

The indigenous species of predatory mites (Acari: Phytoseiidae) as biological control agents of plant pests in Slovenia

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ABSTRACT

Phytoseiid mites are of great importance for the biological control of spider mites, thrips, and whiteflies. In this article, we present six species of predatory mites from the family Phytoseiidae, which are included in the list of indigenous organisms for biological control in Slovenia. These species are *Amblyseius andersoni*, *Neoseiulus californicus*, *N. barkeri*, *N. cucumeris*, *Euseius gallicus*, and *Typhlodromus pyri*. Being included in the list mentioned above, these species have great potential to be used in biological control and are technically qualified sources for the management of several pest species in agricultural production in Slovenia. Detailed information about the feeding habits, food preferences, and biological control potentials of these species is presented herein.

Keywords predatory mites; biological control; indigenous species; Slovenia; Phytoseiidae; *Amblyseius andersoni*; *Amblyseius barkeri*; *Euseius gallicus*; *Neoseiulus californicus*; *Neoseiulus cucumeris*; *Typhlodromus pyri*

Introduction

Biological control is a method of plant protection that involves the use of living beneficial organisms such as predators, parasitoids, entomopathogenic nematodes, fungi, and bacteria, and also protozoa and viruses to suppress or control populations of organisms that are harmful to plants (Trdan *et al.* 2020). In this regard, it is important to choose efficient biological control agents that have short life cycles and high reproduction capacity under a wide range of environmental conditions but also consideration of the risk of their presence for the preservation of nature and its biodiversity.

Predatory mites belonging to the family Phytoseiidae (Acari: Mesostigmata) are important predators that constitute 60% of the biological control market worldwide (Helyer *et al.* 2014; Knapp *et al.* 2018). This family includes more than 2,700 species from 94 genera that were reported from all continents, except Antarctica (Demite *et al.* 2023). Phytoseiid mites have been continuously studied since 1960 due to their key role in augmentative and natural biological control, especially in greenhouses but also in open fields (McMurtry *et al.* 2015). Natural or naturalized populations of phytoseiid mites adapted to local environmental conditions can effectively control the aforementioned pests (Gerson 2014). In contrast, commercially imported predators may interfere with natural predator populations via e.g. intraguild predation, causing pest control failures and displacement of native predators (Döker *et al.* 2021). In addition, certain conditions are needed for the mass rearing, marketing, introduction, release, and use of beneficial organisms. The Administration for Food Safety, Veterinary Medicine,

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and Plant Protection (abbreviated as UVHVVR in Slovenian) in agreement with the ministry responsible for nature conservation, conducts administrative procedures for issuing permits for the introduction, cultivation, marketing, and use of the organisms in question (UVHVVR 2022a). The rules on biological control in Slovenia themselves are written in full in the Official Gazette of the Republic of Slovenia, No. 45/06 (PISRS 2022). In addition, UVHVVR published the lists of indigenous (UVHVVR 2022b) and alien organisms (UVHVVR 2022c) for biological control, and the list of organisms and commercial products for biological control (UVHVVR 2022d).

Due to its location, Slovenia is one of the most diverse countries in the Balkan Peninsula and central Europe in terms of arthropod species richness. Slovenia, located in the northwestern Balkans, is mostly mountainous and forested. The southwest part of the country borders the Adriatic Sea. Moreover, Slovenia is a unique country in terms of its wide variety of habitats, due to the contact of geological units and biogeographical regions, and human influences. The country is home to four terrestrial ecoregions: Dinaric Mountains mixed forests, Pannonian mixed forests, Alps conifer and mixed forests, and Illyrian deciduous forests. When all the geographical and ecological features mentioned above are considered together, it is thought that the region may have great potential for the discovery of new and native phytoseiid species. However, the number of phytoseiid species previously reported from Slovenia is quite low compared to some other European countries such as Greece (about 120 species), France (about 110 species), Germany (about 75 species), Italy (about 100 species), and Spain (about 80 species) (Demite *et al.* 2023). So far, only 36 species of phytoseiids belonging to 13 genera are known in Slovenian fauna (Kreiter *et al.* 2020).

