



***Panonychus* from Georgia: survey, taxonomical status and redescription of *P. hadzhibejliae* (Reck, 1947) (Acari, Tetranychidae)**

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Abstract

A survey of *Panonychus* species was undertaken across Georgia from 2005 to 2014 on various host plants, revealing three species: *Panonychus citri* (McGregor, 1916), *Panonychus hadzhibejliae* (Reck, 1947) and *Panonychus ulmi* (Koch, 1836). New hosts for *P. ulmi* and *P. citri* are recorded, *Buxus sempervirens*, *Hedera colchica* and *Prunus laurocerasus* for *P. ulmi* and *Ficus carica* for *P. citri*, whereas *P. hadzhibejliae* was only found on *F. carica*. The newly collected material also allowed us to investigate the taxonomical status of *P. hadzhibejliae*. The comparison of *P. hadzhibejliae* with the two closely related species sampled in the survey, *P. ulmi* and *P. citri*, and with data of *P. caricae* found in the literature, shows that *P. hadzhibejliae* is a valid species. It can be separated from the three other *Panonychus* species without ambiguity especially using the female dorsal setae length in combination with the ratio between the length of the female dorsal opisthosomal f_2 and h_1 setae and the ratio between the palptarsal terminal eupathidium su and the related solenidion ω . A redescription of *P. hadzhibejliae* is provided including the male and some morphological characters, measurements and drawings of the female that were omitted in the original description. A key to the world species of *Panonychus* is also proposed.

Key words: Acari, Prostigmata, Tetranychidae, *Panonychus*, Georgia, Caucasus

Introduction

Tetranychid mites are common pests of agricultural and ornamental plants. Among the 1288 species that belong to the family Tetranychidae (Migeon & Dorkeld 2015), 69 species distributed throughout 20 genera are recorded from Georgia (Arabuli 2008). In the genus *Panonychus*, only represented by 16 species throughout the world, *P. ulmi* (Koch, 1836) and *P. citri* (McGregor, 1916) have a worldwide distribution, including Georgia. Both of them are serious pests for many crops, whereas *P. hadzhibejliae* (Reck, 1947) and *P. caricae* Hatzinikolis, 1984, are only known from *Ficus carica* L. and encountered in Georgia, Azerbaijan, Armenia (Bagdasarian 1957; Reck 1959, 1976; Wainstein 1960; Mitrofanov *et al.* 1987; Tskitishvili 2000; Arabuli 2008) and Greece (Hatzinikolis 1984), respectively.

These four species of *Panonychus* are closely related but, according to Reck (1947, 1959) and Bagdasarian (1957), *P. hadzhibejliae* can be separated from *P. ulmi* and *P. citri* by using a combination of characters like the colour of dorsal body tubercles, the length of setae, the shape of the terminal palptarsal eupathidium (su) and the ratio between the length of this eupathidium and that of the related solenidion (ω). However, Wainstein (1960), without explanation, stated that there was no reason to distinguish between *P. hadzhibejliae* from *P. citri* thus he considered *P. hadzhibejliae* as a junior synonym of *P. citri*. Later, Ehara & Gotoh (1992) did not include *P. hadzhibejliae* in their key to the world *Panonychus* species. In other works, *P. hadzhibejliae* was generally considered as a valid species (e.g. Mitrofanov *et al.* 1987; Bolland *et al.* 1998) despite no additional arguments being provided in support of this statement. To address the problem of the status of *P. hadzhibejliae*, the present work is first devoted to report the results of a survey of the *Panonychus* species encountered on several host plants

in Georgia. In a second step, to find some possible obvious morphological criteria that would allow us to distinguish between *Panonychus* species, several characters were measured and compared in specimens belonging to the three species that were collected during the survey. As *P. hadzhibejliae* is closely related to *P. caricae* and because both species were described from the same host plant (*F. carica*), the comparison was also extended to this fourth species using data found in the literature. Finally, a redescription of *P. hadzhibejliae*, that includes morphological data and measurements of the female and male that were not included in the original description by Reck (1947), and a key to the world known species of *Panonychus*, are provided.

Material and methods

Survey. Mite specimens were collected from various plants in thirty different locations from the eight regions of Georgia between 2005 and 2014. The elevation and geographical coordinates were recorded for each locality using a handheld Garmin global positioning device. Mites were collected with leaves, twigs and branches, put into plastic bags and transported to the laboratory. They were extracted using a washing method, by filtering the solution on two stacked sieves (mesh size 400 and 20 μm), and picking out mites using a camel hair brush. They were preserved in 75% ethanol and, following clearing in lactic acid, they were mounted on microslides in Hoyer's medium and examined using a phase contrast microscope Olympus® BX50 and a micrometrical scale. Mites were identified using the appropriate literature (including identification keys) that deals with the western Palearctic *Panonychus* species (Reck 1947, 1959; Bagdasarian 1957; Wainstein 1960; Mitrofanov *et al.* 1987; Ehara & Gotoh 1992).

Comparisons between *Panonychus* species. Mites were examined and measured as described above. Comparison of the three species collected in the survey was based on the examination of three characters: i) the dorsal setae length (including the ratio between the lengths of f_2 and h_1 setae); ii) the comparison of the length of the palptarsal eupathidium (su) and that of the related solenidion (ω); iii) the length of the first leg. Forty females of *P. hadzhibejliae* (see redescription for the origin of the material examined) and twenty females of both species *P. ulmi* (Tbilisi, Plato Nutsbidze on *Rosa canina* L. and Tbilisi, III massiv on *Sophora japonica* L.) and *P. citri* (Adjara, village Legva on *Citrus limon* (L.) Osbeck., *Citrus nobilis* Lour. and on *Elaeagnus angustifolia* L.) were measured (see survey for detailed information on the origin of the material examined). Measurements are given in micrometers (μm) and correspond to the average followed by standard error (SE). An ANOVA, completed by a Scheffé post hoc test ($\alpha = 5\%$), assessed the possible differences in measurements of each character between *P. hadzhibejliae*, *P. ulmi* and *P. citri*. Then, a multifactorial analysis using Statistica 10® (StatSoft France 2011) was performed to determine whether some of the taxonomic characters above mentioned would allow the differentiation of several groups that correlate with the species designation among *Panonychus* samples studied. Morphological data on *P. caricae* found in the literature did not allowed us to include this species in these analyses because replicates of measurements were not available. An additional factor, the shape of the terminal palptarsal eupathidium su was also observed but, due to the reduced size of this character, no measurements were taken to be used in the comparison of the species.

Mite redescription. The specimens were examined using a Leica DM LB 2 phase contrast microscope and illustrated with the aid of a drawing tube attachment (*camera lucida*). Line drawings were vectorised, edited and placed into figures using Adobe® Illustrator® CS5. Measurements were taken using the Olympus® BX50 and the procedure previously described. Setae were measured from the centre of their setal bases to their tips. The setal nomenclature used follows Lindquist (1985). Leg setal counts are given in the order: coxa-trochanter-femur-genu-tibia-tarsus. Numbers of setae refer to tactile setae, solenidia are given in parentheses. All measurements are in micrometers and correspond to average followed by minimum and maximum values in parentheses.

