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First Record of *Petrobia* (*Tetranychina*) *harti* (Ewing, 1909) (Acari: Tetranychidae) in Serbia, with Additional Remarks

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Abstract

The species *Petrobia* (*Tetranychina*) *harti* (Ewing, 1909) is reported for the first time in Serbia, also representing the first record of the tribe Petrobiini Reck, 1952 in the country. Including this finding, the number of spider mite species recorded in Serbia now totals 45. This spider mite species was found exclusively on wood-sorrel plants, *Oxalis corniculata* L. and *O. articulata* Savigny., at several localities in the cities of Belgrade and Zrenjanin. The samples were collected during the growing season of 2018 and 2023. Identification of the oxalis mite was based on morphological characteristics. To date, the occurrence of *P.* (*T.*) *harti* on other host plants has not been confirmed anywhere in Serbia. On the observed wood-sorrel plants, *P.* (*T.*) *harti* was recorded in cohabitation only with *Tetranychus urticae* Koch, 1836.

Keywords: oxalis spider mites; Petrobiini; *Oxalis corniculata*; *Oxalis articulata*

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1. Introduction

Spider mites are obligate phytophages that feed on a wide range of 4.105 plant species, including most cultivated crops. They represent the most important group of pest mites in agriculture, forestry, and horticulture. The family Tetranychidae currently comprises 1.362 valid species. Within this family, the subfamily Bryobiinae Berlese, 1913, includes 406 species, of which 156 are classified in the tribe Bryobiini Reck, 1952; 194 species in the tribe Hystrichonychini Pritchard and Baker, 1955; and 56 species in the tribe Petrobiini Reck, 1952. Within the latter tribe, the genus *Petrobia* (Murray, 1877) comprises 44 species grouped into three subgenera: *Mesotetranychus* Reck, 1948, *Petrobia* Murray, 1877, and *Tetranychina* Wainstein, 1960 [1]. The subgenus *Tetranychina* includes 15 species, of which only three are recorded in Europe [ibid].

Research on spider mites in Serbia has led to a total of 44 species from 9 genera being identified so far. Within the subfamily Bryobiinae, 11 species of the genus *Bryobia* Koch 1936 from the tribe Bryobiini have been recorded, along with 1 species of the genus *Tetranycopsis* Canestrini 1889 from the tribe Hystrichonychini, while no species from the tribe Petrobiini have been documented [2–5].

Considering the known distribution of all species within the tribe Petrobiini, it has been established that the vast majority of species have not yet been recorded in Europe [1].

Petrobia (*Tetranychina*) *harti* (Ewing 1909) has so far been found in 38 countries of the Afrotropical, Australasian, Nearctic, Neotropical, Oriental and Palearctic realms, occurring on 47 host plant species belonging to 18 families, most frequently on members of the family *Oxalidaceae* [1]. It inhabits both cultivated and spontaneous herbaceous plants, and, to a

lesser extent, fruit and ornamental broadleaved plants, while records from grasses and conifers are rare [ibid.].

In Europe, this species was first recorded in Greece [6], followed by Portugal [7], Spain [8], Italy [9], France [10], Bulgaria [11] and Hungary [12]. Most European records are from plants of the family *Oxalidaceae*, particularly *Oxalis corniculata* L., followed by *O. articulate* Savign., *O. pes-caprae* L., *O. triangularis* A.St.-Hil, *Oxalis* sp. while individual findings were recorded on *Medicago sativa* L. and *Trifolium* sp. (Fabaceae), *Vitis vinifera* L. (Vitaceae), *Pennisetum longistylum* Hochst, ex A. Rich and *Digitaria sanguinalis* (L.) Scop. (Poaceae), *Citrus maxima* (Burm.) Merr. (Rutaceae), *Fragaria* spp. (Rosaceae), as well as weeds in greenhouses [6–17].

When present in large numbers, *P.* (*T.*) *harti*, causes deformation and discoloration of leaves, leading to reduced plant growth [18]. This phytophagous mites has been recorded as a serious pest of lawns and gardens [19]. However, its impact on cultivated plants in Europe has not yet been investigated.

The aim of this study was to confirm the occurrence of *P.* (T.) *harti* on plants of the genus *Oxalis,* to examine its dispersion on neighbouring herbaceous plants, and to assess the potential impact of this species on agriculture or ecosystems.

