Occurrence and impact of the parasitic mite *Linobia coccinellae* on its host beetle *Chrysomela populi*: implications for its potential as a biological control agent

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Abstract

Due to social demands with regard to sustainability and ecological considerations, an aim of current research in short-rotation coppices (SRC) is to find effective candidates for biological control of pest species. The great red poplar leaf beetle, *Chrysomela populi* L. (Coleoptera: Chrysomelidae), is one of the most harmful pests in the SRC. The endoparasitic mite *Linobia coccinellae* (Scopoli) (Acari: Astigmata, Hemisarcoptidae) lives under the elytra of *C. populi* and feeds on the beetles’ hemolymph. The population dynamics of the mites and their impact on the fecundity and longevity of female beetles were examined in two experiments. To study the occurrence of the mites, beetles were collected from two poplar SRC sites in Germany on three dates. Infestation rates of collected male and female *C. populi* individuals increased over the course of the year and reached 78–97% in the last survey. Females were parasitized more often than males at any time. For the second part of the study, beetles were reared under laboratory conditions to study the development of the mites and their impact on the hosts. For this purpose, half of the females were actively seeded with five adult females of *L. coccinellae* and the other half was used as a control. There was no significant impact on longevity or reproductive traits of the beetles. Despite the high rates of infestation, it appears that the mites do not have a serious effect on female beetles. Thus *L. coccinellae*, by itself, is not an effective biological control agent against *C. populi*. However, it remains to be investigated whether the mites increase the beetles’ susceptibility to other biotic and abiotic factors, and so may contribute to an integrated pest management regime with multiple antagonists.

Introduction

Plantations of fast-growing tree species provide a source of woody biomass for sustainable energy production. In Germany, fast-growing species, such as poplars (*Populus* spp.), willows (*Salix* spp.), and, to a lesser extent, black locust (*Robinia pseudoacacia* L.) are used in short-rotation coppices (SRC). Biotic pests are a serious issue for SRC. Kennedy & Southwood (1984) reported 189 phytophagous insect and mite species associated with poplar, and Führer & Bacher (1991) reported 189 phytophagous insect and mite species associated with poplar, and Führer & Bacher (1991) reported 121 known species of pathogens and insects that can cause serious damage on poplar. Poplar SCR are established by vegetatively produced cuttings (clones). This genetically homogeneous structure makes them even more vulnerable to certain diseases (Tabbush & Parfitt, 1999; Georgi et al., 2018). The red poplar leaf beetle, *Chrysomela populi* L. (Coleoptera: Chrysomelidae), is one of the most common and harmful insect pests of poplar (Templin, 1957; Loi, 1970). Two (under favourable conditions three) overlapping generations of the beetle develop in a single year (Urban, 2006). In spring, at temperatures of 12–13 °C, adults leave their overwintering places and start to feed on young leaves of poplars (Urban, 2006). Urban (2006) and Loi (1970) provide comprehensive accounts on the distribution and biology of *C. populi*. The feeding can cause extensive damage to the growth of the plants, especially on seedlings and on
resprouting SRC (Augustin & Lévéque, 1993). Massive and repeated feeding by *C. populi* can result in delayed appearance of foliage by up to 1 month, or in the death of the tree (Georgi et al., 2018).

To date, high densities of this pest species have been controlled using chemical measures. In addition to those conventional pest-control methods, there is a growing interest in identifying new biological control agents (e.g., pathogenic microorganisms, predatory arthropods, or parasitic insects) to initiate ecologically sustainable pest management programs (Eickwort, 1983a). The subclass of the mites (Acari) seems to be a promising source of potential biological control agents because they comprise a large number of species (between 0.5 and 1 million), of which numerous species have already been proven to influence pests (Holt et al., 2013; Knapp et al., 2018).

Previous studies have shown that the astigmatine mite *Linobia coccinellae* (Scopoli) (Hemisarcoptidae) is found regularly on *C. populi* (Haitlinger, 1999; Trach, 2007). Eickwort (1983a) mentions that *L. coccinellae* “[…] has the same control potential for the Colorado potato beetle as does *Chrysol Cornelobia labidomerae,*” but does not refer to a particular study to prove this point. As there have been no other studies dealing with the occurrence and the influence of *L. coccinellae* on its host, we decided to determine its potential as a biocontrol agent in an integrated pest management (IPM) strategy for SRC.

