Agriculture, Ecosystems and Environment 233 (2016) 67–74

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Intraguild predation among spiders and their effect on the pear psylla during winter

Petráková Lenka[a], Michalko Radek[a,b], Loverre Pamela[a], Sentenská Lenka[a], Korenko Stanislav[c], Pekár Stano[a,*]

[a] Department of Botany and Zoology, Faculty of Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic
[b] Department of Forest Ecology, Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, Brno 613 00, Czech Republic
[c] Department of Agroecology and Biometeorology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences, Kamýcká 129, 165 21, Prague 6 – Suchdol, Czech Republic

ARTICLE INFO

Article history:
Received 20 January 2016
Received in revised form 27 July 2016
Accepted 4 August 2016
Available online xxx

Keywords:
DNA detection
Biological control
Overwintering
Specific primers
Intraguild predation

ABSTRACT

Generalist predators may provide biocontrol service if (1) they are abundant in an agroecosystem, (2) intraguild predation is low, (3) alternative prey is scarce, and (4) pest population increase is slow. These conditions are met in fruit orchards during winter and in early spring. Spiders of the genera *Anyphaena* and *Philodromus* remain active during winter and prey on pests, including overwintering *Cacopsylla pyri*. As these spiders belong to the same guild they can also disrupt their biocontrol potential via intraguild predation. Hence, we aimed here to assess predation frequency on *Cacopsylla* and among these spiders over the course of two winters. We investigated the width of the trophic niche and prey preference of the two winter-active spider species. We developed specific primers and investigated the actual predation by means of molecular methods (DNA detection of prey in the gut of spider predators). From a dozen of potential prey types (11 arthropod orders) offered in the laboratory, both *Anyphaena* and *Philodromus* accepted the majority of them. The trophic niches of both species were thus wide and the overlap was considerable. Both *Anyphaena* and *Philodromus* preferred *Cacopsylla* to spiders. In the field, the frequency of *Anyphaena* individuals which fed on *Cacopsylla* was very high both at the beginning and at the end of winter. The frequency of *Anyphaena* individuals which fed on *Philodromus* was low throughout the two studied winters. The ambient temperature did not affect the frequency of which fed on the pest. Over the two winters, *Anyphaena* captured *Cacopsylla* significantly more often than *Philodromus*. Our results show that winter-active spiders accepted the pear psylla frequently and that intraguild predation was much lower than predation on the pest. Thus winter-active spiders have potential to be used as biocontrol agents.

1. Introduction

The population dynamics of pests are governed by bottom-up and top-down processes (Gratton and Denno, 2003). The latter include the effect of natural enemies, which are abundant in many agroecosystems, such as pome fruit orchards (McMullen and Jong, 1967; Solomon et al., 2000). Some of these predators can have a significant effect on the regulation of pests. This is particularly true for specialised predators, such as coccinellids or predatory mites (e.g. Solomon et al., 2000). Euryphagous predators (i.e. feeding on a wide variety of prey types), which are often much more abundant in agroecosystems, also contribute to the suppression of pests as they may act in synergy (Losey and Denno, 1999). For example, when they have complementary spatial niches and so reduce the enemy-free space for pests (Marc et al., 1999). A number of studies showed that generalist predators can suppress certain pests, particularly early in the season (e.g. Fagan and Hurd, 1994; Riechert, 1999; Boreau de Roince et al., 2013).

The pear psyllids, *Cacopsylla pyricola* (Förster) and *C. pyri* (L.) (Hemiptera: Psyllidae), are considered important secondary pests that can cause significant damage to pear tree foliage and fruits when natural enemies are absent (Solomon et al., 2000; Daugherty et al., 2007). The winter form adult psyllids spend the winter on the buds or under tree bark and when the ambient temperature increases to above 5 °C, they start to invade the foliage of the pear trees, feeding by sucking plant sap (Alston, 2007). Current

---

* Corresponding author.
E-mail address: pekar@sci.muni.cz (S. Pekár).

http://dx.doi.org/10.1016/j.agee.2016.08.008
0167-8809/

management strategies to combat psyllids are based on chemical control early in the season (Westigard et al., 1979; Kocourek and Stará, 2006). In the season, psyllids are consumed by a number of predatory arthropods, such as true bugs, lacewings, coccinellid beetles, and spiders (Solomon et al., 2000; Daugherty et al., 2007; Michalko and Pekár, 2015).

Most spider species abundant in agroecosystems are euryphagous predators (Young and Edwards, 1990; Olszak et al., 1992). Euryphagous spiders can have a strong biocontrol effect on psyllids when other prey is limited. This happens during winter because many insects enter diapause and hide when the temperature drops below a lower temperature threshold. A few spider species actually remain active even during harsh winters. Species of the genera *Anyphaena* and *Philodromus* were found to capture prey at temperatures near to or even below zero (Korenko et al., 2010). Species of these genera are very common in commercial orchards in central Europe and overwinter on the trees (Bogya et al., 1999; Pekár, 1999; Isaia et al., 2010; Korenko and Pekár 2010; Pekár et al., 2015).

