Neoseiulus agrestis as a biological agent, and monitoring of introducted thrips in greenhouses

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Abstract. Oligophagus *Neoseiulus agrestis* (Karg, 1960) can be used as predator on vegetable, flower and berry crops. It is capable of feeding on Tetranychidae and Tarsonemidae. The ability to regulate the number of Thripidae has been established. It lives in colonies of Acaridae mites. The technology of mass breeding allows to accumulate predator population in a loose substrate. The technology of use for this phytoseiid mite should be adapted to each type of plant taking into account the bioecological features. For a greenhouse cucumber, the release should be made at the trellis part of the plant. On flower crops, for example gloxinia, colonization is carried out by sowing the substrate with a predator on all plants in the greenhouse. It is effective on garden strawberries in the struggle against the strawberry mite *Steneotarsonemus pallidus*. The predator prefers to attack the nymphal stages and eggs of the *Tetranychus urticae* mite. It is capable of attacking not only the larvae of *Thrips nigropilosus*, but also its nymphs. In the garden strawberry leaf rosette, it destroys the strawberry mite, at penetration into the inner part of leaf buttons. It is highly sensitive to pesticides from the class of macrocyclic lactones and synthetic pyrethroids. Preparations based on the bacterium *Bacillus thurengiensis* on *N. agrestis* do not have a lethal effect.

1 General characteristics of the species

The Neoseiulus field species *Neoseiulus agrestis* is a member of the family Phytoseiidae (Phytoseiidae), subfamily Amblyseiinae, order Mesostigmata, superorder Parasitiform mites (Parasitiformes), class Arachnids (Arachnida). There is an objective synonym for this species *Typhlodromus agrestis*, included in the genus *Neoseiulus Huges* (Huges, 1948), valid name *Neoseiulus agrestis*.

The genus *Neoseiulus* (Hughes, 1948) [1] is characterized by dorsal shield bearing 17 pairs of almost equally long setae. The anterolateral setae of the 4th pair AL4 (or s4) and the postmedial 2nd pair PM2 (or Z4) differ little from the rest of the lateral setae. However, the postmedial setae of the 3rd pair PM3 (or Z5) are somewhat longer than all dorsal setae.

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The predatory mite *Neoseiulus agrestis* is morphologically similar to *Neoseiulus barkeri* Hughes. It differs in the shape of the spermateca, the funnel of which narrows sharply to the atrium, the preanal pores on the ventroanal shield are widely spaced (Fig. 1).

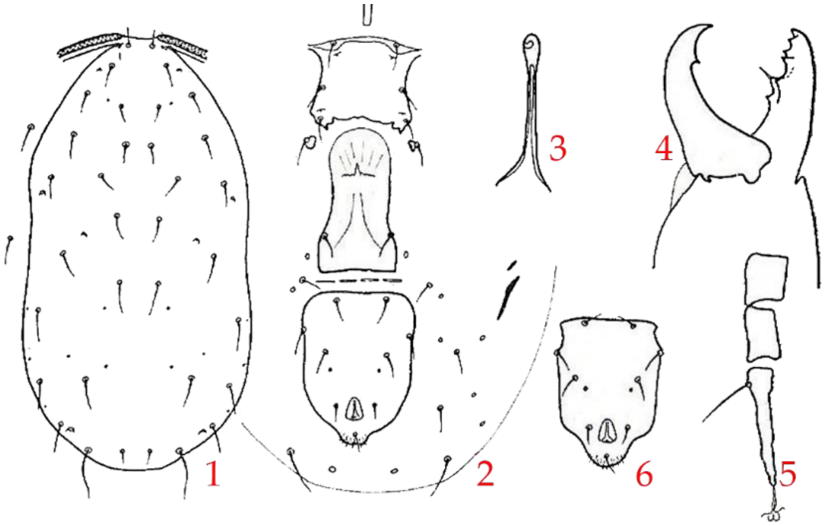

Fig. 1. Morphological features of *Neoseiulus agrestis* female [20]: 1 – dorsal shield chete; 2 – ventral side of the body; 3 – spermatheca; 4 – chelicerae; 5 – macrochete on paw IV; 6 – variation of the ventroanal shield shape.