Among them, *Amblyseius andersoni* (Chant), *Neoseiulus californicus* (McGregor), *N. barkeri* Hughes, *N. cucumeris* (Oudemans), *Euseius gallicus* Kreiter and Tixier, and *Typhlodromus pyri* (Scheuten) are listed as indigenous organisms for biological control in Slovenia (UVHVVR 2022b). Therefore, detailed information on the feeding habits, food preferences, and biological control potentials of these species is presented herein. This study is a continuation of a two-year survey of the distribution of predatory mites in Slovenia (Kreiter *et al.* 2020) and discusses the interest in the results of the surveys in poorly known countries. Some limitations of importing exotic BioControl Agents (BCAs) and the interest to be independent of the international market, underlined in the Nagoya protocol, are more and more transcribed worldwide in National regulations. This limits the market of BCAs between countries.

Presentation of six species of indigenous Phytoseiid predatory mites in Slovenia

Amblyseius andersoni (Chant)

Amblyseius andersoni (Figure 1) was first described by Chant in 1957 based on individuals collected from prune in Rosedale, British Columbia, Canada. Natural populations of *A. andersoni* are currently known in about 30 countries and four continents including Europe (Demite *et al.* 2023). It has been observed on cultivated plants in orchards (apple, peach, pear, and citrus) and vineyards, particularly in humid areas (Chant and Hansell 1971; Papadoulis and Emmanouel 1991; IvancichGambaro 1994; Papaioannou-Souliotis *et al.* 1994; Nicotina 1996; Duso and Pasini 2003; Ragusa 2006). It has been reared on a commercial scale since 1995 and utilized to control several mite species such as the two-spotted spider mite *Tetranychus urticae* Koch, the apple rust mite *Aculus schlechtendali* (Nalepa), the European red mite *Panonychus ulmi* (Koch), the western flower thrips *Frankliniella occidentalis* (Pergande) and the tomato russet mite *Aculops lycopersici* (Massee) (Knapp *et al.* 2018).

This species was the second most common phytoseiid mite after *Typhlodromus pyri* during surveys conducted between 1997-2003 in the Podravje and Prekmurje regions in Slovenia, (Miklavc and Milevoj 2007). In the following years, it was found in some regions, such as



Figure 1 Adult female of *Amblyseius andersoni* (photo: Institut Agro Montpellier).

the Ljubljana basin area in 2012 and Primorska (Sermin) in 2017. By 2018, it was collected from a series of host plants such as grape (*Vitis vinifera* L.), sour cherry (*Prunus cerasus* L.), walnut [*Juglans regia* (L.)], apple (*Malus domestica* Borkh.), linden (*Tillia cordata* Mill.), oak (*Quercus robur* L.) in many places including Straža, Ravni, Arnovo Selo, Pacerag, Izola, Pesnica, Bukovica, and Ljubljana (Bohinc *et al.* 2019; Kreiter *et al.* 2020).

According to the classification system proposed by McMurtry *et al.* (2013), *A. andersoni* is a type IIIb generalist predator living on glabrous leaves. It can feed and reproduce on a wide range of food sources, including plant-feeding mites belonging to Eriophyidae, Tarsonemidae, Tetranychidae, and Tenuipalpidae families, as well as on thrips, whiteflies, and nematodes (Nguyen *et al.* 2015). In addition, in the absence of its preliminary prey, *A. andersoni* feeds and reproduces on the pollen of *Typha latifolia* L. and the mycelium of grape downy mildew (GDM) *Plasmopara viticola* (Berk & Kurt) Berlese & de Toni (Lorenzon *et al.* 2012). It can also utilize plant exudates and honeydew as survival food in the absence of its preliminary prey (McMurtry and Croft 1997). Therefore, contrary to the many other specialized phytoseiid mites to their prey, *A. andersoni* may still be abundant in natural and agricultural ecosystems without any additional support or release.