2. Materials and Methods

The present study was conducted in 2018 and 2023. Sampling included 23 herbaceous plant species from 14 plant families (Table 1) at several localities (Table 2).

Table 1. Plant species and number of samples.

No. of Plant Species	Plant Species	Family	No. of Samples
1	*Amaranthus retroflexus*	Amaranthaceae	1
2	*Ambrosia artemisiifolia*	Asteraceae	3
3	*Artemisia vulgaris*	Asteraceae	4
4	*Ballota nigra*	Lamiaceae	3
5	*Chenopodium album*	Chenopodiaceae	1
6	*Cichorium intybus*	Asteraceae	4
7	*Cirsium arvense*	Asteraceae	7
8	*Convolvulus arvensis*	Convolvulaceae	2
9	*Daucus carota*	Apiaceae	3
10	*Euphorbia cyparissias*	Euphorbiaceae	2
11	*Euphorbia salicifolia*	Euphorbiaceae	1
12	*Lamium purpureum*	Lamiaceae	2
13	*Lotus corniculatus*	Fabaceae	2
14	*Malva sylvestris*	Malvaceae	2
15	*Matricaria inodora*	Asteraceae	1
16	*Oxalis articulata*	Oxalidaceae	3
17	*Oxalis corniculata*	Oxalidaceae	8
18	*Plantago lanceolata*	Plantaginaceae	3
19	*Polygonum aviculare*	Polygonaceae	8
20	*Potentilla reptans*	Rosaceae	4
21	*Stellaria media*	Caryophyllaceae	8
22	*Taraxacum officinale*	Asteraceae	8
23	*Trifolium repens*	Fabaceae	5
	Total		85

Table 2. Sampling locations and records of *Petrobia* (*Tetranychina*) *harti* on plants.

Location	Date	Plants Species	No. of Stages of *P.* (*T.*) *harti*		
			F	M	N
Belgrade, Zemun 44°50′23″ N, 20°24′45″ E	26 April 2018	16 (*Oxalis articulata*)	4	4	3
		17 (*Oxalis corniculata*)	12	7	8
		4, 7, 8, 9, 12, 18, 19, 20, 21	/	/	/
	5 November 2023	16 (*Oxalis articulata*)	10	8	10
		17 (*Oxalis corniculata*)	21	17	21
		6, 7, 8, 19, 20, 21, 22	/	/	/
Belgrade, Novi Beograd 44°49′32″ N, 20°22′51″ E	20 August 2023	17 (*Oxalis corniculata*)	9	5	6
		4, 7, 9, 14, 19, 20, 21, 22, 23	/	/	/
Belgrade, Zemun 44°50′26″ N, 20°24′41″ E	19 August 2023	17 (*Oxalis corniculata*)	10	4	9
		3, 4, 7, 21, 22, 23	/	/	/
Belgrade, Zemun 44°50′20″ N, 20°24′45″ E	18 August 2023	17 (*Oxalis corniculata*)	4	1	5
		19, 20	/	/	/
Belgrade, Novi Beograd 44°49′24″ N, 20°23′56″ E	18 August 2023	17 (*Oxalis corniculata*)	16	9	15
		2, 3, 6, 7, 10, 11, 13, 18, 19, 20, 21, 22	/	/	/
Belgrade, Čukarica 44°46′44″ N, 20°24′23″ E	20 August 2023	17 (*Oxalis corniculata*)	6	2	4
		2, 3, 7, 9, 19, 20, 21, 22	/	/	/
Zrenjanin, Bagljaš 45°22′49″ N, 20°22′21″ E	22 August 2023	17 (*Oxalis corniculata*)	7	2	2
		2, 5, 6, 7, 12, 13, 15, 19, 20, 22, 23	/	/	/
Belgrade, Borča 44°52′43″ N, 20°29′18″ E	18 August 2023	16 (*Oxalis articulata*)	6	2	3
		1, 3, 6, 10, 14, 19, 20, 21, 22	/	/	/

Species of the genus *Oxalis* were sampled purposefully and other listed herbaceous plants were collected in their immediate vicinity. Of the total 23 plant species sampled, only two belonged to the genus *Oxalis*. Samples of *Oxalis* species accounted for 13% of the total number of samples.