Neoseiulus agrestis is widespread in Europe [3, 4] and mainly found in soil and litter [5 – 7], especially in winter [8]. Mites of this species do not belong to obligately plant-dwelling mites-phytoseids. It is occasionally found on grassy plants, even less often on low-growing shrubs (blackberries) [9, 10]. It is very rarely found on garden strawberries (*Fragaria x ananasa*) and strawberries (*Fragaria moschata*).

Fig. 2. Two females of Neoseiulus agrestis attacked the deutonymph of black-haired thrips Thrips nigropilosus.

The type of power supply is not exactly set. However, it prefers habitat to hunt tyroglyphid mites, and other groups of arthropods with soft body coverings. It is capable of attacking tetranich mites, tarzonemid mites [11] and thrips (Fig. 2). The development cycle consists of 4 stages – egg (ovum), larva, nymph (protonymph and deutonymph), imago (female).

Adult females have a narrow dorsal shield: length 360 microns, width 175 microns [12]. The body color is light brown (Fig. 2). There are 17 pairs of setae on the dorsal shield; all setae are smooth and short, their length is less than the distance to the bases of the corresponding setae of the subsequent rows. The peritremes reach the setae D1. The wind-anal shield is slightly wider than the genital one, with rounded upper corners, caudally narrowed; the preanal pores are small, rounded, widely spaced.

The funnel of the spermateca is elongated, it expands strongly towards the top (to the bubble), its length exceeds its own maximum width by almost 3 times. The atrium is large, directly adjacent to the base of the funnel. There is 1 tooth on the movable finger of the chelicerae, 3 distal and 2 basal teeth on the stationary one. The male is unknown. Reproduction occurs by parthenogenesis according to the type of telitokia (virgin females lay unfertilized eggs, from which only females develop) [13].

The eggs are of pale whitish in color. The shape is elongated-oval, almost the same width throughout. The larvae are pale from white to translucent in color. There are a pair of long setae on the opisthosome. There are only three pairs of legs. Without nutrition, organism molts into protonymph. The second and third stages of preimaginal development (protonymphs and deutonymphs) have four pairs of legs. They are somewhat milky in color. Body length is 0.2–0.4 mm.

2 Development cycle of *N. agrestis*

Female mites of *Neoseiulus agrestis* are reluctant to attack relatively larger females of the common spider mite *Tetranychus urticae*, preferring to attack the preimaginal phases of development of this victim. Therefore, in the experiment, each female predator was provided with 10 deutonymphs of a spider mite every day.

Experiments to assess the duration of development of the predatory mite *Neoseiulus agrestis* are carried out at constant temperatures of 25–26 ° C, which is in optimal range for the development of phytoseids, and air humidity level of 90–95% [14] is required. It is found that the development of the predatory mite *Neoseiulus agrestis* at feeding on spider mite deutonymphs, compared with other species of phytoseids, is slowed down [15], whereas the strawberry mite is more favorable food for development (Table 1).

After a short pre-oviposition period, during which the first egg is formed, *Neoseiulus agrestis* females enter a long oviposition period. The maximum daily egg production is achieved on the 12th day, averaging 2.5 eggs per 1 female. After reaching the maximum, a slow decline occurs, ending with the transition of females to the post-hypositional period, when the predator still feeds, but does not reproduce. The average duration of oviposition in Neoseiulus agrestis is about a month (Table 2).

Table 1. Duration of preimaginal development of *Neoseiulus agrestis*.

Development age (female)	**Preimaginal development (day) with nutrition**	
	Tetranychus urticae	*Tarsonemus pallidus*
Egg (ovum)	2.15 ± 0.03	2.3 ± 0.12
Larva	0.82 ± 0.03	0.9 ± 0.06
Protonymph	3.53 ± 0.20	1.7 ± 0.15
Deythonymph	1.89 ± 0.09	1.8 ± 0.18
Summ	8.39 ± 0.23	6.7 ± 0.27

This parthenogenetic predator species, in comparison with bisexual species, has the longest egg laying period [16]. Also, *Neoseiulus agrestis* is comparatively more prolific (Table 2).