Results and discussion

Survey. *Panonychus* species were found in 73 of the sites sampled. Among them, 252 females and 74 males of *P. hadzhibejliae* were collected in 36 collection sites, 52 females and 10 males of *P. ulmi* were recorded in 23 samples, and 37 females and 10 males of *P. citri* were found in 14 samples.

Panonychus hadzhibejliae was only found on *F. carica* whereas *P. ulmi* and *P. citri* were collected on 11 and 5 plants species, respectively. Three new host plants for *P. ulmi* are recorded: *Buxus sempervirens* L., *Hedera colchica* (K. Koch) K. Koch and *Prunus laurocerasus* L. In one collection site *P. citri* was found sympatric with *P. hadzhibejliae*, on *F. carica*, which is a new host plant for this species.

***Panonychus hadzhibejliae*—Georgia:** Qvemo qartli, Tbilisi, Plato Nutsubidze, 41°42.891' N, 44°43.862' E, 6 ♀, 3 ♂, 26.vi.2012, 7 ♀, 2 ♂, 4.vii.2012, 17 ♀, 5 ♂, 25.vii.2012, 13 ♀, 3 ♂, 28.vii.2012, 7 ♀, 2 ♂, 29.vii.2012, 4 ♀, 1 ♂, 1.viii.2012, 19 ♀, 1 ♂, 22.viii.2012, 4 ♀, 4 ♂, 26.viii.2012, 1 ♀, 2.ix.2012, 7 ♀, 12. ix.2012, 9 ♀, 4 ♂, 14.x.2012, Host plant—*F. carica*, coll. E. Kvavadze; Qvemo qartli, Tbilisi, Legvta khevi, 41°40.909' N, 44°47.003' E, 14 ♀, 6 ♂, 3.vii.2006, 2 ♀, 1 ♂, 26.viii.2012, Host plant—*F. carica*, coll. E. Kvavadze. Kakheti, village Vardisubani, 41°55.838' N, 45°26.710' E, 8 ♀, 13.ix.2011; 1 ♀, 3.vi.2012, 10 ♀, 6 ♂, 26.vi. 2012, 6 ♀, 3 ♂, 9.viii.2012, 12 ♀, 4 ♂, 15.x.2013, Host plant—*F. carica* L., coll. T. Arabuli; Kakheti, Lagodekhi, National park, 41°52.147' N, 46°21.570' E, 5 ♀, 1 ♂, 25.ix.2012, Host plant—*F. carica*, coll. T. Arabuli; E. Kvavadze. Kakheti, Lagodekhi, Aghmashenebeli St., 41° 50.154'N, 46° 16.819'E, 3 ♀, 1 ♂, 4.viii.2014, Host plant—*F. carica*, coll. T. Arabuli; Kakheti, Lagodekhi, village Rachisubani, 41° 48.849'N, 46° 17.847'E, 7 ♀, 1 ♂, 4.viii.2014, Host plant—*F. carica*, coll. T. Arabuli; Kakheti, Lagodekhi, village Matsimi, 41°48.064'N, 46° 18.311'E, 14 ♀, 3 ♂, 4.viii.2014, Host plant—*F. carica*, coll. T. Arabuli; Imereti, Chiatura, village Darkveti, 42°32.249' N, 43°32.281' E, 6 ♀, 3 ♂, 24.ix.2011, Host plant—*Ficus carica* L., coll. T. Arabuli; Imereti, Chiatura, village Sveri (West Georgia), 42°13.961' N, 43°18.467' E, 3 ♀, 1 ♂, 26.x.2012, Host plant—*F. carica*, coll. T. Arabuli; Guria, Ozurgeti, village Shua serebi (West Georgia), 41°38.364' N, 42°22.993' E, 7 ♀, 1 ♂, 20.ix.2012, Host plant—*F. carica*, coll. T. Arabuli. E. Kvavadze. Samegrelo, Tsalenjikha, village Chqvaleri, 42°43.673' N, 42°04.906' E, 2 ♀, 4 ♂, 28.x.2012, Host plant—*F. carica*, coll. T. Arabuli; Samegrelo, village Mukhuri, 42°37.132' N, 42°09.846' E, 6 ♀, 5 ♂, 23.ix.2014, Host plant—*F. carica*, coll. T. Arabuli; Adjara, Kobuleti, Dikhagudzuba, 41°51.756' N, 41°47.618' E, 2 ♀, 1 ♂, 19.vi.2005, Host plant—*F. carica*, coll. T. Arabuli. E. Kvavadze; Adjara, village Makhinjauri, 41°40.509' N, 41°41.868' E, 15 ♀, 9.ix.2012, Host plant—*F. carica*, coll. T. Arabuli; Adjara, Mtirala National Park, village-Chakvistavi, 41°40.885' N, 41°51.912' E, 21 ♀, 1.vii.2013, Host plant—*F. carica*, coll. T. Arabuli; Adjara, village Legva, 41° 51.474'N, 41° 56.509'E, 4 ♀, 2 ♂, 14.ix.2014, Host plant—*F. carica*, coll. T. Arabuli; Racha, Ambrolauri, village-Tsesi, 42°32.305' N, 43°12.046' E, 10 ♀, 6 ♂, 22.viii.2014, Host plant—*F. carica*, coll. T. Arabuli.

