26:187–193
- StatSoft Inc (2001) Statistica (data analysis software system), version 6. www.statsoft.com
- Sukhareva SI (1992) Chetirekhnogie kleshchi na zlakah. (Four-legged mites on grasses). S. Peterburgskii Gosudarstveni Universitet, Sant Petersburg, p 230
- Sukhareva SI (2001) Four-legged mites (Acari: Tetrápodili) of the genus *Aceria* from plants of the family Asteraceae with the description of a new species. *Acarina* 9(1):131–141
- Tabachnik B, Fidell L (1996) Using multivariate statistics, 3rd edn. Harper Collins, New York
- Zand EH, Beckie J, Myhre CD, Loeppky HA (2002) Response of two Canada thistle (*Cirsium arvense*) varieties to herbicides. *Can J Plant Sci* 82(3):625–628
- Zar J (1999) Biostatistical analysis, 4th edn. Prentice-Hall, New Jersey