In urban areas, *O. corniculata* and *O. articulata* grow particularly successfully in sites where many plant species fail to survive, such as cracks in the asphalt, gaps in concrete near building foundations, neglected street planters, and greenhouse floors.

To detect the presence of *P.* (*T.*) *harti*, samples of *O. corniculata* and *O. articulata* were collected once at each location. Additional samples of herbaceous plant were also collected once at each location within a 3 m radius of the infested *Oxalis* plants to assess the potential spread of *P.* (*T.*) *harti* to other host plants. Several years of regular inspections in two greenhouses provided no evidence of *P.* (*T.*) *harti* spreading on indoor-grown plants. Therefore, in both cases, samples were collected only from the area around the greenhouse.

Plant samples were collected by cutting off the entire aerial part and placing them in nylon bags. Sample size varied depending on the number and biomass of the selected plants at each site. The collected plant samples were transported to the Laboratory of the Department of Entomology and Agricultural Zoology, Faculty of Agriculture, University of Belgrade. All samples were subjected to 30 min of etherization with ethyl acetate immediately before examination to immobilize the mites. Each sample was examined either directly under a Leica Wild M3Z stereo microscope or after shaking the large samples in a Petri dish. All collected mites were subsequently placed in a clearing fixative, consisting of a mixture 1:5 of lactic acid (88%) and ethanol (70%). Permanent mounts were prepared in Heinze's medium [20] and deposited in the collection of the Department of Entomology and Agricultural Zoology.

Mites were examined using an Olympus BX53 microscope, equipped with the software package for measuring and photographing, Imaging Software cellSens Entry 2 (CS-EN-V2). Identification was performed using several keys for the family Tetranychidae [21–26] and additional studies providing valuable keys and redescriptions of *Perobia* species [19,27–30]. The catalogue and global database of spider mites were also consulted to verify species distribution [1,31].

Microscopic measurements of selected morphological characters were performed on 10 female and 10 male specimens of *P.* (*T.*) *harti*. The parameters measured included body length and width, dorsal setae length, length of legs I-IV, relative ratios of leg lengths I-IV, and the length of individual joints of leg I (tarsus, tibia, genu, femur and trochanter). The relative length of these segments was determined relative to the length of leg I. The obtained values of the selected morphological characters were compared with those reported in the literature [27,29].

3. Results

In all samples of *O. corniculata* and *O. articulate,* active colonies of *P.* (*T.*) *harti* were found, including all developmental stages: eggs, larvae, nymphs, and adults (Figure 1). A total of 105 females, 65 males, and 86 nymphs were collected (Table 2), along with numerous larvae and eggs. The only exception was a sample of *O. articulata*, where only recognizable exuviae of *P.* (*T.*) *harti* and typical damage symptoms on the leaves were observed. This species was active on the underside of the leaf, where feeding causes distinct chlorotic spots that later merged (Figure 2). Leaf discoloration was diffuse in milder infestations and extensive in severe ones. Due to loss of turgor, leaves were sometimes slightly deformed.

Figure 1. *Petrobia* (*Tetranychina*) *harti*—active life stages (larvae, nymphs and adults) and eggs.

In only two samples of *O. corniculata*, from a greenhouse and a garden, sporadic individuals of *Tetranychus urticae* Koch 1836 were found in cohabiting with *P.* (*T.*) *harti*, without any web and eggs, probably dispersed by air currents.