In addition, Szabo and Penzes (2013) found that high numbers of *A. andersoni* mites were overwintering in the ground litter in a Hungarian apple orchard. After transferring the ground litter to a new young orchard, the orchard became rapidly infested with *A. andersoni*. The population count of leaf samples showed that the species became the dominant phytoseiid mite in the orchard, in one growing season only. The case indicated that the ground litter acted as a perfect source and shelter for *A. andersoni*. In the wild, this species also found a reservoir and hibernation site at the wild red champion *Selene dioica* (L.) Clairv. plant, which has hairy leaves and produces a sufficient supply of nectar and pollen (Helyer *et al.* 2014). Because *A. andersoni* shows a wide range of tolerance to temperature and could be still active at lower temperatures, it can be considered a key predator to be used in the biological control of aforementioned pests at the early stages of infestations when temperatures are lower (Li *et al.*, 2019). Furthermore, previous studies also reported that the wild populations of *A. andersoni* showed a remarkable level of tolerance to a wide range of pesticides such as bifentazete, indoxacarb, pymetrozine, tebufenozide in the State of Washington (James 2002) and in Northeastern Italy (Pozzebon *et al.* 2015). Therefore, due to the reasons explained above, *A. andersoni* could be considered one of the most suitable BCAs for IPM programs.

***Neoseiulus barkeri* Hughes**

Neoseiulus barkeri (Figure 2) was first described by Hughes in 1948 based on the material collected from barley in England. It is a cosmopolitan phytoseiid species and its natural



Figure 2 Adult female of *Neoseiulus barkeri* Hughes (photo: Johan Witters).

populations are reported in more than 50 countries on different continents including Australia, Africa, Europe, and North America (Milevoj 2011; Demite *et al.* 2023). In addition to its natural populations, *N. barkeri* has been commercialized for biological control of several thrips species, in particular onion thrips *Thrips tabaci* Lindeman and western flower thrips *Frankliniella occidentalis* (Pergande), and also tarsonemid mites (Tarsonemidae), since 1981 (Fan and Petitt 1994a; Knapp *et al.* 2018; UVHVVR 2022b). It is also used against *T. urticae* in cucumber (Fan and Petitt 1994b). Fan and Petitt (1994a) showed that augmentative releases of *N. barkeri* provided control of *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) on peppers. The presence of *N. barkeri* in Slovenia was first confirmed by Kreiter *et al.* (2020) based on a single female collected from a cucumber (*Cucumis sativus* L.) field in Bukovica village.

According to McMurtry *et al.* (2013), *N. barkeri* is a type IIIe generalist predator from soil-litter habitats. Besides its predation potential on thrips species, *N. barkeri* has also been used for the biological control of the broad mite *P. latus* in protected crops (Fan and Petitt 1994a). In addition, laboratory and greenhouse experiments have shown this predator to be a successful biological control agent for the management of bulb scale mite, *Steneotarsonemus laticeps* (Halbert) (Acari: Tarsonemidae), a serious pest of amaryllis in European countries (Messelink *et al.* 2012).

The juvenile period of *N. barkeri*, from the egg-hatching until the emergence of adults lasts 7-8 days at 25 °C. The lifespan of adult females is 55-70 days depending on the diet, while it is shorter for males (around 44-47 days). One adult female may produce 1.3 to 1.9 eggs per day, depending on the diet, and up to 56 eggs over its life span (Momen 1995). When the adult females fed on *T. urticae* protonymphs, under laboratory conditions, consumption may reach up to 20.95 protonymphs/day and around 541 protonymphs for a total of 25.83 reproductive days (Momen 1996).