*Linobia coccinellae* lives under the elytra and hind wings or on the abdomen of *C. populi* where it feeds on the host’s hemolymph (Trägårdh, 1943; O’Connor, 1982; Haitlinger, 1999). Individuals of *L. coccinellae* are milky white and have an oval or pentagonal, soft idiosoma (Baker & Wharton, 1952; Tarasi et al., 2001). Females are larger than males: females are 485–498 μm long and 291–349 μm wide, whereas males are 378–485 μm long and 242–300 μm wide (Tarasi et al., 2001). For their developmental stages egg, larva, protonymph, tritonymph, and adult a change of host is not necessary. Usually astigmatine mites go through a deutonymph stage, which is highly specialized for phoretic dispersal. However, *L. coccinellae* does not have a deutonymph stage as a consequence of the permanent association with its host species *C. populi* (O’Connor, 1982). Infestations of *L. coccinellae* can be so severe that they may cover nearly the entire abdomen of the beetle, and such infestations may have a negative impact on the host (Georgi et al., 2012). To date, knowledge of the ecology of *L. coccinellae* is scarce and incomplete.

A well-studied species is the mite *Chrysomelobia labidomerae* Eickwort (Podapolipidae), which is an ectoparasite of the milkweed leaf beetle, *Labidomera clivicollis* (Kirby), and has a very similar life cycle to *L. coccinellae*. *Chrysomelobia labidomerae* also feeds on the hemolymph of its host, it parasitizes the host in large numbers, and does not depend on a change of host individual to complete its development (Baker & Eickwort, 1975; Eickwort, 1975). Under laboratory conditions, Baker & Eickwort (1975) studied the population dynamics of *C. labidomerae* and its impact on *L. clivicollis*. They concluded that even at very high population densities *C. labidomerae* has a non-pathogenic effect on its host, as verified by Eickwort & Eickwort (1986) over the course of experiments to identify a potential biological control agent for the beetle. In contrast to these results, Abbot & Dill (2001) detected that the survival of stressed and malnourished adults of *L. clivicollis* is reduced and the mating performance of male beetles changes when there are high densities of *C. labidomerae*.

Podapolipid mites indistinguishable from *C. labidomerae* were reported on Colorado potato beetles, *Leptinotarsa decemlineata Say*, in Mexico (Eickwort, 1983a) – these mites were indicated to influence the mortality and fecundity of the host, and they might provide a basis for biological control programs.

As these studies have not produced unambiguous results regarding the impact of the mites on their hosts, there is still a need for investigation of the impact of *L. coccinellae* on *C. populi*. This study consists of two parts. First, the proportion of adults of *C. populi* infested by the mite and the number of mites on the beetle were determined over the course of the year. Second, the influence of *L. coccinellae* on the longevity and fertility of *C. populi* was investigated.

### Materials and methods

#### Occurrence of *Linobia coccinellae* in the field

This part of the study was conducted from May to July 2012. Examination sites were two short-rotation coppices (SRC) in Germany. The first SRC was in Großschirma, Saxony (50°58′04.8″N, 13°13′08.4″E), established in 2010 on an area of 13 ha, including the poplar varieties Max 1, Max 3, Max 4 (*Populus nigra × P. maximowicizii*), and NE42 (*P. maximowicizii × P. trichocarpa*). This SRC was used as a plant nursery and harvested annually. The other SRC was in Sorno, Brandenburg (51°34′37.2″N, 13°39′14.4″E), was planted in 2009 on an area of 6 ha, and contained the poplar varieties AF2 (*P. nigra × P. deltoides*), Max 1, Max 4, and Androscoggin (*P. maximowicizii × P. trichocarpa*). A smaller part (ca. 0.7 ha) of the SRC was newly planted in March 2012, which was mainly used for this study.

One aim of this study was to identify potential differences in parasitism between male and female beetles. As the beetles cannot be reliably sexed based on external morphological differences, samples of poplar leaf beetles in copula were randomly collected from the poplar leaves.
Impact of Linobia coccinellae on the host beetle

The second part of the study extended from June to August 2014. On the SRC Großschirma, pupae and adults of the poplar leaf beetle were collected. Adults were kept at room temperature in rearing boxes with fresh branches of the poplar clone Max 3 and sorted by the density of infestation with *L. coccinellae*. Pupae were placed individually in glass vials with gauze-caps and kept for the whole study in an Economic Premium ICH climate chamber (Snijders Scientific, Tilburg, The Netherlands) at 25 ± 1 °C, 70 ± 10% r.h., and L16:D8 photoperiod. After emerging, beetles were placed separately in clear plastic Petri dishes with three vents (94 mm diameter, 16 mm high) which contained young leaves of the poplar clone Max 3. To prevent the leaves from drying out, a thin layer of agar (CAS-nr. 9002-18-0) was added to the Petri dishes. Beetles were fed, cleaned, and the agar was replaced at 1- to 2-day intervals. The sex of the beetles was determined using data on the genital papillae. If mites were present, they were counted using a stereomicroscope and distinguished into three categories: eggs, larvae, and post-larval stages – larvae and later stages (protonymph, tritonymph, and adult) were differentiated by the number of leg pairs: three vs. four, respectively. We did not further differentiate post-larval stages, because this would have required the removal of all guanine from mites with concentrated potassium hydroxide (KOH). Only after that, determination based on the genital papillae is possible with a light microscope. This is very elaborate and for matters of occurrence, a precise stage differentiation is not relevant.

