



Persian J. Acarol., 2022, Vol. 11, No. 2, pp. 365–370.
<https://doi.org/10.22073/pja.v11i2.72456>
Journal homepage: <http://www.biotaxa.org/pja>



Correspondence

The species composition of herbivorous acarofauna in the south of Western Siberia

Ekaterina Ulyanova¹, Irina Andreeva² and Elena Shatalova³

1. Laboratory of Biological Control of Phytophages and Phytopathogens, Siberian Federal Scientific Center of Agro-Bio Technologies of the Russian Academy of Sciences, Krasnoobsk 630501, Novosibirsk Region, Russian Federation, Russia; E-mail: festica2@gmail.com
2. Laboratory of Biological Control of Phytophages and Phytopathogens, Siberian Federal Scientific Center of Agro-Bio Technologies of the Russian Academy of Sciences, Krasnoobsk 630501, Novosibirsk Region, Russian Federation, Russia; E-mail: iva2008@ngs.ru
3. Laboratory of Biological Control of Phytophages and Phytopathogens, Siberian Federal Scientific Centre of Agro-Bio Technologies of the Russian Academy of Sciences, Krasnoobsk, Novosibirsk Region, Russian Federation, Russia; E-mail: elenashatalova@mail.ru

PAPER INFO.: Received: 16 November 2021, Accepted: 31 December 2021, Published: 15 April 2022

At present, in different regions of the world, including the Russian Federation, an expansion of the distribution range and an increase in the harmfulness of phytophagous mites (Arachnida: Acari) on various plant species is observed, caused by objective reasons (Cherkezova 2010; Zeynalov 2013; Kamayev and Mironova 2018; Marić *et al.* 2018). One of the main factors affecting the species diversity of acarofauna is the changing weather and climate conditions observed in recent years in almost all continents (Pareek *et al.* 2017; Anonymous 2021; Bondareva and Chumak 2021). The increase in the range of crops and varieties grown and the emergence of pest populations resistant to chemical acaricides also have a significant impact on the spread and harmfulness of herbivorous arthropods (Van Leeuwen *et al.* 2010; Bergeron and Schmidt-Jeffris 2021; Bondareva and Chumak 2021).

Almost every year, new-to-science or invasive species of phytophagous mites are discovered in various crop cultivation areas, nature reserves and urbanized areas (Marić *et al.* 2018; Bahirai *et al.* 2021; Kamran *et al.* 2021; Mahdavi *et al.* 2021). Introduced species pose a significant threat; the risk of their introduction with imported planting material into new regions is currently increasing significantly, as observed, for example, in the European part of the Russian Federation (Kamayev and Mironova 2018; Kamayev and Karpun 2020). For example, in a study of spider mites on ornamental plants in urbanized areas of the Black Sea coast of Krasnodar Krai in Russia, *Oligonychus hondoensis* (Ehara), an invasive species for the acarofauna of the study region, was noted for the first time (Kamayev and Karpun 2020). In European countries, e.g. in Serbia, the species diversity of Tetranychidae increased from 17 previously recorded species to 23 due to the detection of six species new to the country, while the range of host plants favorable for the development of Tetranychidae family members has significantly expanded (Marić *et al.* 2018). Researchers identified 21 species of Eriophyidae causing teratogenic changes in woody plants in

How to cite: Ulyanova, E., Andreeva, I. & Shatalova, E. (2022) The species composition of herbivorous acarofauna in the south of Western Siberia. *Persian Journal of Acarology*, 11(2): 365–370.

pest complexes of Grodno Poneman Region (Republic of Belarus) (Glyakovskaya and Petrov 2016).