P. (*T.*) *harti* was not recorded on any of the 21 other herbaceous plant species liosted above (Table 2).

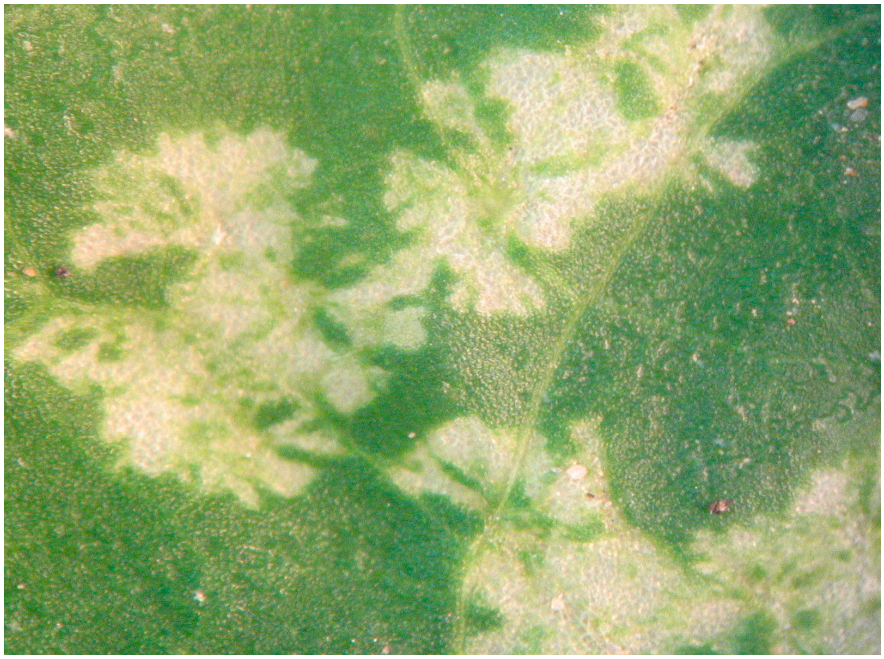

Figure 2. *Petrobia* (*Tetranychina*) *harti*—typical damage symptoms on the leaves of *Oxalis*, merging chlorotic spots.

The female of *Petrobia* (*T.*) *harti* (Figure 3) can be recognized by the following characters: dorsal setae borne on strong tubercles (Figure 4); dorsocentral setae slender and approximately three times as long as the distance between their bases; tubercles of dorsocentral setae c1, d1 and e1 separated; dorsal opisthosomal setae longer than the longitudinal distances between bases of consecutive setae, setae v2, sc2, c3, and h1 shorter than the remaining dorsal setae; and a smooth, anteriorly rounded stylophore.

Figure 3. *Petrobia* (*Tetranychina*) *harti*—Female, lateral view.

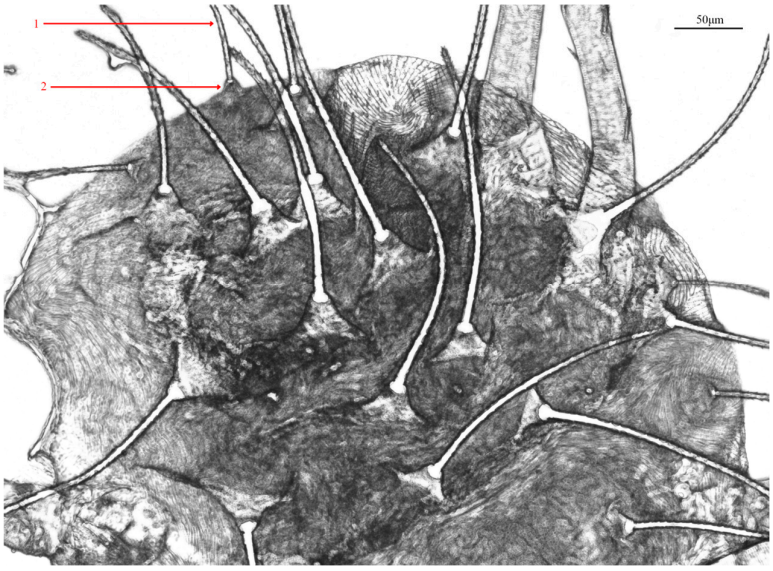

Figure 4. *Petrobia* (*Tetranychina*) *harti*—Female, 1-dorsal seta, 2-strong tubercle.

The male (Figure 5) can be recognized by dorsal setae borne on small tubercles, usually shorter than the distance between their bases. The setae *c1* are longer than the subsequent pairs of dorsocentral setae. Dorsal setae are much shorter and broader than those of the female. The aedeagus (Figure 6) is lanceolate, gradually tapering, and further narrowed at the tip.