***Panonychus ulmi*—Georgia:** Qvemo qartli, Tbilisi, Plato Nutsubidze, 41°43.859' N, 44°42.804' E, 1 ♀, 27.vii.2006, 4 ♀, 1.viii.2012, Host plant—*R. canina*, coll. E. Kvavadze; Qvemo qartli, Tbilisi, III massiv, 41°41.278' N, 44°52.496' E, 4 ♀, 1.viii.2012, 5 ♀, 10.viii.2012, 4 ♀, 24.x.2012, 2 ♀, 1 ♂, 1.xi.2012, 11 ♀, 19.xi.2012, Host plant—*S. japonica*, coll. T. Arabuli; Qvemo qartli, Tbilisi, village Lilo, 41°41.908' N, 44°48.791'E, 9 ♀, 4 ♂, 1.viii.2012, Host plant—*Rubus idaeus* L., coll. T. Arabuli; Kakheti, village Vardisubani, 41°55.863' N, 45°26.714' E, 2 ♀, 13.ix.2011, 5 ♀, 15.x.2013, Host plant—*Prunus domestica* L., coll. T. Arabuli; Kakheti, village Vardisubani, 41°55.831' N, 45°26.760' E, 1 ♂, 9.viii.2012, Host plant—*R. idaeus*, coll. T. Arabuli; Mtsketa-Mtianeti, Khevsureti, village Chirdili, 42°92.821' N, 44°06.099'E, 1 ♀, 30.ix.2007, Host plant—*Ulmus foliacea* Gilib., coll. E. Kvavadze; Samegrelo, Kolkheti, Churia, 42°32.471' N, 41°63.736' E, 1 ♀, 17.viii.2009, Host plant—*U. foliacea*, coll. T. Arabuli; Samegrelo, village Mukhuri, 42°37.132' N, 42°09.846' E, 2 ♀, 2.xii.2012, Host plant—*Cydonia oblonga* Mill., coll. T. Arabuli; Samegrelo, Khobi gorge, 42°39.551' N, 42°16.591' E, 3 ♀, 1.x.2009, Host plant—*Castanea sativa* Mill., coll. T. Arabuli; Samegrelo, Tsalenjikha, village Naguli, 42°43.539' N, 42°04.800' E, 1 ♀, 2.xii.2012, New host plant—*B. sempervirens*, coll. T. Arabuli. E. Kvavadze; Guria, Ozurgeti, 41°47.861' N, 42°11.292' E, 1 ♀, 20.ix.2012, New host plant—*H. colchica*, coll. T. Arabuli; Adjara, Mtirala National Park, village Chakvistavi, 41°40.880' N, 41°51.909' E, 7 ♀, 2 ♂, 1.vii.2013, Host plant—*Persica vulgaris* Mill., coll. T. Arabuli; Adjara, Mtirala National Park, 41°40.675' N, 41°51.874' E, 3 ♀, 2 ♂, 1.vii.2013, New host plant—*P. laurocerasus*, coll. T. Arabuli.

***Panonychus citri*—Adjara, village Legva, 41° 51.469'N, 41° 56.508'E, 3 ♀, 2 ♂, 14.ix.2014, Host plant—*C. limon*, coll. T. Arabuli; Adjara, village Legva, 41° 51.465'N, 41° 56.502'E, 4 ♀, 1 ♂, 14.ix.2014, Host plant—*C. nobilis*, coll. T. Arabuli; Adjara, village Legva, 41° 51.474'N, 41° 56.509'E, 9 ♀, 1 ♂, 14.ix.2014, Host plant—*E. angustifolia*, coll. T. Arabuli; Adjara, village-Chakvi, 41° 43.953'N, 41° 44.159'E, 1 ♀, 14.ix.2014, Host plant—*C. nobilis*, coll. T. Arabuli; Adjara, village Makhinjauri, 41°40.661' N, 41°41.864' E, 4 ♀, 2 ♂, 9.ix.2012, Host plant—*C. nobilis*, coll. T. Arabuli; Guria, Ozurgeti, 41°56.208' N, 42°59.337' E, 2 ♀, 1 ♂, 18.ix.2012, Host plant—*E. angustifolia*, coll. T. Arabuli; Guria, Ozurgeti, 41°56.256' N, 42°56.395' E, 11 ♀, 2 ♂, 18.ix.2012, Host plant—**

Citrus trifoliata L., coll. T. Arabuli; Imereti, village kumistavi, 41°22.534' N, 42°35.877' E, 3 ♀, 1 ♂, 30.xii.2012, Host plant—*C. nobilis*, coll. T. Arabuli; Kakheti, Lagodekhi, village Matsimi, 41° 48.064'N, 46° 18.311'E, 3 ♀, 2 ♂, 4.viii.2014, New host plant—*F. carica*, coll. T. Arabuli.

Comparisons between *Panonychus* species. Significant differences between measurements of specimens belonging to the three species collected in the survey were observed for all the characters considered (Table 1). In the multifactorial analysis this results in a clear delineation observed between *P. hadzhibejliae*, *P. ulmi* and *P. citri* specimens (Fig. 1). Results show that three main factors explain most of the variability (86.3%) observed in the 16 characters examined among these three species of *Panonychus*. The first factor that clearly separates *P. hadzhibejliae* from the two other species corresponds to the dorsal setae length (with the exception of setae f_2 , h_1 and the ratio f_2/h_1), the second is length of the leg I and the last one is the ratio su/ω (Fig. 1).

TABLE 1. Comparison of 16 characters for specimens of four *Panonychus* species, showing mean, standard error (SE), ANOVA and Scheffé's test results. Within a line, values sharing a common letter are grouped together by Scheffé's test (v_2 to h_1 are dorsal setae, su and ω are palptarsal eupathidium and solenidion, respectively. Lengths are provided in micrometers).

	<i>P. ulmi</i> (n=20)		<i>P. citri</i> (n=20)		<i>P. hadzhibejliae</i> (n=40)		P	<i>P. caricae</i> ¹
	Mean	SE	Mean	SE	Mean	SE		Mean
v_2	62.4	1.3	b 67.5	1.1	a 57.2	0.7	c <0.0001	55.0
sc_1	187.6	2.0	b 207.4	1.7	a 131.3	1.9	c <0.0001	163.0
sc_2	120.0	1.6	b 129.3	1.5	a 84.5	2.1	c <0.0001	100.0
c_1	188.8	3.0	b 202.5	1.6	a 125.6	2.0	c <0.0001	166.0
c_2	175.0	2.4	b 213.5	2.5	a 123.7	2.5	c <0.0001	158.0
c_3	111.2	2.1	a 115.3	1.0	a 69.9	1.6	b <0.0001	89.0
d_1	180.1	3.0	b 202.0	2.3	a 133.0	1.7	c <0.0001	178.0
d_2	165.3	2.3	b 184.3	2.4	a 125.3	2.1	c <0.0001	169.0
e_1	150.5	3.2	b 168.0	3.0	a 121.1	1.4	c <0.0001	149.0
e_2	147.0	2.5	a 147.8	2.5	a 108.7	1.7	b <0.0001	118.0
f_1	112.0	1.1	a 108.3	1.6	a 82.0	1.3	b <0.0001	87.0
f_2	66.1	1.1	a 39.0	0.3	c 53.2	0.8	b <0.0001	44.0
h_1	43.3	0.4	a 39.1	0.3	b 39.0	0.4	b <0.0001	42.0
f_2/h_1	1.53	0.03	a 0.99	0.00	c 1.36	0.02	b <0.0001	1.05
Leg 1 length	254.3	3.7	b 261.8	2.2	b 287.3	1.4	a <0.0001	-
su/ω ²	1.29	0.02	b 1.18	0.02	c 2.01	0.03	a <0.0001	-

¹data found in the original description by Hatzinikolis (1984).

²10 specimens of each species were available to examine this character.

Generally speaking, if we consider the dorsal setae, from the v_2 to f_1 setae, with one or two possible exceptions, *P. citri* females bear significantly longer dorsal setae than *P. ulmi* females, which also have longer dorsal setae than *P. hadzhibejliae* females (Table 1). In *P. caricae*, dorsal setal length falls between *P. ulmi* and *P. hadzhibejliae*. Among them, the length of setae like sc_1 , c_1 , c_2 , d_1 and d_2 would be the most efficient way to separate *P. hadzhibejliae* from *P. caricae*, as they are to separate *P. hadzhibejliae* from *P. citri* and *P. ulmi*.

