Prospects for use of the predatory mite *Transeius herbarius* (Weinstein, 1960) (Mesostigmata: sam. Phytoseiidae, subfamily. Amblyseiinae)

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Abstract. The predatory mite *Transeius herbarius* (Wainstein, 1960) is used as a specialized acariphage mainly on berry crops. In the open ground, *T. herbarius* is one of the effective predators of strawberry (Tarsonemidae) and spider mites (Tetranychidae). The predator can penetrate into the primordial, reproduces better in humid places, migrating 2–3 meters per season. On strawberries effectively regulates the strawberry mites population and even uses proportionate female spider mites in the food chain. The predator is amenable to breeding on loose substrate using barn mites of various species. High survival rate is found on industrial uterine plantings of garden strawberries in the open ground, with use of complex of protective measures including insecticides. Due to the natural small population of this predator in the fields, research and saturating releases in a normalized amount are required for optimal protection from pests.

1 Relevance of research and characteristics of the species

Transeius herbarium (Weinstein, 1960) is part of the family of Phytoseiids (cucumbers), Amblyseiinae subfamily, Mesostigmata order, superorder of Parasitiform mites (tomatoes), class Arachnids (arachnids). The basionym is *Typhlodromus herbarius* Weinstein, 1960. The initial description is made based on the standard material collected on burdock and thistle in Kazakhstan (near Alma-Ata) [1].

Historical changes in the generic (subgeneral) name: *Amblyseius (Amblyseius) herbarius* (Weinstein, 1960); *Amblyseius herbarius* (Weinstein, 1960); *Neoseiulus herbarius* (Weinstein, 1960) [2]. Included in the *Transeius* Chant & McMurtry, 2004 genus. At present time the valid name is *Transeius herbarius* (Weinstein, 1960).

The predaceous mite *Transeius herbarius* has a wide Euro-Siberian geographic extent, is found in various countries of Europe and Asia. It is confined to open biotopes of grassy communities. But, being eurytopic species, it also penetrates into forest plant communities. It is most common on herbaceous plants, both broad-leaved and cereal, occasionally found

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on shrubs and small trees. This mite is also found in leaf litter and in a chicken nests [1], lives on plants of the genus Rubus in Iran [3].

Transeius herbarius is a permanent component and largely confined to berry agrocenoses on garden strawberries [4, 5]. It occurs together with herbivorous mites, whiteflies and thrips, lives in colonies of *Tetranychus urticae*, *Tetranychus turkestani* mites. It is also known from colonies of the tarzonemid strawberry mite *Steneotarsonemus pallidus* on garden strawberries.

The development cycle of *Transeius herbarius* consists of 4 phases (or ages) – egg, larva, nymph (two stages, or two ages – protonymph and deutonymph), imago (female). The body is oval–elongated, 0.4 mm long, 0.3 mm wide. The color is pale straw, but when fed by spider mites it becomes a more contrasting shade (Fig. 1a). When fed by thrips, the body color changes to brownish (Fig. 1b). When fed by pink eriophyid mite Transeius herbarius turns orange (Fig. 2).

The dorsal shield (Fig. 4) is oval, with shallow lateral recesses, well sclerotized, mostly smooth, only in front along the edges with oblique strokes; its length is 350 microns, width 190 microns [6].

a *b*

Fig. 1. Attacks of Transeius herbarius: a) by two females on twospotted spider mite Tetranychus

Fig. 2. Two females of Transeius herbarius in an eriophyid mite colony on a greenhouse rose leaf.

There are 17 pairs of setae on the dorsal shield: 9 pairs of microchete setae (7–14 microns); 7 pairs of longer setae (22–50 microns). The PM2 seta is long (70 microns), goes beyond the flow of the PL3 seta. The peritremes are long, but do not reach the level of the tech setae D1. Ventroanal shield with light lateral recesses, transversely striated, bears 3 pairs of preanal setae; there are no anal pores. The length of the wind shield is 128 microns, the width is 97 microns. The funnel of the spermatheca is small, narrow at the base and saucer–shaped at the top, the atrium is sessile. The movable finger of the chelicerum carries 2 additional teeth; the fixed finger carries 6 teeth. There are macrochetes on the leg of the IV pair, their length is 50 microns on the knee, 38 microns on the shin, 73 microns on the foot.