Wu *et al.* (2016) also reported that releases of *N. barkeri* significantly reduced both larval and adult western flower thrips in greenhouse-grown cucumbers during the seven weeks of the study period. The same study also proved that the entomopathogenic fungi *Beauveria bassiana* Bals.-Criv., which is often used by growers as a biological control agent against the same pest, can cause up to 77.5% mortality in the predatory mites *N. barkeri*. The interactions between multiple natural enemies are important aspects of biological control and in case the interaction is unbeneficial, a different strategy should be applied in the release of multiple BCAs. Wu *et al.* (2017) found that the single application of *B. bassiana* followed by the release of *N. barkeri* two

weeks after spraying further suppressed *F. occidentalis* population in five weeks. According to the authors, while *Beauveria bassiana* reduced *F. occidentalis* populations by 70 and 64%, for the years 2013 and 2015, *N. barkeri* further reduced the pest populations by 72 and 75% in the same period, respectively.

***Neoseiulus cucumeris* (Oudemans)**



Figure 3 Adult female of *Neoseiulus cucumeris* (photo: Institut Agro Montpellier).

Neoseiulus cucumeris (Figure 3) was first described by Oudemans in 1930 based on the material collected from *Cucumis melo* L. (Cucurbitaceae) in Bure, Meurthe et Moselle, France. It is a cosmopolitan species and its natural populations were reported in about 50 countries in Asia, Europe, America, and Australia (Demite *et al.* 2023). It has been reared on a commercial scale since 1985, and utilized to control several pest species in particular *T. tabaci* and *F. occidentalis* (Knapp *et al.* 2018; UVHVVR 2022b). It is now become one of the top four phytoseiid mites used as biological control agents (Knapp *et al.* 2018). Products based on *N. cucumeris* are available in the Slovenian market (UVHVVR 2022d). In Slovenia, *N. cucumeris* was found for the first time in a single location in an intensive apple orchard between 1997 and 2003 (Miklavc 2006). It is an abundant phytoseiid species in the northeastern part of the country and is mainly found in cucumbers and peppers (*Capsicum annuum* L.) (Milevoj 2011).

Similar to *N. barkeri*, *N. cucumeris* is also known as a type IIIe generalist predator from soil-litter habitats (McMurtry *et al.* 2013). Like many other generalist phytoseiid mites, *N. cucumeris* can be reared on acarid mites. Its predation and reproduction potentials were proven on *Polyphagotarsonemus latus* (Banks), *Phytonemus pallidus* (Banks), *T. urticae*, and also on fungi (Gerson *et al.* 2003). It is also can feed on different kinds of pollens and establish a remarkable population before pest arrival (Ranabhat *et al.* 2014).

These predatory mites prefer warm temperatures for their development, with the lower temperature and relative humidity consecutively thresholds being around 8 °C and 65%. Above that, the higher the temperature the faster their development until around 30 °C. At 35 °C only 50% of the eggs hatch and 90% of the larvae will not survive in two days. Mating is essential for *N. cucumeris* reproduction and must be repeated several times because egg-laying females only produce eggs for around 20 days after their emergence, and then they die. The success of *N. cucumeris* against thrips depends on the size of the prey larvae. First-instar thrips larvae are taken easily compared to the second-instar larvae, as well as the larvae from smaller thrips species. On optimum conditions, an adult predatory mite can consume around six first instar thrips larvae a day (Malais and Ravensberg 2004).

In a laboratory study conducted by Li *et al.* (2021), *N. cucumeris* was fed with the eggs of *Tyrophagus curvipenis* Fain and Fauvel (Acari: Acaridae) as an alternative food source.

On this diet, *N. cucumeris* needs approximately six days to complete the juvenile stage with a prey density of at least 60 eggs, while at lower food density they die as deutonymphs because of starvation. The larvae are not predacious, whereas the protonymphs and deutonymphs are actively searching for food. In general, the higher the prey population resulted in higher predation, with up to 66.30 eggs preyed out of 80 *T. curvipes* eggs provided. It was also found that at the same prey density, the predator with conspecifics ate significantly fewer eggs compared to the lone predator.

***Neoseiulus californicus* (McGregor)**



Figure 4 Adult female of *Neoseiulus californicus* preying on a two-spotted spider mite immature (photo: Institut Agro Montpellier).