The length of the foreleg and the ratio between the terminal eupathidium of the palptarsus su and that of the related solenidion ω show significant differences (Table 1) and allow separation between *P. hadzhibejliae* from *P. citri* and *P. ulmi* (Fig. 1). The difference between the length of su and that of ω was underlined by Reck (1947, 1959) and by Bagdasarian (1957) who used this criterion as a diagnostic character. According to the drawing of the palptarsus of *P. caricae* by Hatzinikolis (1984), su and ω seem to be similar in length. Thus, using this criterion to separate *P. hadzhibejliae* from the three remaining species would be of interest but the quality of mountings and the optical performances of the microscope may affect its efficiency.

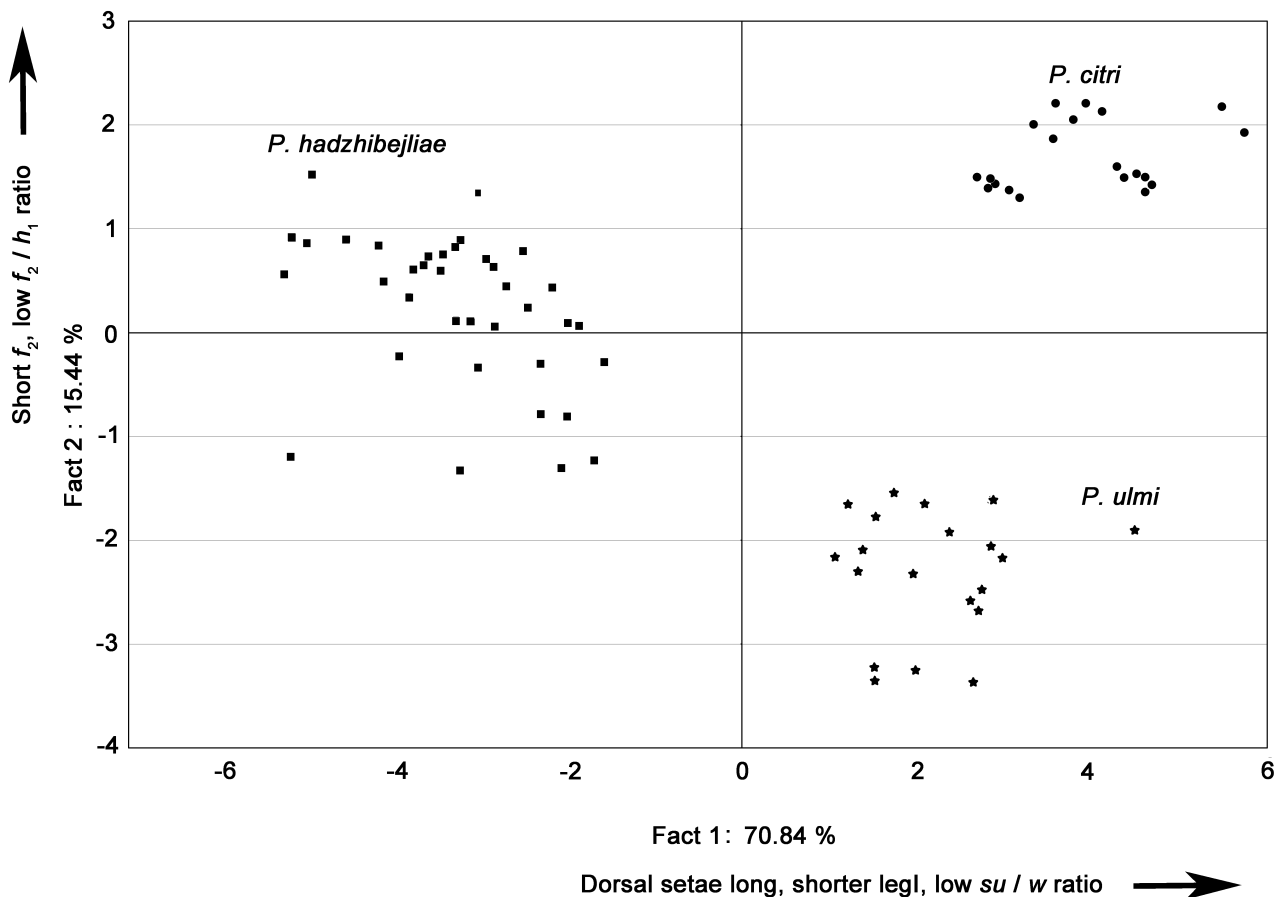


FIGURE 1. Scatter plots of the first two multifactorial axes for 16 morphological characters of *Panonychus hadzhibejliae*, *Panonychus ulmi* and *Panonychus citri*. Percentages in axes refer to the amount of variation accounted for by the first and second axes in the multifactorial analysis.

The second factor of the multifactorial analysis allows a clear distinction of *P. ulmi* from *P. citri* due to differences in f_2 length and to the values of the f_2/h_1 ratio. Using these criteria, *P. hadzhibejliae* is in an intermediate position between *P. ulmi* and *P. citri* (Table 1 and Fig. 2–4). If the value of the ratio f_2/h_1 is significantly different between the three species (Table 1), in practice, it would be of a greater value to distinguish between *P. citri* from both *P. ulmi* and *P. hadzhibejliae* as it was previously used by Reck (1947, 1959). Although no statistical results of this ratio are available for *P. caricae*, the data of Hatzinikolis (1984) show that *P. caricae* is close to *P. citri* (f_2 and h_1 setae similar in length) thus it can be clearly separated from *P. ulmi* and *P. hadzhibejliae* by this criterion (f_2 setae obviously longer than h_1 setae).

The difference in shape of the eupathidium *su* noticed by Reck (1947) is confirmed. In females of *P. hadzhibejliae* it is slightly inflated distally (see description Fig. 12). According to the drawings of Hatzinikolis (1984) this is also the case in *P. caricae*. In the specimens of *P. citri* and *P. ulmi* that we have examined, *su* is not inflated distally. Again, as the examination of this morphological character may be affected by the quality of mountings and by the optical characteristics of the microscope, when few specimens are available, this criterion should be only used to confirm identification after using the more obvious criteria cited above.

Mite redescription

Family Tetranychidae Donnadieu, 1875

Subfamily Tetranychinae Berlese, 1913

Tribe Tetranychini, Reck, 1950

Genus *Panonychus* Yokoyama, 1929

Panonychus hadzhibejliae (Reck, 1947)

(Figures 2, 5–22).