In Western Siberia, changes in the phytosanitary situation in agrocenoses are also observed, aggravated by the transition of some minor mite species to the pest rank. The two-spotted spider mite *Tetranychus urticae* Koch was not of significant importance in the open ground conditions of Western Siberia previously. However, in recent years, a high number of this phytophage has been periodically observed on soybeans, clover, alfalfa and other forage crops (Andreeva *et al.* 2019). The harmfulness of phytophagous mites is also increasing on ornamental crops used in landscaping of urban and private areas. However, the information presented in domestic sources covers, as a rule, the results of studies of acarofauna in the European part of Russia and adjacent territories. Such observations have been made on fruit, ornamental, including tree and shrub species, in the Krasnodar Territory, the Moscow and Kirov regions, the North Caucasian zone of Russia and some other regions of the country (Cherkezova 2010; Popov 2013; Zeynalov 2013; Pestov *et al.* 2018; Kamayev and Karpun 2020), while there is no such information on Siberia.

Phytophagous mite species belong to different families of the Acariformes (Arachnida: Acari). They have a variety of morphological and biological characteristics, different damage symptoms and degrees of damage. Most phytophagous mites have a stabbing-sucking mouthpiece, with which they suck the contents of the cells of leaves or other plant parts, causing deformation, discoloration, premature wilting and, consequently, reduced crop yields or ornamental value. Among herbivorous species, spider mites (Trombidiformes: Tetranychidae) and four-legged mites (Trombidiformes: Eriophyoidea) are the most important as pests in Western Siberia. They include both polyphagous and specialized species. Due to their short developmental cycle, phytophagous mites can produce many generations per season and, under favorable conditions, their abundance and harmfulness increase rapidly.

As the species composition and distribution of spider mites and eriophyid mites in the open ground of the Siberian region are not actually studied, this line of research was the purpose of our work.

The acarofauna was studied in vegetable, field crops, fruit gardens and ornamental nurseries, landscape architecture and landscaping objects of Novosibirsk city and wild plants in natural biocenoses located in the Priob'ye forest-steppe (Novosibirsk region, 54° 52' 24" N, 83° 00' 09" E) in 2017–2021. The climate of the zone is continental, with relatively short and moderately warm summers and long-cold winters. The average duration of the period with air temperatures above 5 °C is about 150 days. The hydrothermal coefficient with air temperatures above 10 °C is 1.0 on average for each year.

The weather and climatic conditions of the growing seasons 2017–2021 in the study area differed from the mean annual values, both in terms of temperature and precipitation. Three of the 5 seasons (2017, 2019 and 2020) were marked as warm, with exceeding the mean annual temperature in some months reaching 4.6–4.8 °C. At the same time, the deviation from the norm was observed mainly in the spring (April, May) and autumn (September) months, which led to a prolongation of plant vegetation. The years 2018 and 2021 were characterized by a cold, prolonged spring, which resulted in significant shifts in the sowing and planting dates of many crops, which also affected pest reproduction. In terms of the amount of precipitation in the study years, there was an extremely uneven distribution, both by year and by month and 10-day periods of specific growing seasons. Thus, 2017, 2018 and 2021 were characterized by excessive moisture, with the exception of some months when the amount of precipitation was below normal. In the growing season of 2019, there was an alternation of months with excessive moisture and dry periods. In 2020, both temperatures and precipitation exceeded the long-term average.

To detect phytophagous mites, cultivated and wild plants were examined; if there were signs of pest infestation, plant material (leaves, needles, twigs, etc.) with mites on them was collected for further diagnosis in laboratory. In agricultural crops, sampling of pest-infested plants consisted of

10–20 samples depending on the number of phytophages. On woody and deciduous shrubs, at least 10 leaves were collected from the lower part of the crown; on conifers, 10-cm branches of the lower tier were cut off from different sides of the tree. Mites were extracted from plant samples by two methods: by brushing and by washing and filtering in alcohol (Boller 1984). All samples were first temporarily preserved in 70 % ethanol. Then the mites were placed on slides in the Hoyer's medium according to Walter and Krantz (2009). Specimens were examined using a Zeiss light microscope.

Table 1. Species composition of herbivorous mites on cultivated and wild plants in open ground conditions in the forest-steppe of the Priob'ye region (Western Siberia), 2017–2021.