Neoseiulus californicus, previously known as *Amblyseius californicus* (Figure 4), was first described by McGregor in 1954 based on a single male collected from lemon in Whittier, California, USA. Its natural populations have been reported in about 30 countries around the world (Demite *et al.* 2023). It has been available in international markets since 1985 for spider mite control. Nowadays, together with other three phytoseiid mites species, namely *Amblyseius swirskii* Athias-Henriot, *Phytoseiulus persimilis* Athias-Henriot, and *N. cucumeris*, it covers two-thirds of the entire arthropod biological control agent market (Knapp *et al.* 2018). However, there had been confusion concerning the true identity of *N. californicus* until its type specimen had been located by Beaulieu and Beard (2018). Although the latter authors figured out that the type specimen of *N. californicus* is identical to the male of *N. barkeri*, and the well-known species which is commercially available in international markets is identical to the *N. chilensis* (Dosse), they proposed to maintain the usage of the name *N. californicus* (McGregor) for the species concept of Athias-Henriot (1977) (Beaulieu *et al.* 2019).

In Slovenia, the species was first recorded in 2012 in Korte (Primorska region), and Ljubljana areas on various crops, such as watermelon (*Citrullus lanulus* [Thunb.] Matsum. and Nakai), eggplant (*Solanum melongena* L.), and apple (*Malus domestica* Borkh.), both in the greenhouses and in the open fields (Trdan *et al.* 2013). After that, its populations were found in many regions in Slovenia, such as in central Slovenia and Slovenian Istra, on many vegetables, fruits, and ornamental plants (Milevoj 2011; Trdan *et al.* 2013; Bohinc *et al.* 2019). The commercial products of *N. californicus* are available in the Slovenian market (UVHVVR 2022d).

Neoseiulus californicus is a type II selective predator of tetranychid mites. It prefers to feed on spider mites (Gomez-Moya *et al.* 2009), but can also consume other mite species of

phytophagous mites of other families such as Eriophyidae, Tarsonemidae, and Tydeoidea, like for example the tarsonemid mite *P. pallidus* (Easterbrook *et al.* 2001), small insects such as thrips (Rodriguez-Reina *et al.* 1992) and even pollen when prey is unavailable (Rhodes and Liburd 2006; Ragusa *et al.* 2009) (Figure 5). Therefore, in the absence of spider mite prey, this species can survive by consuming other food sources such as thrips, molds, and plant exudates and nectars (Malais and Ravensberg, 2004). This species develops faster when the temperature is warmer, with a lower temperature and minimum relative humidity threshold of around 10 °C and 60% (Malais and Ravensberg 2004). Lebdi-Grissa *et al.* (2004) showed that *N. californicus* developed well at 24, 30, and 35 °C. The fastest juvenile development from egg to adult and the generation time decreased with increasing temperatures, with the best result (3.9 days and 8.6 days) at 35 °C. However, the development parameters showed better results at 30 °C, with the highest net reproduction rate of 23 female progenies/female, survival of immature mites of 90%, and fecundity of 35.2 eggs/female. At 24 °C, the value of the female lifespan is the highest, which was 15.7 days. A similar result reported by Nguyen and Amano (2009) stated that the mating duration is inversely related to the temperature for the temperature 18-30 °C. However, the optimum temperature for an egg-laying female was 25 °C, with a total of 46.1 eggs laid in a life cycle. In addition, previous studies reported that dry-adapted strains of *N. californicus* showed greater levels of tolerance to low humidity compared to the other phytoseiid species (Walzer *et al.* 2007; Palevsky *et al.* 2008; Döker *et al.* 2016).



Figure 5 Eggs and adult females of a laboratory-reared population of *Neoseiulus californicus* feeding on *Tetranychus urticae* (red form) (photo: İsmail Döker).