A unique feature of the predatory mite T. herbarius is its ability to predominantly reproduce parthenogenetically, although males are rarely found in natural populations. The reproductive behavior of T. herbarius manifests itself in the form of telitokia [7], a phenomenon in which only females develop from laid unfertilized eggs.

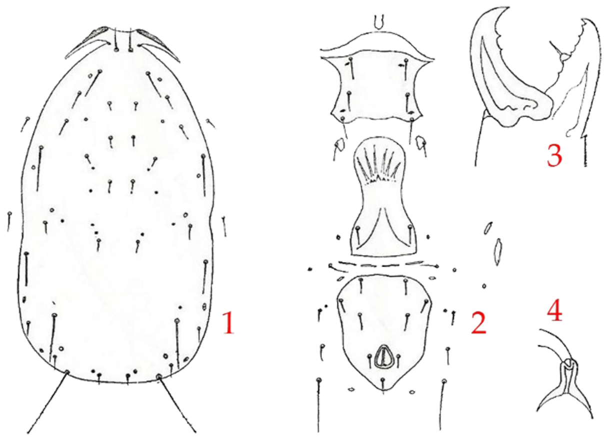

Fig. 3. Morphological features of Transeius herbarius [6]: 1 – the dorsal shield of the female; 2 – the ventral side of the female's body; 3 – female chelicerae; 4 – spermateca.

Eggs (ova) are quite large in relation to the size of the female's body. Pale whitish in color, translucent. It has the normal shape of an asymmetric ellipse. When laying, the egg is slightly glued to the surface of the substrate, more often it is attached to a leaf hair. Through the transparent shell of the egg, it is possible to trace the change in the state of the embryo over time: in the middle of embryonic development, the germ leaves are visible, and in the last stages of embryo development, the forming limbs of the future larva are visible.

The larvae are pale, translucent to white in color. There are a pair of long tail setae on the opisthosome. There are only three pairs of legs. The oral apparatus is well developed. The larva is sedentary, it does not move far from the empty exuvium. Without additional nutrition, the larva overflows into the next stage (protonymph), for which, apparently, it lacks an egg yolk, which the larva endogenously feeds on.

The protonymph is whitish; it has four pairs of legs. This is the first actively feeding phase of the development of Transeius herbarius. The protonymph develops normally when feeding on herbivorous mites in the preimaginal phases of development and their eggs.

The deutonymph appears after the second molt. The body is whitish in color. It also has four pairs of legs. Very agile and voracious. Being in this phase, predatory mites increase significantly in size. By the end of the deutonymphal phase, all organ systems that ensure the vital activity of the adult stage are finally formed. The deutonymph that has finished feeding goes into a state of pre–midnight rest, then sheds for the last time and turns into an imago.

Transeius herbarius originates from the temperate continental climate of Europe, so the range of normal development is located within 12–32 ° C. In early spring, when positive temperatures are established, predators leave their wintering grounds. For the development of predatory mites, temperatures in the range of + 20–30 ° C, relative humidity over 70% and a light period of 14–16 hours are most favorable. When feeding on spider mites, the duration of preimaginal development of *Transeius herbarius* is 7 days (Table. 1), and the female's life expectancy is about 27 days (Table 2).

Obligate aphagia is noted for the larvae of *Transeius herbarius* – in less than a day, without feeding, they moulted into a protonymph. The voracity of the protonymph *Transeius herbarius* during development is 51.2 spider mite eggs, the voracity of the deutonymph is 58.7 eggs of the victim.

Table 1. Impact of prey type on duration of the predatory mite *Transeius herbarius* development $T = 25°C$; $RH = 80–90\%$; $F = 16$ hours [8].

Development age	Stage duration, days	
	Tetranychus urticae eggs (ova)	*Steneotarsonemus pallidus* mite
Egg (ovum)	2.3	2.4
Larva	0.8	0.8
Protonymph	1.9	1.6
Deythonymph	2.1	1.8
Summ	7.1	6.6

After molting on imago, female phytoseids do not immediately begin laying eggs. The parthenogenetic type of reproduction of *Transeius herbarius* does not affect the duration of formation of the first egg [9]. The maximum daily egg production is achieved on the 9th day, averaging 2 eggs per female. During the reproductive period (22 days), females lay an average of 44 eggs.