Genus/species of the mite	Year of collection	Collecting habitat	Host plant
Tetranychidae			
<i>Tetranychus urticae</i> Koch	2017–2021	Agrocenoses, biocenoses, plant nurseries	Fabaceae, Rosaceae, Cannabaceae, Poaceae, Salicaceae, Papaveraceae, Grossulariaceae, Lamiaceae, Tropaeolaceae, Convolvulaceae, Asphodelaceae, Campanulaceae, Hydrangeaceae
<i>Tetranychus atlanticus</i> McGregor	2020–2021	Agrocenoses	<i>Triticum</i> sp.
<i>Schizotetranychus schizopus</i> Zacher	2019–2021	Biocenoses, park areas	<i>Salix</i> spp.
<i>Neotetranychus</i> sp.	2021	Private territories	<i>Rubus idaeus</i> L.
<i>Oligonychus ununguis</i> Jacobi	2019–2021	Coniferous nurseries, urban and private landscape facilities	<i>Picea abies</i> (L.), <i>Picea obovate</i> var. <i>Glauca</i> Ledeb., <i>Picea Engelmannii</i> Parry, <i>Abies sibirica</i> Ledeb.
Eriophyidae			
<i>Aceria</i> sp.	2020–2021	Agrocenoses	<i>Triticum</i> sp.
<i>Stenacis triradiatus</i> (Nalepa)	2018–2021	Garden centers, private territories	<i>Salix</i> spp.
<i>Aculus tetanothrix</i> Nalepa	2019–2021	Biocenoses	<i>Salix</i> spp.
<i>Eriophyes sorbi</i> Canestrini	2020–2021	Urban and private landscape facilities	<i>Sorbus aucuparia</i> L.
<i>Cecidophyopsis ribis</i> Westwood	2017–2021	Private landscape areas, plant nurseries	<i>Ribes nigrum</i> L.
<i>Eriophyes tiliae</i> (Pagenstecher)	2019–2021	Urban and private landscape facilities	<i>Tilia cordata</i> Mill.
<i>Phytoptus tetratrichus</i> Nalepa	2019–2020	Urban landscape facilities	<i>Tilia cordata</i> Mill.
<i>Eriophyes</i> sp.	2020	Urban and private landscaping facilities	<i>Tilia cordata</i> Mill.
<i>Eriophyes pyri</i> (Pagenstecher)	2020	Plant nurseries	<i>Pyrus ussuriensis</i> Maxim.
<i>Aculus schlechtendali</i> Nalepa	2020	Private territories	<i>Malus domestica</i> Borkh.
Unidentified Eriophyidae	2020–2021	Urban and private landscape facilities	<i>Picea abies</i> (L.), <i>Lonicera tatarica</i> L., <i>Ribes uva-crispa</i> L., <i>Syringa josikaea</i> J. Jacq. ex Rchb., <i>Spiraea japonica</i> L., <i>Quercus robur</i> L., <i>Picea abies</i> (L.), <i>Picea obovate</i> Ledeb.

Over the years of observations in the surveyed area, spider mites were found on many plant species belonging to different botanical families in various habitats (Table 1). The most frequent species was two-spotted spider mite *T. urticae* Koch, that was found on 31 plant species belonging to 13 families. This mite's hosts included economically important field crops such as cultivated

soybean (*Glycine max* L.), alsike clover (*Trifolium hybridum* L.), and goat's rue (*Galega orientalis* Lam.); vegetable crops such as common bean (*Phaseolus vulgaris* L.), cucumber (*Cucumis sativus* L.), eggplant (*Solanum melongena* L.), apple tree (*Malus domestica* Borkh.), blackcurrant (*Ribes nigrum* L.), strawberry (*Fragaria ananassa* Duch.); nasturtium (*Tropaeolum majus* L.), morning glory *Ipomoea purpurea* L., lobelia (*Lobelia erinus* L.), spirea (*Spiraea japonica* L.F.), panicle hydrangea (*Hydrangea paniculate* Siebold) and others. The pest habitats were characterized by different microclimates, ranging from moderately humid to arid.