For every individual beetle, the body length was determined using a digital caliper (accuracy of 0.1 mm) and the weight was determined using a digital laboratory scale (accuracy of 0.001 g). Then, the elytra and hind wings were cut and the entire beetle was examined for mites of the species *L. coccinellae*. The number of mites per host beetle may be associated with the beetles’ length and/or body weight. If mites were present, they were counted using a stereomicroscope and distinguished into three categories: eggs, larvae, and post-larval stages – larvae and later stages (protonymph, tritonymph, and adult) were differentiated by the number of leg pairs: three vs. four, respectively. We did not further differentiate post-larval stages, because this would have required the removal of all guanine from mites with concentrated potassium hydroxide (KOH). Only after that, determination based on the genital papillae is possible with a light microscope. This is very elaborate and for matters of occurrence, a precise stage differentiation is not relevant.

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Five days after emergence of the females, one uninfested male (1–5 days old) was added to each Petri dish that contained one infested or one uninfested female. Those pairs of beetles were kept separately in the climate chamber. Males were added to prevent unintended impact by the mating status, which is known to influence longevity and fecundity of chrysomelid beetles (Zhao et al., 2019). The beetles were checked at 1- to 2-day intervals for the vitality and number of eggs laid. Eggs were removed after counting. Once a week, the infested females were examined for the development of the mites using the same procedure as described before, pinning the beetle and digitally storing the photographs of the abdominal terga. The hind wings and the elytra of females of the control group were raised once a week for a few seconds to expose them to comparable stress as the infested beetles. Dead males were replaced, as long as males were available. As the study focuses on the influence of mites on female beetles only, males were removed when an associated female died. The sex of every dead beetle was determined by dissection of its genitals. The study ended with the death of the last female on 24 August.

Statistical analysis

All statistical analyses were carried out in R v.3.5.3 (R Core Team, 2019) using the R packages ‘dplyr’ v.0.8.0.1 (Wickham et al., 2019) and ‘tidyr’ v.0.8.3 (Wickham & Henry, 2019). The graphs were plotted with the package ‘ggplot2’ v.3.1.1 (Wickham, 2016). To determine whether the means of two normally distributed groups are equal, the two-sample t-test was used. As a non-parametric alternative, we used the Mann–Whitney U test. The level of significance (α) is 0.05. Survival analysis was based on the Kaplan–Meier estimator from the ‘survival’ package in R v.2.43-3 (Therneau & Grambsch, 2001; Therneau, 2015). This is a non-parametric means of estimating survival while taking into account the censoring time (Kaplan & Meier, 1958). For statistical comparison of the survival
curves, a log-rank test was performed, which calculates the $\chi^2$ for each event time for each group and sums the results. The summed results for each group are added to derive the ultimate $\chi^2$ to compare the full curves of each group (Rich et al., 2010).

**Results**

**Occurrence of Linobia coccinellae in the field**

In total 599 beetles (298 females, 301 males) were collected on the three dates at the two sites. A few beetles escaped from the transport box, which explains the difference in number of female and male beetles despite collecting pairs. As intended, the number of collected beetles was about 100 for each survey, except for Sorno on 12 June. On 21 May, the plantation manager of Sorno applied a chemical treatment using ‘Karate Forst flüssig’ (100 g l$^{-1}$ lambda-cyhalothrin; Syngenta Agro, authorization nr. 005618-00) in the 0.7-ha part of the plantation that had been established in March 2012 to control a locally limited high density of *C. populi*. Because of this, we were only able to find three beetle pairs at Sorno during the second survey at this site. Therefore, the informative value for this day is very limited.

**Length and weight of Chrysomela populi.** On average female beetles are larger than males, but the distributions of length and weight overlap (Figure 1). Mean (± SD) body length (10.6 ± 0.5 vs. 9.6 ± 0.4 mm) and weight (0.14 ± 0.02 vs. 0.08 ± 0.01 mm) differed significantly between the sexes (t-test: $t = 28.5$, d.f. = 597, $P < 0.001$).