Material examined. The specimens examined for the redescription were collected from *F. carica*: 22 ♀ and 7 ♂ Tbilisi, Nutsubidze; 13 ♀ and 7 ♂ Imereti, Chiatura; 5 ♀ Kakheti, Vardisubani (see survey for detailed information). 18 ♀ and 5 ♂ Tbilisi, Nutsubidze, 10 ♀ and 5 ♂ Imereti, Chiatura, 5 ♀ Kakheti, Vardisubani are deposited in the Institute of Entomology (Arthropods Laboratory), Agricultural University of Georgia; 4 ♀ and 2 ♂ Tbilisi, Nutsubidze, 3 ♀ and 2 ♂ Imereti, Chiatura housed in the collection of the Centre de Biologie et de Gestion des Populations UMR CBGP (INRA / IRD / CIRAD / Montpellier SupAgro) France.

Female (N=40): Body colour and dorsal tubercles dark red, body oval, strongly inflated, 425 (380–460) long including gnathosoma, 315 (300–350) wide.

Dorsum. Dorsum with 13 pairs of setae, prodorsum bearing 3 pairs, opisthosoma 10 pairs. All dorsal body setae stout, spiculate, roughly pubescent, tapering to tip, inserted on strong tubercles, well exceeding base of seta next behind, d_1 longest, h_1 shortest (Figs. 5,7). Outer sacral setae f_2 stouter and longer than caudal setae h_1 (Fig. 2). Length of body setae: v_2 57 (50–62); sc_1 131 (120–145); sc_2 84 (75–95); c_1 126 (112–140); c_2 124 (115–140); c_3 70 (60–85); d_1 133 (115–150); d_2 125 (105–140); e_1 121 (110–135); e_2 109 (95–130); f_1 82 (70–90); f_2 53 (50–62); h_1 39 (35–42).

Propodosomal striation mostly longitudinal. **Hysterosomal striation** transverse between horizontal rows of setae, longitudinal between setae of same horizontal row, except between setae e_1 and f_1 bases, irregular forming sometimes a diamond-shaped like pattern between these setae. Striation longitudinal laterally. Lobes on hysterosomal striation appear small, poorly developed, difficult to see, triangularly rounded to rounded when fully visible (Fig. 6)

Gnathosoma. Stylophore longer than broad, slightly notched anteriorly, 100 (95–110) long, 75 (72–78) wide. Palptarsus solenidion ω 2.5–3 long, two times shorter than terminal eupathidium su (5–6), su almost 2 times longer than broad, distal part slightly inflated, about 4 in width, wider than base 2.5 (Figs. 11–12). Eupathidium ul'' 9.5 (9–10) longer than ul' , 7.6 (7–8). Peritreme straight, ending in simple bulb, small variations may occur (Fig. 13).

Venter. Medioventral lobes on striation present, more or less obvious in some specimens, rare or absent between setae $1a$ and $4a$, obvious and more developed laterally. Area immediately anterior to genital flap with irregular striae becoming longitudinal anteriorly (Fig. 14). Two pairs of ventrocaudal ($h_{2,3}$) setae (para-anals) and pseudanal ($ps_{1,2}$) setae (anals).

Legs. Empodia I–IV clawlike with 3 pairs of proximoventral hairs (Fig. 10). Leg setal counts as follows:

I 2 – 1 – 8 – 5 – 7 + (1) – 12 + (1) + 2 duplexes

II 2 – 1 – 6 – 5 – 5 – 11 + (1) + 1 duplex

III 1 – 1 – 3 – 3 – 5 – 9 + (1)

IV 1 – 1 – 1 – 3 – 5 – 9 + (1)

Solenidion of distal member of duplex of tarsus I (ω'') 67 (64–70) more than twice as long as solenidion of proximal duplex (ω') 28 (27–29) (Fig. 8). Fastigial seta fi'' 10 (9–11), shorter than fi' 13 (12–14), fi'' about half length ω' . Tarsus I with 3 tactile setae and 1 solenidion proximal to proximal duplex setae, dorsolateral solenidion (ω''_1) 23 (22–24) slightly shorter than distance between its base and that of proximal duplex.

Length of first leg (femur to tarsus) 287 (275–300), tarsus I 94 (87–95), tibia I 50 (47–52), genu I 44 (42–47); femur I 93 (87–95); Leg II 225 (215–230), leg III 237 (225–250), leg IV 245 (237–262).

Male (N=14): body 372 (330–420) long including gnathosoma, 183 (177–192) wide. Colour in life deep red. **Dorsum.** All dorsal body setae as in females, arising from strong tubercles: v_2 49 (42–56); sc_1 82 (66–103); sc_2 71 (57–82); c_1 75 (58–92); c_2 88 (70–103); c_3 61 (47–78); d_1 78 (64–93); d_2 89 (70–106); e_1 56 (41–67); e_2 64 (50–75); f_1 37 (30–43); f_2 31 (25–37); h_1 23 (19–30)

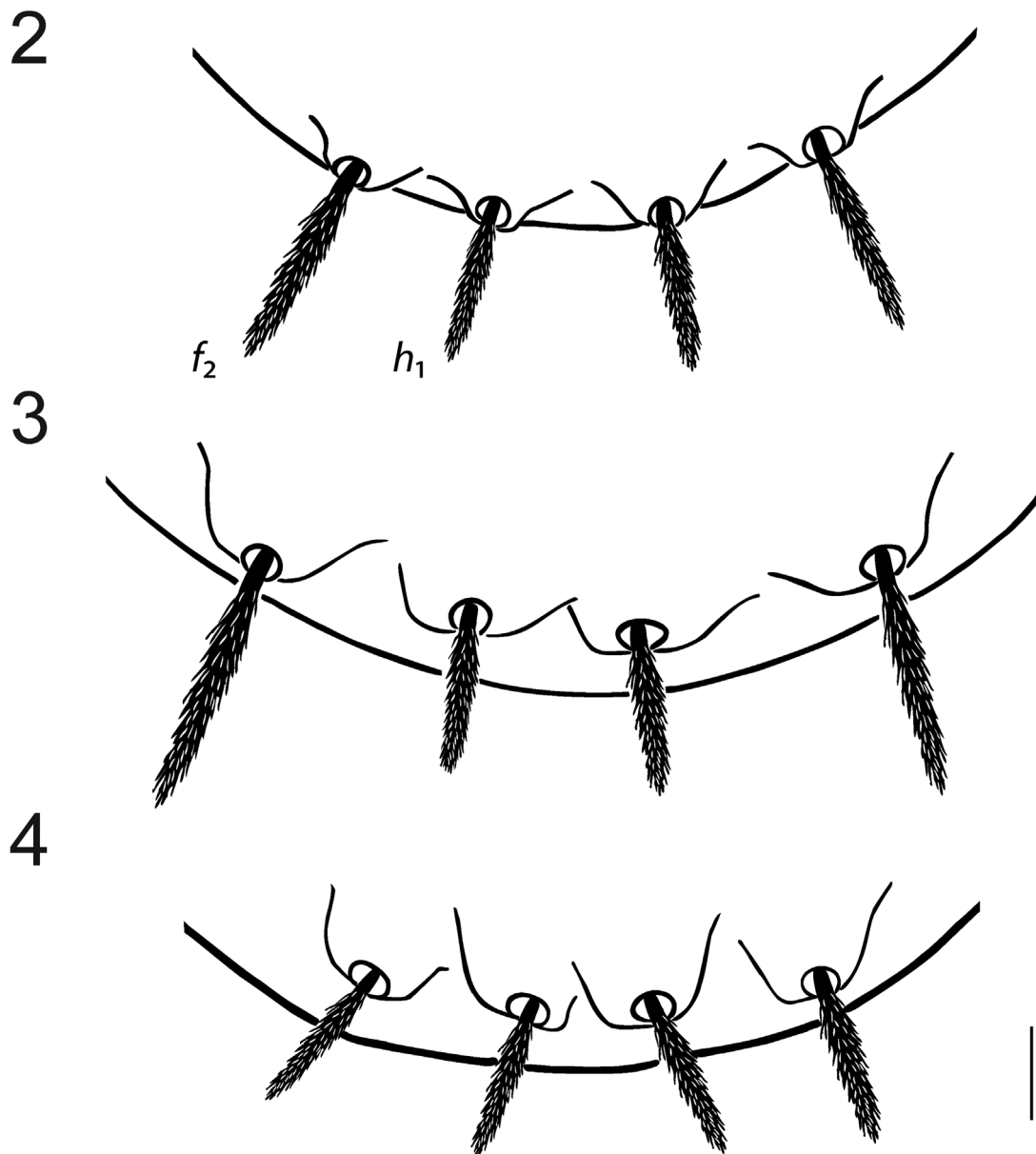
Gnathosoma. Stylophore notched anteriorly, 75 (78–70) long, 54 (55–53) wide; eupathidium su about 2.5 times longer than broad, 3.9 (3.5–4.5) long, 1.7 (1.5–1.8) wide, narrowed distally, slightly longer than palptarsal