Tetranychus atlanticus McGregor preferred to infest cereal crops, particularly wheat. Specialized species such as *Schizotetranychus schizopus* Zacher were present both on wild willows growing in moistened areas in the Ob River floodplain and on ornamental willows (globe willow) in residential areas of Novosibirsk with drier climate. At the same time, partial or complete loss of ornamental properties of plants was observed in some cases. *Neotetranychus* sp. inhabited variety raspberries of individual garden plots, often reaching high numbers. *Oligonychus ununguis* Jacobi was found everywhere on coniferous crops, such as common spruce, Siberian spruce, and Siberian fir in city parks and other landscaping objects, as well as in nurseries on imported material of Engelmann spruce. Young plantings of conifers and large trees in the first two or three years after transplanting were affected by *O. ununguis*. The damaged trees showed yellowing of the needles and subsequent needle drop, which resulted in a significant reduction of their ornamental qualities. The timing of emergence and abundance of the phytophage varied from year to year and depended primarily on weather conditions. Thus, mass infestation of conifers by the pest was observed during the warm growing season of 2020. In 2021, the period of spruce spider mite infestation was significantly shorter and the damage was less noticeable, which was probably due to the colder winter, late spring and cooler summer.

The family Eriophyidae mainly inhabited woody and shrub species – little-leaf linden (*Eriophyes tiliae* (Pagenstecher), *Phytoptus tetratrichus* (Nalepa), *Eriophyes* sp.), mountain ash (*Eriophyes sorbi* Canestrini), apple tree (*Aculus schlechtendali* (Nalepa)), various willow species (*Stenacis triradiatus* (Nalepa), *Aculus tetanothrix* (Nalepa)). Four-legged mites were particularly abundant on the little-leaf linden and various species of willow. In addition, members of this family were found on edible honeysuckle, gooseberry, Hungarian lilac, Japanese spirea, English oak, and Siberian spruce (mites are not identified at present). In these crops, the numbers of Eriophyidae varied widely, from single individuals to high abundance. Also, under regional conditions, eriophyid mites (*Aceria* sp.) were found in small numbers on selected varieties of wheat, causing damage to young leaves, causing them to curl and fold inwards. Such damage caused a reduction in the photosynthetic capacity of the plants.

The results of monitoring and collection of phytophagous mites in the south of Western Siberia indicate an increase in the role of these arthropods as pests of agricultural and ornamental crops. Thus, the common spider mite had no practical significance in the open ground conditions of our region two decades ago, but now this phytophage massively invades such crops as soybean, clover, beans, alfalfa, cereals and others (Andreeva *et al.* 2019). Observations showed that representatives of the family Tetranychidae were especially abundant in years with growing season temperatures exceeding the mean annual values (2019, 2020). In such warm and dry years, spider mites appeared on forage plants already in spring (May-early June), and at the end of vegetation their number and harmfulness increased significantly.

Four-legged mites (Eriophyidae) pose a serious threat to cultivated plants, in particular members of the genus *Aceria*, which, in addition to direct harm, can spread viral diseases of plants. For example, the wheat gall mite, *Aceria tosichella* Keifer, is a vector of several types of phytopathogenic viruses, including wheat streak mosaic virus (Navia *et al.* 2013; Khalaf *et al.* 2020). Damage by gall mites to leaves of woody species leads to a decrease in plastid pigments. Such changes in the photosynthetic apparatus are particularly dangerous for tree stands in urban areas (Pestov and Ogorodnikova 2019).

As a result of the study, it was found that the open ground conditions of the forest-steppe in the south of Western Siberia are inhabited by a rather extensive species composition of plant-eating mites. A total of 5 species of spider mites (Tetranychidae) infesting 36 plant species from 15 botanical families were recorded during the survey. The species composition of host plants of Eriophyidae mainly includes tree and shrub species; representatives of the genus *Aceria* were also found on cereals. Thus, in recent years, the phytosanitary situation in the Siberian region has significantly changed due to acarofauna, both in various types of agrocenoses and on ornamental crops used for landscaping of urbanized areas. Timely detection and accurate diagnosis of phytophagous mites is a prerequisite for preventing their mass reproduction and damage to cultivated plants.

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