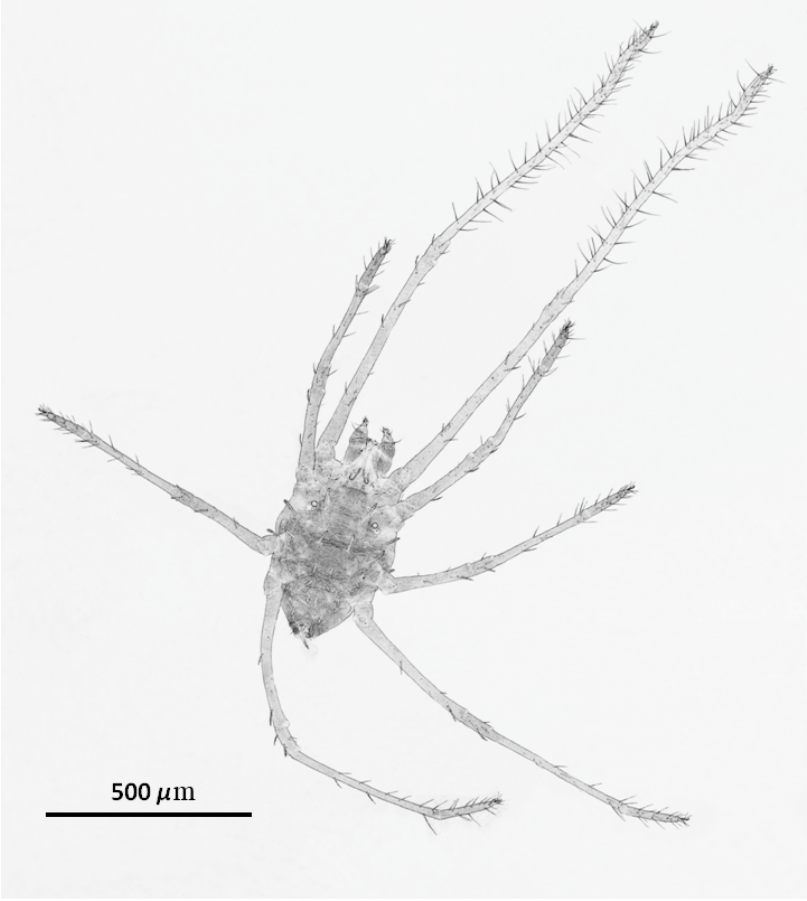

Figure 5. *Petrobia* (*Tetranychina*) *harti*—Male, dorsal view.

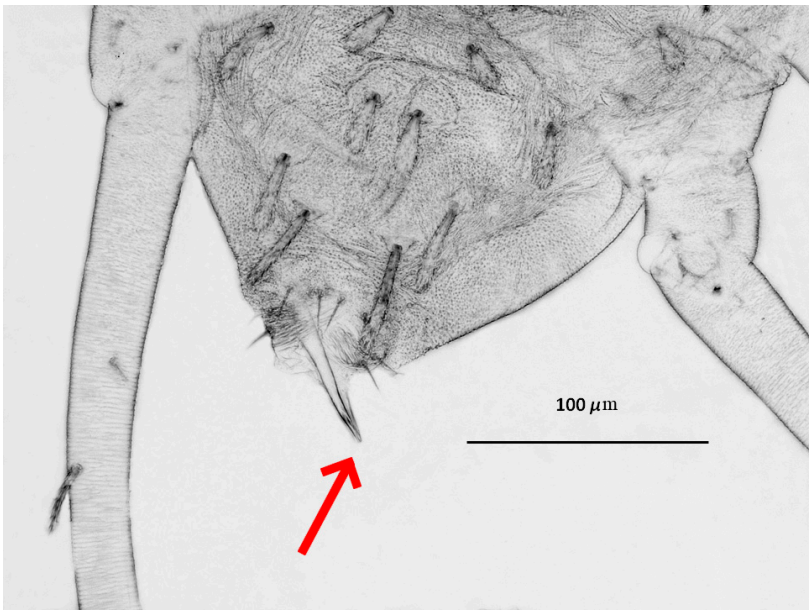

Figure 6. *Petrobia* (*Tetranychina*) *harti*—Male, aedeagus.

The morphological characteristics and their measurements of the identified species *P.* (*T.*) *harti* (Table 3) are consistent with the morphology of the subgenus *Petrobia* (*Tetranychina*), which is characterized by the presence of three pairs of prodorsal bristles and ten pairs of opisthosomal bristles, all or some situated on prominent tubercles; true pad-like claws with one pair of tentacle hairs; legs I and IV very long; tarsus I (Figure 7) with two pairs of duplex setae and uncinate empodia with two ventral rows of tenent hairs; peritremes that may be simple or distally hooked.