During the first day after molting on imago, young females are not active in search of prey, consuming no more than 4–6 spider mite eggs. On the second day, the consumption rate increases to 20–30 eggs. Females show the greatest voracity during the reproductive period. *Transeius herbarius* females are characterized by a significant peak of voracity at the beginning of this period. The average daily consumption rate reaches 50.2 spider mite eggs. The female *Transeius herbarius* destroys 2–3 female spider mites per day. In general, during its lifetime, the predator is able to destroy about 1265 eggs of the victim

Table 2. Biological parameters of the predatory mite *Transeius herbarius* $T = 25°C$; $RH = 80–90\%$; $F = 16$ hours [8].

Parameter	*Tetranychus urticae*	*Steneotarsonemu s pallidus*
Period duration, days		
Pre reproduction	2.3	2.7
Reproduction	22.0	2.6
Post reproduction	3.0	5.6
Prolificacy, eggs number		

Daily average	1.97	1.4
Overall	44.0	3.6

Being a specialized predator of the spider mite, Transeius herbarius is characterized by a high value of the biotic potential of the population (r_m). The phytoseiid mite *Transeius herbarius* adheres to the following life strategy – increases fertility with complete rejection of the bisexual type of reproduction, which significantly increases the rate of reproduction per generation (R_0).

Table 3. Demographic parameters of the predatory mite *Transeius herbarius* at 25–26 °C

Freatures of population	*Tetranychus urticae* ova [8]	*Tetranychus urticae* female [9]
Generation duration, T	22.37	15.60
Reproduction rate, R_0	44.45	24.08
Veritable population growth rate, r_m	0.170	0.204

2 Laboratory population

Transeius herbarius is cultivated on some species of barn mites from the family Acaridae (synonym Tyroglyphidae) – *Tyrophagus putrescentiae*, *Acarus siro* [10, 11]. Promising food mites are the narrow mite *Thyreophagus entomophagus*, the hairy mite *Lepidoglyphus destructor*.

Consideration of medical and environmental safety issues arising during breeding and use of acariphage shows that predatory mite *Transeius herbarius* is safe for humans and warm-blooded animals. The predaceous mite is safe for beneficial insect pollinators and biological control agents against harmful arthropods.

3 Scope of application

Transeius herbarius belongs to the group of oligophages adapted to inhabit all layers of the dense web of mites of the genus Tetranychus. It feeds on a variety of small arthropods, mainly thrips, mites and ticks. *T. herbarius* is able to feed on the larvae of the whitefly *Trialeurodes vaporariorum* [12]. The predaceous behavior of *Transeius herbarius* on the following spider mites is recorded:

- *Tetranychus urticae* (common spider mite),
- *Tetranychus cinnabarinus* (red, or carmine, spider mite).

This predator also effectively feeds on tarzonemid mites, in particular, *Steneotarsonemus pallidus* (strawberry transparent mite). On the plants of garden strawberries, the acariphage finds its victim – an ordinary spider mite on fully formed leaves. On penetration into the primordial leaves, it actively destroys the strawberry mite. Per day, 1 female predator destroys up to 30–50 spider mite eggs. It is also found that the predator *Transeius herbarius* is able to feed on the Western flower thrips *Frankliniella occidentalis* (Fig. 4).

In laboratory conditions, *Transeius herbarius* is tested against thrips on cucumber leaf carvings to determine the regulatory potential of the predator. Previously, 5 female thrips are placed on the experimental sheet. After 2 weeks, when the larvae of thrips appeared (about 15 individuals of each age), 1 female predatory mite is placed on each cutout.

It is found that *T. herbarius* actively destroyed thrips [13]. Biological efficiency 6 days after colonization of the predator is 97.2%. By this time, the number of *T. herbarius* offspring reached an average of 8 individuals. The high biological efficiency of *T. herbarius* is confirmed by data on the number of thrips larvae that have passed into the nymphal stage. The proportion of thrips nymphs on the fourth day reached 41.3%; by the 6th day, not a single thrips larva had completed development. Based on laboratory experiments, it can be assumed that *T. herbarius* can be used in programs to suppress the abundance of Western flower thrips at moderate temperatures (15–20 °C), whereas it is known that *Neoseiulus barkeri* is more effective at elevated temperatures [14].