The voracity of *Neoseiulus agrestis* females increases from the beginning of the oviposition period and reaches a maximum on 10-15 days, when they are able to destroy about 10 deutonymphs of the spider mite every day. In the future, the course of feeding activity monotonously decreases, decreasing on the 32nd day to the consumption level of 3-3.5 individuals of the victim. In the future, mites begin to feed irregularly, stop laying eggs, and their motor activity drops sharply – predatory mites move into the post-exposure period, completing their life cycle.

Table 2. Fertility and voracity of *Neoseiulus agrestis* females.

Biological parameter	**At feeding on mites**		**Variance ±**
	Deutonyms of *Tetranychus urticae* [13]	**Female *Tarsonemus pallidus* (original data)**	
Preoveposition duration, day	2.4 ± 0.15	2.1 ± 0.4	0.3
Oviposition duration, day	24.1 ± 2.51	25.3 ± 4.9	1.2
Average daily fertility, egg	2.13	1.7 ± 0.2	0.43
Oviposition fertility, egg	52.5 ± 1.26	41.8 ± 7.4	10.7
Consumed preys at preoveposition, pcs.	10.5 ± 0.95	-	-
Consumed preys at oveposition, pcs.	166.2 ± 3.63	-	-
Average daily voracity, pcs.	6.9	43.6	36.7

According to demographic indicators, the parthenogenetic species *Neoseiulus agrestis* is not inferior to some bisexual species of phytoseids [17] (Table 2). The biotic potential (r_m) is quite high: when fed with spider mites – 0.163, when fed with strawberry transparent mite – 0.182.

Table 3. Population features of *Neoseiulus agrestis* when feeding on deutonymphs of the spider mite *Tetranychus urticae* (t = 26 °C).

Demographic parameter	**Designation**	**Value**
Population increase during *T* period	R_0	15.68
Average generation time	T	16.89
Maximum population increase rate	λ	1.18
Specific population increase rate (biotic potential)	r_m	0.163
Mortality of females in offspring in the preimaginal phases of development	M_{pr}	63.3

3 Laboratory population

On the possibility of laboratory cultivation of *N.agrestis* on astigmatic mites (n/a. *Acariformes*, from Stigmata, sam. *Tyroglyphidae*) was first indicated in the works of Yu.I. Meshkov [16, 17, 18]. It was found that when contained in wheat bran, the predatory mite feeds on the elongated putrefactive mite. *Tyrophagus putrescentiae*. At 25 ° C, the duration of preimaginal development is 5.9 days. With 2 weeks of breeding, the population increases by 150.8 times. A high proportion of eggs and preimaginal phases (Table. 4) indicates favorable conditions for development on alternative feed.

Table 4. Population growth of predatory mite *Neoseiulus agrestis* in wheat bran substrate with elongated putrefactive mite *Tyrophagus putrescentiae* (t=25°C)

The initial number of females	The ratio of offspring units to 1 female (on day 14)					
	egg	larva	nymph	female	male	total
5	44.4	16.6	60.2	29.6	-	150.8

When feeding on barn mites, *N.agrestis* rapidly finishes preimaginal development (Table 5). The mortality rate of immature individuals is only 2.3%. The dynamics of egg laying by *N. agrestis* females is characteristic of phytoseids developing under favorable conditions. Most of the eggs (50-60%) are laid during the 1st week of the reproductive period. By the end of the 2nd week, females manage to lay the bulk of eggs (85-90%).

Demographic parameters (Table 5) give an idea of the potential growth in the population of the predatory mite *N.agrestis* at the initial stage of cultivation, when there are no restrictions either in the amount of food or in the occupied space. Thus, the population of *N. agrestis* is able to increase 30.89 times in 15.34 days. Thus, a population whose density was initially 5 individuals/cm3 should have 70.4 individuals/cm3 after 1 week, and 140.8 individuals/cm3 after 2 weeks.

Table 5. Biological features of the predatory mite Neoseiulus agrestis when feeding on the flour mite Acarus siro (t=25°C).