These species are assumed to be euryphagous predators (Michalko and Pekár, 2015). They actively hunt spiders on the foliage of trees, thus belong to the same guild (Cardoso et al., 2011). As a consequence, due to euryphagy, their biocontrol potential can be disrupted via intraguild predation (IGP) (Polis and Strong, 1996; Finke and Denno, 2005; Straub et al., 2008). The existence of stage-structured populations in these predators facilitates IGP as older (larger) stages of one species catch younger (smaller) stages of the other (Polis and Holt, 1992). IGP can be severe – in particular, when alternative prey is scarce, e.g. during overwintering (Korenko and Pekár, 2010). IGP has been frequently observed among spider species in a variety of agricultural habitats but has rarely been quantified. Thus, the degree to which IGP limits the *Cacopsylla* suppression is unknown.

Recently, using a simulation of a complex IGP model system, we have shown that these two spider species can contribute considerably to the reduction of winter populations of *C. pyri* (Pekár et al., 2015). The model was parametrised using values obtained from laboratory experiments and field observations under varying temperature. The predictions of the model corresponded well with the real situation, but the frequency of predation in the field was only estimated not observed. This is because spider predation is difficult to observe in the field due to the small size of spiders, their cryptic behaviour, and their mode of feeding. Spiders feed by liquid ingestion and it is impossible to find solid prey remains in their gut contents (Greenstone, 1999). Modern approaches such as gut content detection by DNA fingerprinting and other molecular techniques (Sunderland et al., 1999) allow the possibility of reliable prey detection. In fact, the molecular detection of prey-specific DNA that remains in the gut of predators, such as spiders, by polymerase chain reaction (PCR) based techniques is currently widely applied (Symondson, 2002; King et al., 2008; Pompanon et al., 2012; Chapman et al., 2013). This approach can reveal predation events without disturbance and provides prey-predator interaction data at species level.

Our aim in this study was to find the widths of the trophic niches and prey preferences of two winter-active spider species that are dominant in a pear orchard. We quantified the actual predation on *Cacopsylla* and among these spiders over the course of two winters. We supplemented laboratory feeding trials with prey DNA detection in field-captured spiders. For this purpose, we developed specific primers and tested the DNA degradation rate under a low temperature that corresponded to winter temperatures in central Europe.

2. Materials and methods

2.1. The study site

The field work was conducted in a commercial pear orchard in Brno, Czech Republic (49° 9′ 41.635″ N; 16° 35′ 27.612″ E). The orchard is 6.5 ha in area. The pear trees are planted in rows separated by a distance of 3 m. The trees are 27 years old and approx. 2.5 m tall. During each of the studied winters, no pesticides were applied in the orchard. A number of spiders were found on the bark of pear trees during winter, in particular *Anyphaena accentuata* (Walckenaer) (subsequently named *Anyphaena*); *Philodromus* spp. (*P. cespitum* (Walckenaer), *P. buchari* Kubcova, *P. albidus* Kulzcynski, *P. praedatus* O. P.-Cambridge, and *P. aureolus* (Clerck), subsequently named *Philodromus*); *Dictyna* spp.; *Micaria* spp.; and *Theridion* spp. (Pekár, unpublished). Concerning psyllids, only one species, *Cacopsylla pyri* (subsequently named *Cacopsylla*), was found to occur in the orchard. Forty five cardboard traps (80 × 35 cm) were installed around the trunks (one per tree) in October 2013. The traps were wrapped around trunks 50 cm above the ground. Regularly, 15 randomly chosen traps were inspected for winter-active spiders at each sampling date.

Temperature records (day means) over the two winters were obtained from a thermometer installed in the orchard, situated 0.5 m above ground, and set to record temperature every 10 min throughout the year.

2.2. Prey acceptance

Specimens of *Anyphaena accentuata* (N = 120) and *Philodromus buchari* (N = 26) both in juvenile stages were collected from corrugated cardboard trap bands installed on tree trunks in the pear orchard in the spring, then brought to the laboratory and kept in a chamber at 15–20 °C under a 12:12 h (L:D) photoperiod. Each spider was kept singly in a tube (15 mm diameter, 60 mm long) and provided with a few drops of water once per three days. The average prosoma length of *Anyphaena* spiders was 2.3 mm (SE = 0.02) and that of *Philodromus* was 1.8 mm (SE = 0.01). The spiders were fed *ad libitum* three days before the start of experiments using *Drosophila melanogaster* (Meigen) flies. Individuals of *P. buchari* were reared to adulthood to confirm species identity using Nentwig et al. (2014) and Kubcová (2004).

Fourteen prey types were used in the experiment (Table 1). Prey specimens were either collected by beating tree branches in the pear orchard (Araneae, Acari, Sternorrhyncha, Heteroptera, Neuroptera, Hymenoptera, Lepidoptera) or came from laboratory cultures (Collembola, Orthoptera, Coleoptera, Diptera). The size (body length without appendages) of all offered prey was measured using an ocular micrometer in an Olympus SZ 40 stereomicroscope with an accuracy of 0.1 mm.

After three days of starvation, spiders were placed singly in Petri dishes (5 cm in diameter) with a filter paper at the bottom. In the case of *Anyphaena*, 20–30 individuals were randomly selected from the whole sample to test for each prey type thus an incomplete block design was used. Each individual (i.e. the experimental unit) was tested with two or three prey types. In the case of *Philodromus*, a complete block design was used, i.e. each specimen was tested with each prey type, which was offered in a random order. Altogether, 318 trials with *Anyphaena* and 286 trials with *Philodromus* were performed.

After five minutes of acclimatisation, one prey individual was released into the dish. If the spider accepted the prey, it was left to consume it and another prey was offered after three days. If the spider did not accept the prey, it was removed and another prey type was offered. The prey was classified as accepted if the spider