Table 3. Results of measuring the morphological characters of *Petrobia* (*Tetranychina*) *harti*.

Measured Morphological Characters (μm)	Females			Males		
	Min	Max	M ± SD	Min	Max	M ± SD
body length	383.85	672.25	584.08 ± 99.62	337.42	448.64	408.46 ± 32.58
body width	237.14	517.81	418.60 ± 97.72	214.68	266.42	245.75 ± 19.46
length of leg I	1083.07	1392.21	1244.88 ± 88.07	1117.78	1267.46	1203.25 ± 48.43
length of tarsus I	155.48	191.65	176.40 ± 9.93	162.01	181.28	171.67 ± 7.39
length of tibia I	441.76	547.45	498.54 ± 37.81	456.09	527.64	485.50 ± 25.09
length of genu I	50.84	66.44	58.79 ± 5.19	44.44	60.27	51.97 ± 5.62
length of femur I	384.13	523.22	478.07 ± 41.19	423.41	504.52	465.63 ± 132.19
length of trochanter I	37.92	55.77	46.21 ± 6.76	27.59	36.10	31.27 ± 2.88
length of leg II	419.59	615.45	534.84 ± 53.83	513.38	595.74	539.47 ± 24.87
length of leg III	469.00	675.95	596.31 ± 67.87	502.77	621.43	575.66 ± 122.09
length of leg IV	821.18	1043.91	932.31 ± 77.99	769.84	928.87	862.68 ± 42.50
the proportion of the leg pairs I:II:III:IV	1:0.43:0.48:0.69			1:0.45:0.48:0.72		

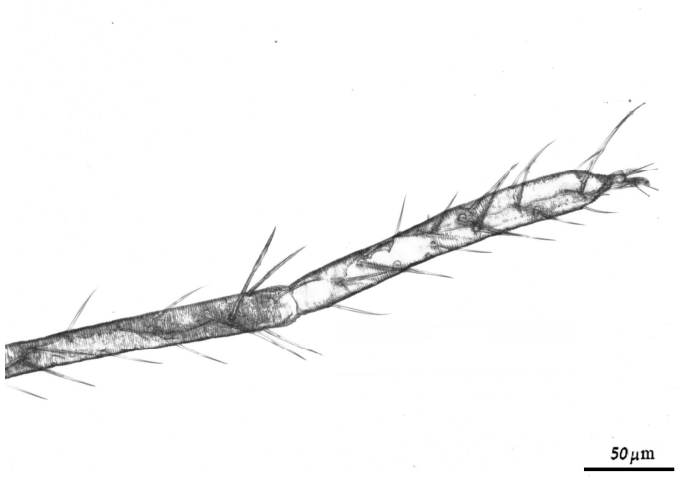

Figure 7. *Petrobia* (*Tetranychina*) *harti*—Female, tarsus of leg I.

In addition, the measured morphological characters of female and male are compared with the data provided by Ehara [27] (Table 4) and Ryu and Ehara [29] (Table 5).

Table 4. Comparison of the measured lengths of the morphological characters of *Petrobia* (*Tetranychina*) *harti* with the results from literature [27].

Measured Morphological Characters (µm)	Present Results	Ehara	Present Results	Ehara
	Female		Male	
body length	384–672	440–550	337–449	360
body width	237–517	280–380	215–266	180
the ratio of the lengths of leg pairs	I > IV > III > II	I > IV > III > II	I > IV > III > II	I > IV > III > II
the ratio of the length of the leg I to the body	leg I is about twice as long as the body (2.13:1)	leg I is about twice as long as the body	leg I about three times as long as the body (2.95:1)	leg I about three times as long as the body
length of tarsus I *	14.2	14	14.3	14
length of tibia I *	40.0	38–43	40.3	37–40
length of genu I *	4.7	5	4.3	4
length of femur I *	38.4	38–42	38.7	37
length of trochanter I *	3.7	4	2.6	4

* Relative lengths of segments in leg I.

Table 5. Comparison of the measured lengths of the dorsal setae (µm) of *Petrobia* (*Tetranychina*) *harti* with the results from literature [29].