According to Marafeli *et al.* (2011), although *N. californicus* can feed and reproduce in all life stages of *T. urticae* it prefers the larvae. The authors found that adult males, adult females, nymphs, and larvae of *N. californicus* consumed an average of 21.9, 34.2, 18.7, and 9.9 *T.*

urticae larvae per day, respectively. Adult females are found to be the most efficient predator with a predation rate of 86.3% out of 40 given prey. It can migrate from grasses to fruit trees or grapevines and vice versa (Auger *et al.* 1999). It is a specialist predator of *T. urticae* on annual plants and woody species; and of *P. ulmi* and various *Tetranychus* spp. (and perhaps eriophyid mites) on trees and less frequently on grapevines (Auger *et al.* 1999).

***Euseius gallicus* Kreiter and Tixier**



Figure 6 Adult female of *Euseius gallicus* (photo: Juliette Pijnakker).

Euseius gallicus (Figure 6) was first described by Kreiter and Tixier in 2010 based on the material collected from *Prunus cerasus* L. (Rosaceae) in Montpellier, France (Tixier *et al.* 2010). Subsequent studies showed that its natural populations are widely distributed around European countries including Slovenia (Döker *et al.* 2014; Tsolakis and Ragusa 2017; Bohinc *et al.* 2018; Kreiter *et al.* 2020). This species was first found in Slovenia in Šempeter pri Gorici (Primorska region) in 2017, on the blackberry (*Rubus fruticosus* L.) leaves (Bohinc *et al.* 2018). In 2018, it was found in Sečovelje (Parecag) on the persimmon tree (*Diospyros kaki* Thunb.), in Dragonja on the turpentine tree (*Pistacia terebenthus* L.), and in Lucija on cucumbers (Bohinc *et al.* 2019).

In general, the *Euseius* species are known as pollen-feeding generalist predators and belong to the type IV group (McMurtry *et al.* 2013). These species are general feeders and can consume mites, thrips, plant sap, and pollens (University of California 2022). In addition, they can also feed and survive on plant tissues without causing economic damage, when their primary prey are absent (Nomikou *et al.* 2003; Adar *et al.* 2012). Furthermore, due to the presence of more pollen, their populations increase and peak during the blossoming period of crops or other plants nearby in the absence of any arthropod prey (Croft *et al.* 2004). Due to their role as a standing army on the plants before pest arrivals, they might be considered one of the most important components of IPM programs.

The larvae of *Euseius* spp. do not feed while the nymphs and adults are active predators. The color of nymphs and adult mites depends on their diet, can be red after feeding on red mites, yellow after feeding on thrips, and white after consuming pollens. Except when feeding or molting, they usually avoid direct sunlight and move quickly. The development time from egg

to adult is 6-10 days, and the females live around 30 days and produce up to 27 eggs depending on the variety of their diets. In a warm place like California, 8 to 12 generations per year can be reported (University of California 2022).

Pijnakker *et al.* (2014) reported *E. gallicus* as a promising biological agent against western flower thrips in the greenhouses of cut roses in the Netherlands. In this case, *F. occidentalis* occurred in the greenhouse at a low number and resulted in visible cosmetic damage on cut roses. Due to the low number of prey, the other predatory mites such as *P. persimilis* failed to make good colonization and protect the plants. *Euseius gallicus* in combination with additional commercial pollen established a stable population even six weeks of the absence of the pest prey.

Van Houten *et al.* (2016) reported that the development time from egg to egg-laying female is affected by temperature. At 13 °C, the development takes 22 days with 1.1 eggs laid/day/female, while at 25 °C, the development takes 5 days only with 3.6 eggs laid/day/female. The same source also reported that the oviposition rates of female *E. gallicus* are different depending on the diet. On *T. lativolia* pollen and the combinations of those pollens with the first instar of *F. occidentalis*, the oviposition rates were the highest, which were reported at 3.85 eggs/day/female. The predation of *E. gallicus* to the first instar of *F. occidentalis* is recorded at 2.60 killed thrips a day, and the number declined close to zero kills a day when *T. lativolia* pollens were also available in their diet.

***Typhlodromus pyri* Scheuten**



Figure 7 Adult female of *Typhlodromus pyri* preying on a two-spotted spider mite female (photo: Institut Agro Montpellier).