solenidium ω 3.5 (3–4). Eupathidium ul'' 7.4 (7–8) longer than ul' , 5.6 (5–6.5) (Fig. 20). Peritreme as in female (Fig. 21).

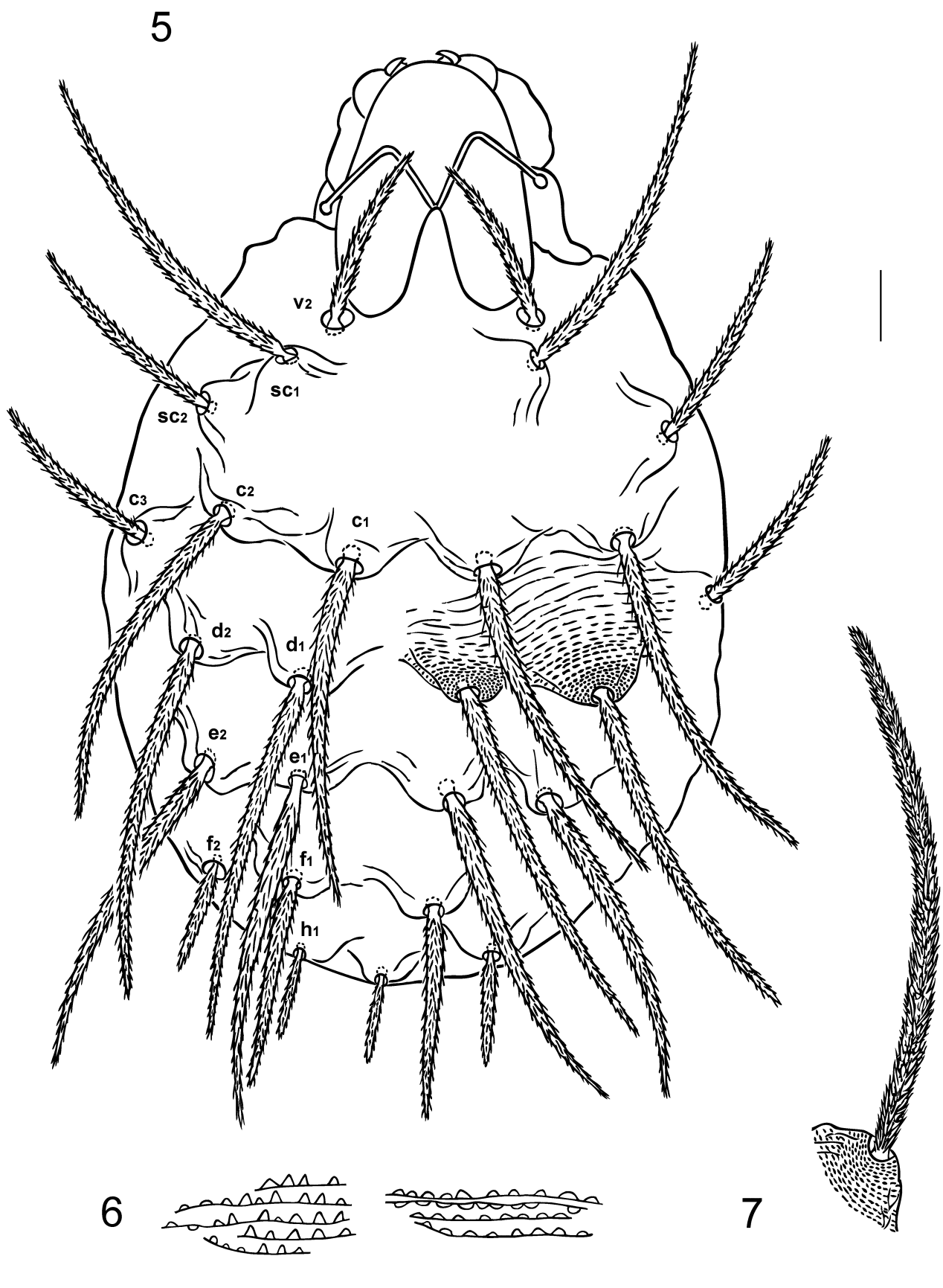
Venter. Ventral striae without lobes.