Biological parameter	Value
Preimaginal development, day	5.8 ± 0.05
Preoveposition duration, day	1.8 ± 0.5
Reproduction duration, day.	21.6 ± 4.6
Average daily fertility, egg	1.38
Oviposition fertility, egg	31.7 ± 3.8
Average generation time	15.34
Population reproduction value (R_0)	31.6
Specific population increase rate (biotic potential, r_m)	0.225

Consideration of medical and environmental safety issues arising during breeding and use of acariphage shows that predatory mite *N. agrestis* is safe for humans and warm-blooded animals. Allergic reactions in the maintenance personnel during its dilution and application are not recorded. The predaceous mite is safe for beneficial insect pollinators and biological control agents against harmful arthropods.

4 Scope of application

The predatory mite N.*agrestis* is characterized by obligate parthenogenesis, which proceeds according to the type of telitokia [18]. *Telitokia* in acariphages is interesting not only from a theoretical, but also from a practical point of view. The use of such a predatory agent in the biological protection of plants from pests is attractive, according to L.A. Kolodochka [13], for the following reasons: 1) simplifies the emergence of daughter populations of acariphages during the settlement of predators in new habitats, since any individual can be the ancestor of a new colony; 2) food resources in populated areas are used more economically, since there are no males in the population of the calf species.

N. agrestis is one of the effective predators against tarzonemids on garden strawberries [10, 15]. In laboratory conditions at 26 ° C, the female predator destroys 40-50 *tarzonemus* individuals per day and lays 1-2 eggs during this time. In the Matveevskoye and Moskovsky greenhouse complexes, it was successfully used to control thrips and spider mites on cucumber.

It also attacks larvae and nymphs of some species of thrips. When released to potted plants, begonia (Izmailovsky SDS, Moscow) successfully suppressed the growth of the black-haired thrips *Thrips nigropilosus*.

Short-term storage of population biomaterial (imago and nymphs of predatory mite) can be preserved in the refrigerator for 5 – 7 days before releases, at a temperature of 8–10 ° C.

Long-term storage requires the predatory mite is kept in the refrigerator at 15–17 ° C for up to 2 – 3 months with mandatory feeding of mites every two weeks with forage mites from the *Tyroglyphidae* family.

5 Results of the study

It has been experimentally shown that during the preimaginal development, the deutonymphs of the predator *N. agrestis* destroy 1.8 times more spider mite eggs than smaller protonymphs of preimaginal individuals. However, the nymphs of the predatory mite *N. agrestis* are more voracious than the nymphs of the specific acariphage *Phytoseiulus persimilis* (Table 6).

It is possible that for the multi-row predator *N. agrestis*, spider mite eggs are less complete for effective nutrition than for the specialized oligophagus *P. persimilis.*

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

Predatory mite species	**Spider mite eggs eaten (*Xsr* ± *Sx*) by age**		
	protonymph	**deutonymph**	**total**
Neoseiulus agrestis	44.3 ± 3.7	81.4 ± 9.5	125.7 ± 7.2
Phytoseiulus persimilis	18.0 ± 1.5	37.8 ± 5.3	55.8 ± 4.3

6 Discussion

The mite *Neoseiulus agrestis* (Karg, 1960) is a typical inhabitant of industrial plantations of garden strawberries. However, the number of its populations is quite low in various types of management. Most often, this is attributed to incorrect protection systems, which are often aimed at exterminating plants in the inter-row space. Chemical protective equipment used around landings also includes completely destructive measures that destroy the ecological niches of predators. They also cause ecological shifts in the relationship between predators and pests, causing the main damage.

This is due to two main factors. By the autumn period, the increased population goes to winter in the root part of strawberry plants. In low-snow winters, there is a significant drop off. The mortality of overwintered mites is influenced by early spring temperature fluctuations. In the spring period, the number of the main prey of the predator, the strawberry mite, is also low, that results in low fertility of the phytoseiid mite.

It is necessary for specialists to investigate, summarize the available monitoring data, and make scientifically sound planning. With the scientific support of specialists, to carry out the release of predatory mites according to scientifically substantiated data on industrial plantings (plantations) of garden strawberries [19, 20].

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