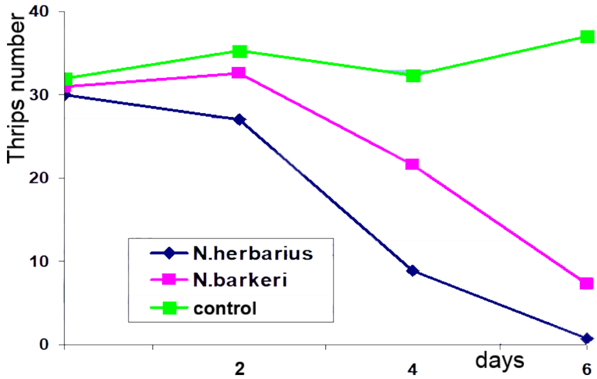

Fig. 4. Comparative activity of two species of phytoseiid mites on the larva of thrips urticae female; b) by one female on larvae of the second age of the Western flower thrips.

For colonization (by flood or seasonal release method) of predatory mites, it is necessary to pre-breed target mites in biolab or biofactory. The problem of mass breeding for some predatory mites can be partly solved by using alternative food sources, for example, some species of astigmatic mites (Astigmata Acariformes: Acaroidea) [4]. In particular, for the commercial reproduction of the predatory mite *T. herbarius* as a protein feed can be used: elongated putrefactive mite *Tyrophagus putrescentiae*, cheese mite *Tyrolichus casei* or narrow mite *Thyreophagus entomophagus*.

The ability of *T. herbarius* to enlarge population on substrate of an elongated mite is studied. Duration of preimaginal development at 25 °C is 6.2 days; the average fertility of females reaches 23.0 eggs; population growth rate (r_m) is 0.218 with an average generation time (T) of 14.37. Thus, the acaroid mite is the optimal food for the mass breeding of this acariphage. A conclusion that the introduction of a new type of entomo- and acariphage into practice will generally increase the reliability of the protective system in greenhouse conditions can easily be drawn.

Conditions of predatory mite culture preservation during short-term storage are the refrigerated area for 5–7 days before releases at a temperature of 8–10 ° C.

4 Results of experimental study

It has been experimentally shown that during the preimaginal development, the deutonymphs of the predator *T. herbarius* destroy similar number of spider mite eggs, compared with small protonymphs. At the same time, the nymphs of the predatory mite *T. herbarius* are more voracious than the nymphs of the specific acariphage *Phytoseiulus persimilis* (Table 6).

Table 6. Voracity of phytoseiid mites during the preimagal development period

Species	Number of spider mite eggs consumed (X_{av})		
	Protonymph	Deythonymph	Overall
Transeius herbarius	51.2 ± 4.3	58.7 ± 8.4	125.7 ± 11.2
Phytoseiulus persimilis	18.0 ± 1.5	37.8 ± 5.3	55.8 ± 4.3

It is possible that for the polyphagus predator *T. herbarius*, the eggs of the spider mite are less complete for effective nutrition than for the specialized oligophagus *P. persimilis*. On the other hand, the development of predatory mites is prolonged, so they eat more prey eggs.

5 Discussion

The *T. herbarius* mite is the most effective predator on garden strawberries in the fight against strawberry and spider mites. It is able to augment its population with good reproduction rate, without delay in growth and development. By observations, the *T. herbarius* mite performs well in temperate climatic conditions, but in case of pest outbreaks, saturating colonization is required. Insecticides and acaricides of systemic action are prohibited in the Russian Federation for use on strawberries, in particular [15]. However, mother cultures, breeding lines, and collections require complete elimination of strawberry and spider mites, which is impossible with the use of pesticides alone. It is important to develop protective measures using predaceous mites in the localization of greenhouse conditions (collections, lines, etc.).

It is important to draw an expert assessment before planning protective measures for lines, hybrids, varieties or collection samples. Relying only on the chemical protection brings unreasonable risks, as it is shown on many examples in the Russian Federation, and in other countries, which indicate inefficiency of seed plots, even on the industrial level without biological method implementation [16, 17]. In foreign countries, due to pests, the lifetime of seed plots and industrial plantings is shortened by secondary diseases caused by pathogens of the root and other parts of berry bushes [18]. The innovative research is very profitable and promising in Russia [19] as predaceous mites naturally reduce significantly pesticide stresses over agrocenoses [20, 21]. It is explicitly shown that in the Russian Federation the use of the predator *Transeius herbarius* (Wainstein, 1960) is promising, but without expert aid it can lead to unprofitable efforts.

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