Legs. Empodia clawlike with 3 pairs of proximoventral hairs increasing in length with the rank of the leg between leg I and leg III (Figs. 17–19). Leg setal counts as follows:

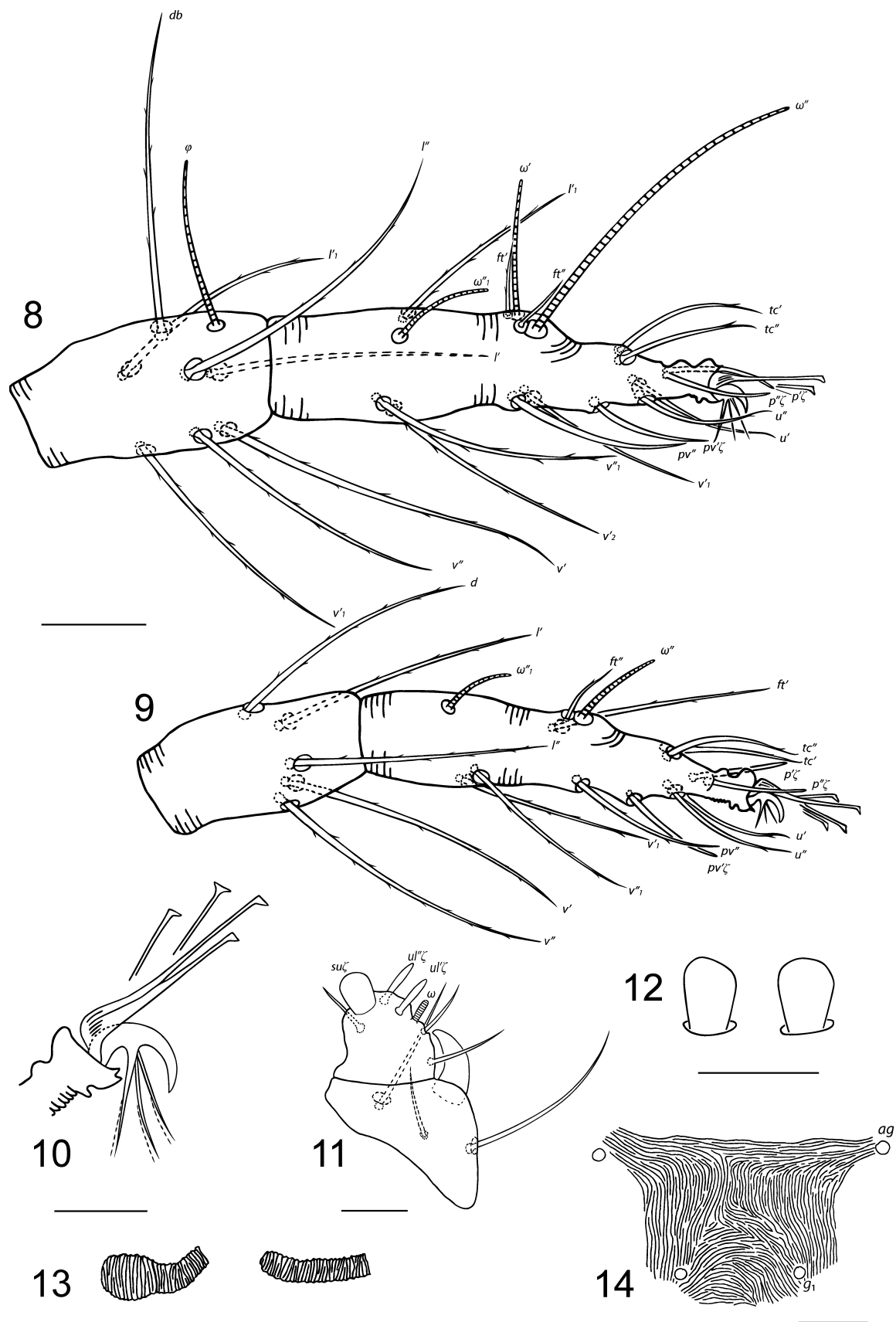
- | | |
|-----|---|
| I | 2 – 1 – 8 – 5 – 7 + (4) – 12 + (3) + 2 duplexes |
| II | 2 – 1 – 6 – 5 – 5 – 11 + (1) + 1 duplex |
| III | 1 – 1 – 3 – 3 – 5 – 9 + (1) |
| IV | 1 – 1 – 1 – 3 – 5 – 9 + (1) |



FIGURES 2–4. Dorsohysterosomal caudal parts in three *Panonychus* species showing f_2 and h_1 setae. 2, *Panonychus hadzhibejliae*; 3, *Panonychus ulmi*; 4, *Panonychus citri*. Scale bar = 20 μ m (2–4).



FIGURES 5–7. *Panonychus hadzhibejliae*, female. 5, dorsal aspect; 6, lobes on dorsohysterosomal striae; 7, dorsal body seta (sc_1). Scale bars = 25 μm (5), 10 μm (6), 20 μm (7).



FIGURES 8–14. *Panonychus hadzhibejliae*, female. 8, tarsus and tibia I; 9, tarsus and tibia II; 10, empodium and claws; 11, palpal tibia and tarsus; 12, variations in *su* eupathidium; 13, peritremal distal part; 14, anterogenital area. Scale bars = 20 μ m (8, 9, 14), 10 μ m (10–13).

Solenidion of distal member of duplex of tarsus I (ω'') 59 (55–64) about twice as long as solenidion of proximal duplex (ω') 33 (30–37) (Fig. 15). Fastigial seta ft'' short 8.5 (7–10), half length of ft' 17 (15–19). Tarsus I with 3 tactile setae and 3 solenidia proximal to proximal duplex setae, dorsolateral distal solenidion (ω''_1) 25.5 (24–27) longer than distance between its base and that of proximal duplex. On leg II, solenidion of duplex (ω'') 23 (21–25) twice as long as ft'' 11.5 (11–13) (Fig. 16).

Length of the first leg (tarsus to femur): 293 (278–309), tarsus I 96 (90–104), tibia I 54 (57–48), genu I 45 (41–50); femur I 98 (92–105); Leg II 229 (223–243), leg III 237 (225–250), leg IV 255 (245–265).

Aedeagus. Aedeagus without distinct knob, bent dorsad near at right angle to dorsal margin of shaft, weakly sigmoid, with tapering distal part and acute tip pointing caudad (Fig. 22).

Discussion

There is no doubt that *P. hadzhibejliae* is a valid species. The lack of detailed data in the original description made its status doubtful despite some criteria that were provided to separate it from *P. citri* and *P. ulmi*. Indeed, as the leg chaetotaxy and the shape of the aedeagus does not allow to the separation of *P. hadzhibejliae* from its closely related species, the new data provided in this redescription and the comparison of some characters have filled this gap. This is particularly the case of the dorsal setae lengths, complemented by the drawing *in habitus* that allows us to clearly distinguish this species from the three other closely related species. The taxonomical value of the ratio su/ω used by Reck (1947, 1959) to distinguish between *P. hadzhibejliae* from both *P. citri* and *P. ulmi* is confirmed, and it is linked to other characters that obviously differ between these three species.

Panonychus hadzhibejliae was previously only known from the Kakheti region where it was described in Georgia. Our survey shows that this species is present in all the regions of Georgia, not only from the type locality, which is congruent with its current known distribution that includes Armenia and Azerbaijan (Mitrofanov *et al.* 1987).