Nomenclature of the Dorsal Setae by Ehara [27]	Present Results		Ryu and Ehara	
(by Sanchez et al. [28])	Female	Male	Female	Male
P1 (v2)	91.1	26.6	90.5	27.4
P2 (sc1)	131.2	52.0	130.0	51.0
P3 (sc2)	82.0	35.8	81.8	35.0

Table 5. *Cont.*

Nomenclature of the Dorsal Setae by Ehara [27]	Present Results		Ryu and Ehara	
C1 (c1)	184.9	33.3	185.1	32.8
C2 (d1)	198.8	23.5	197.0	23.0
C3 (e1)	194.7	22.0	194.3	21.1
C4 (f1)	181.3	21.1	179.9	20.2
H (c3)	70.0	26.2	69.8	25.0
L1 (c2)	174.3	37.0	172.5	36.2
L2 (d2)	180.8	25.2	178.4	24.6
L3 (e2)	173.9	22.5	173.4	21.8
L4 (f2)	142.1	23.3	143.5	22.6
CL (h1)	92.1	30.1	93.0	29.0

4. Discussion

Our finding adds the tribe Petrobiini, the genus *Petrobia*, and the species *P.* (*T.*) *harti* to the fauna of Serbia, which now comprises 45 recorded species belonging to 10 genera.

The symptoms caused by oxalis spider mites on *O. corniculata* and *O. articulata* correspond to those described in the literature ([18,19,27,32,33], etc.).

Regarding taxonomic considerations, according to Sanchez et al. [28], *P.* (*T.*) *harti* resembles *P.* (*T.*) *hispaniola* Sanchez & Flechtmann, 2014 in the dorsal body setae and length of leg I, but differs in the shape of peritreme that is irregularly swollen at the distal portion in a simple chamber, while in *P.* (*T.*) *hispaniola*, it ends in a more complex globular structure, forming anastomosing chambers.

A comparison of morphological characteristics (Table 4) indicates that differences between the Serbian and Japanese populations are limited to the body length and width of adults of both sexes [27]. These differences are probably due to slide preparation techniques. On the other hand, the ratio of the length of leg I to body length, the ratio of the lengths of leg pairs I-IV, and the relative lengths of segments of leg I and are aligned with the measurements reported for Japanese populations [27]. The lengths of dorsal correspond to those recorded for Korean populations [29].

Data on distribution and host plants suggest that *P.* (*T.*) *harti* is an allochthonous species in Europe. Our samples were collected from allochthonous but widely distributed species of wood-sorrel in Serbia. *O. corniculata* is a cosmopolitan weed believed to originate from East Asia [34,35]. *O. articulata* is native to the temperate regions of South America and is now present in more than 40 countries worldwide, where it has mainly been introduced as an ornamental garden plant [35,36]. In certain parts of the world, both plant species are considered potentially invasive environmental weeds [37,38].

Regarding the records of *P*. (*T*.) *harti* in Serbia, this mite was found exclusively on spatially isolated wild *Oxalis* plants in urban and semi-urban habitats, while its spread from wood-sorrels to surrounding plants was not observed at any of the studied localities. Moreover, based on the compiled and verified data on recorded species of Tetranychidae, *P.* (*T.*) *harti* has never been detected on other plant species in Serbia over the past thirty years of research.

Given the striking colouration, size and unique morphology of *P*. (*T*.) *harti*, the possibility of oversight or misidentification can be excluded. Our findings suggest that this species is practically monophagous on wood-sorrels in Serbia.

In contrast, although *P.* (*T.*) *harti* is also reported as monophagous on *Oxalis* species in Bulgaria, it has been noted that, at high population densities, it may spread to other host plants [11]. There are also reports indicating that *P*. (*T*.) *harti* can pose a significant threat to clover fields, meadows and pastures [32,39].

Based on all the above, we conclude that *P.* (*T.*) *harti* in Serbia has no practical significance for cultivated, horticultural and fodder plants, either in protected areas or in open-field conditions.

Future research should focus on assessing the potential of *P.* (*T.*) *harti* as a biological control agent for the management of widely distributed *Oxalis* weeds in greenhouse production. Continued investigation into the distribution of this thermophilic oxalis spider mite is also needed to determine its northern range limit in Europe.

In addition, future studies in Serbia should monitor whether *P.* (*T.*) *harti* expands its host range or causes damage to cultivated plants, and, if necessary, conduct further research to assess its potential impact.

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Conflicts of Interest: The authors declare no conflicts of interest.

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