Typhlodromus pyri (Figure 7) was described by Scheuten in 1857 based on the material collected from *Pyrus communis* L. (Rosaceae) in Bonn, North Rhine-Westphalia, Germany. It is a cosmopolitan species and its natural populations have been reported in over 40 countries around the world (Demite *et al.* 2023). In addition, it is also reared on a commercial scale and available in international markets since 1990 (Knapp *et al.* 2018). It was found to be the most dominant species in intensive apple orchards in Slovenia between 1997 and 2003 (Miklavc and Milevoj 2007).

According to McMurtry *et al.* (2013), *T. pyri* is a type IIIa generalist predator that lives on pubescent leaves. It can feed and reproduce on several food sources such as grapevine leaf rust mite *Calepitrimerus vitis* (Nalepa), European red mite, two-spotted spider mite, and grape erineum mite *Colomerus vitis* (Pagenstecher), as well as on several plant pathogenic fungi

(Zemek and Prenerová 1997; Pozzebon and Duso 2008; UVHVVR 2022b). Despite its ability to feed on plant tissues and produce some apparent scars on apple leaves and fruits, the damage caused by this predator is considered minor and without economic importance (Sengonca *et al.* 2004).

Miklavc (2006) conducted a comprehensive study on the life cycle *T. pyri* fed with European red mites and brown almond mites *Bryobia rubrioculus* (Scheuten). They showed that around 8-10 days period is needed for the development of *T. pyri* from eggs until the end of the deutonymph stage, for both males and females irrespective of the diet. The lifespan of *T. pyri* females on both diets was similar, i.e. 27.5 days on *P. ulmi* and 25.4 days on *B. rubrioculus*. Also, one single female adult produces up to 17 eggs, with average oviposition of 6.94 and 8.33 eggs per female insect, consecutively on *P. ulmi* and *B. rubrioculus* diets.

Zacharda and Hluchy (1997) reported the success of *T. pyri* as a biological agent against two-spotted spider mites in greenhouse strawberries. It was introduced with a predator: prey ratio of 1:10. After two weeks of release, the population density of active instars of *T. urticae* was reduced by 50%. The introduction of *T. pyri* was done in early April, and then this biological control agent protected the strawberry plants for at least six weeks before *T. urticae* population started to slightly increase. A more recent study by Lorenzon *et al.* (2018) reported the successful control of spider mites, *Eotetranychus carpini* (Oudemans) and *P. ulmi* in a vineyard in Veneto, Italy. The control was successfully conducted by the release of *T. pyri*, with or without the addition of another predatory mite *Kampimodromus aberrans* (Oudemans). However, the presence of *T. pyri* reduced the population of the naturally occurring predatory mite *A. andersoni*, suggesting intraguild predation of *T. pyri* to the resident phytoseiid*.

Conclusions

In this paper, we present six species of predatory mites, which currently represent 17% of the species on the list of indigenous organisms for biological control in Slovenia. It is a list of natural enemies that Slovenian farmers can use to control pests of cultivated and wild-growing plants. Although 36 species from the Phytoseiidae family, which is the world's best-known family of predatory mites, have been found on the territory of Slovenia (Kreiter *et al.* 2020), at least three of the world's most widespread species cannot be used in biological control in our country, as they do not yet have the status of indigenous species in Slovenia. *Amblyseius swirskii*, *P. persimilis*, and *A. limonicus* were already recorded in Primorska region, but according to Kreiter *et al.* (2020) most likely originated from commercial releases into greenhouses.

Predatory mites, the use of which is recommended for the biological control of phytophagous mites, thrips, and whiteflies, both in greenhouses and outdoors, will continue to gain importance in the future, as biological control represents an increasingly widespread alternative to chemical control of plant pests (Barratt *et al.* 2018; Trdan *et al.* 2020). With the planned large reduction in the use of pesticides in Europe already in the near future (EIP-AGRI, 2022), the most likely use of biological control agents will be among the most common measures to maintain the abundance of harmful organisms below the harmful threshold.

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