Key to the world species of *Panonychus**

- 1 Dorsohysterosomal setae not set on tubercles. 2
- Dorsohysterosomal setae set on obvious tubercles. 3
- 2 Male tarsus II with 1 tactile seta and 1 solenidion proximal to duplex setae; aedeagus dorsal margin of the shaft with a prominent process, distal upward part poorly developed, not sigmoid, ending in a round tip (on Bamboo, *Sasa chartacea*; Japan). *P. pusillus* (Ehara & Gotoh, 1987)
- Male tarsus II with 3 tactile setae and 1 solenidion proximal to duplex setae; aedeagus distal upward part short, slightly sigmoid with truncate tip (on Bamboo, *Sasa senanensis*; Japan) *P. akitanus* Ehara, 1978
- 3 Aedeagus with a ball-shaped knob (on *Achyranthes aspera*, *Vitis* sp.; Taiwan). *P. globosus* Tseng, 1974
- Aedeagus without terminal knob. 4
- 4 Aedeagus distal portion not undulate, bent up and forward 5
- Aedeagus distal portion undulate, bent posteriorly 6
- 5 Tip of the aedeagus bent forward; female duplex setae on tarsus II with proximal tactile member shorter than distal associated solenidion (on *Malus domestica* cv. Delicious de Viscas; Peru). *P. inca* De Vis & De Moraes, 2002
- Tip of the aedeagus not bent forward; female duplex setae on tarsus II with proximal tactile member more or less longer than distal associated solenidion (on *Ulmus davidiana*; Japan). *P. thelytokus* Ehara & Gotoh, 1992
- 6 Genua I and II with 4 tactile setae, genu III with 2 tactile setae (on bamboo, *Sasa borealis* and *Sasa senanensis*; Japan). *P. bambusicola* Ehara & Gotoh, 1991
- Genua I and II with 5 tactile setae, genu III with 3 tactile setae. 7
- 7 Genu IV with 2 tactile setae (on Compositae, Cucurbitaceae, Leguminosae, Malvaceae, Moraceae, Rosaceae and Urticaceae; Brazil, China, Japan, Tawan & USA). *P. caglei* Mellot, 1968
- Genu IV with 3 tactile setae 8
- 8 Female dorsohysterosomal setae f_2 and h_1 similar in length 9
- Female dorsohysterosomal setae f_2 obviously longer than h_1 13
- 9 Female dorsohysterosomal setae c_3 more than 100 μ m long, ratio c_1/h_1 about 5 or more. 10
- Female dorsohysterosomal setae c_3 less than 100 μ m long, ratio c_1/h_1 about 4 (on *Ficus carica*; Greece). *P. caricae* Hatzinikolis, 1984
- 10 Aedeagus stout, sigmoid distal part about as long as dorsal margin of the shaft (on some Cannabaceae, Menispermaceae, Moraceae and Rosaceae; Iran & Japan) *P. mori* Yokoyama, 1929

- Aedeagus with sigmoid distal part thinner, longer than dorsal margin of the shaft 11
- 11 Aedeagus with sigmoid distal part thin and long, about twice as long as dorsal margin of the shaft (on Caricaceae, Leguminosae, Meliaceae, Menispermaceae, Moraceae, Oleaceae, Passifloraceae, Rosaceae, Rutaceae and Taxaceae; Australia, China, Myanmar, Papua New Guinea, Taiwan & Thailand) *P. elongatus* McGregor, 1916
- Aedeagus with sigmoid distal part about 1.5 times as long as dorsal margin of the shaft 12
- 12 Aedeagus turns upward at an angle about 50° to the ventral margin of the shaft; female dorsal seta e_2 noticeably shorter than e_1 , ratio between female dorsal setae sc_1 and f_2 about 6 (on *Osmanthus*; China and Japan). *P. osmanthi* Ehara & Gotoh, 1996
- Aedeagus turns upward at an angle between 67-78° to the ventral margin of the shaft; female dorsal seta e_2 approximately as long as e_1 , ratio between female dorsal setae sc_1 and f_2 about 5 (on various hosts; worldwide distribution)
..... *P. citri* (McGregor, 1916)
- 13 Female dorsohysterosomal setae not arch-shaped (on *Malus domestica*; Taiwan). *P. lishanensis* Tseng, 1990
- Female dorsohysterosomal setae arch-shaped. 14
- 14 Female dorsohysterosomal setae c_3 less than 100 µm long, ratio c_1/h_1 about 3, palptarsal eupathidium *su* about twice as long as related solenidion ω (on *Ficus carica*; Armenia, Azerbaijan & Georgia) *P. hadzhibejliae* (Reck, 1947)
- Female dorsohysterosomal setae c_3 more than 100 µm long, ratio c_1/h_1 greater than 4, *su* as long as related solenidion ω (on various hosts; worldwide distribution). *P. ulmi* (Koch, 1836)

* *Panonychus spinigerus* (Lucas, 1849) was not included in the key because its assignation to the genus *Panonychus* is questionable. In our opinion, unlike Oudemans (1931) and Bolland *et al.* (1998), this species does not belong to this genus. Indeed, in the original description, several important data that are mentioned lead us to that conclusion: i) according to Lucas (1849), this species can be separated from *T. lintearius* Dufour, 1832 by the number of its (dorsal?) body setae, which are in greater number in *P. spinigerus*; ii) the same author also separated *T. lintearius* from *P. spinigerus* using the size and the shape of the legs and the size, the colour and the arrangement of leg setae: in *T. lintearius* the legs are stout whereas they are thin, long (= spindly) and bear shorter, thinner and narrower (the meaning may be more dense) yellow setae in *P. spinigerus*; iii) in *P. spinigerus* the female body colour is dark yellow. In the drawing *in habitus* of this species by Lucas (1849), despite a slightly unusual pattern in the dorsal setal arrangement, 12 pairs of dorsal body setae are represented (the drawing suggests that the h_1 setae may be in a ventral position so that they are not visible). Thus the number of dorsal setae seems to fit with that found in *Tetranychini*, which is conflicting with the text of the description of *P. spinigerus* (see i). Nevertheless, this drawing confirms that the legs are long, the forelegs being as long as or slightly longer than the body. This character does not fit with the genus *Panonychus*, and neither does the dark yellow body colour. Moreover, the result of the comparison by Lucas of the leg setae appearance in *P. spinigerus* with those of *T. lintearius* is surprising because the leg setae of *Panonychus* are not more dense or thinner than in *Tetranychus*. This also confirms that this species would not belong to the genus *Panonychus*. Therefore, we consider the species *Panonychus spinigerus* (Lucas, 1849) to be *incertae sedis*.

Acknowledgements

The first author would like to thank the Georgian National Foundation (SRNSF), which financed the study of *Panonychus* species. Anastasia Tsagkarakou (NAGREF, Heraklion, Greece) is deeply acknowledged for her attempts (unfortunately unsuccessful) to find the type specimens of *P. caricae* and to collect some specimens of this species in type localities.

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