**Parasitism rate of Chrysomela populi.** Over the course of the year, the percentage of adult *C. populi* parasitized by *L. coccinellae* increased on both collection sites (Table 1). The rate of parasitized individuals in Sorno already exceeded 50% in May, whereas this value was surpassed in Großschirma at the second survey, in June. Except for the first collection at Großschirma the percentage of infested males was lower than the percentage of infested females in all surveys. The difference in parasitism rates between the sexes was larger at Großschirma.

A distinct difference was seen in the parasitism rate of beetles between the two collection sites. At the first collection, in May, in Sorno beetles were infested more than twice as often as in Großschirma. Also at both other dates, beetles were 15–20% more frequently parasitized in Sorno than in Großschirma.

**Stage abundance of Linobia coccinellae.** The numbers of eggs, larvae, and post-larval stages (protonymph, tritonymph, and adult) of *L. coccinellae* on adults of *C. populi* fluctuated widely between the collection dates, collection sites, and individual beetles (Table 1). More mites were found on female than on male beetles [mean ± SD = 97.4 ± 126.1 (n = 191) vs. 28.0 ± 43.5 (n = 171); Mann–Whitney U test: $W = 22,040$, $P < 0.001$]. The number of mites also differed between the collection sites (Sorno: 73.0 ± 108, n = 166; Großschirma: 57.5 ± 96.6, n = 196; $W = 13,284$, $P = 0.003$).

The maximum number of eggs of *L. coccinellae* per beetle was 525, the maximum number of larvae was 171, and the maximum number of post-larvae was 192. The maximum total number of stages – found on a female beetle

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Figure 1 Distribution of body length (mm) and weight (g) of female (n = 298) and male (n = 301) *Chrysomela populi* adults collected on three dates and two sites.
| Collection date | 2 May 2012 | 11 June 2012 | 9 July 2012 |
|-----------------|------------|--------------|-------------|
|                | ♂ | ♀ | Total | ♂ | ♀ | Total | ♂ | ♀ | Total |
| **Großschirma** |   |   |     |   |   |     |   |   |     |
| Parasitism rate (%) | 35 | 21 | 28 | 50 | 83 | 66 | 63 | 92 | 78 |
| n               | 100 | 100 | 200 | 50 | 46 | 96 | 49 | 50 | 99 |
| No. eggs        | 1.0 ± 3.0 | 19.9 ± 42.6 | 8.1 ± 27.4 | 15.4 ± 24.1 | 76.3 ± 82.4 | 52.1 ± 72.0 | 9.1 ± 16.7 | 30.6 ± 49.2 | 21.9 ± 40.7 |
| No. larvae      | 0 | 0 | 0 | 12.2 ± 16.9 | 38.6 ± 40.1 | 28.1 ± 35.2 | 0.3 ± 1.4 | 4.6 ± 11.3 | 2.9 ± 9.0 |
| No. post-larvae | 4.3 ± 8.1 | 17.1 ± 29.5 | 9.1 ± 19.9 | 13.6 ± 18.7 | 43.9 ± 48.9 | 31.9 ± 42.3 | 6.9 ± 13.1 | 24.1 ± 48.6 | 17.2 ± 39.2 |

| Collection date | 2 May 2012 | 12 June 2012 | 17 July 2012 |
|-----------------|------------|--------------|-------------|
|                | ♂ | ♀ | Total | ♂ | ♀ | Total | ♂ | ♀ | Total |
| **Sorno**       |   |   |     |   |   |     |   |   |     |
| Parasitism rate (%) | 61 | 70 | 66 | 67 | 100 | 83 | 96 | 98 | 97 |
| n               | 49 | 50 | 99 | 3 | 3 | 6 | 50 | 49 | 99 |
| No. eggs        | 5.7 ± 9.5 | 15.3 ± 35.3 | 10.9 ± 27.0 | 39.5 ± 47.4 | 90.0 ± 86.7 | 69.8 ± 31.9 | 45.8 ± 49.0 | 140.7 ± 127.5 | 93.2 ± 107.3 |
| No. larvae      | 0 | 0 | 0 | 18.0 ± 4.2 | 26.7 ± 26.0 | 23.2 ± 19.1 | 2.8 ± 9.5 | 9.5 ± 21.7 | 6.1 ± 17.0 |
| No. post-larvae | 2.6 ± 3.0 | 3.4 ± 6.0 | 3.0 ± 4.9 | 57.0 ± 32.5 | 68.0 ± 73.1 | 63.6 ± 54.5 | 5.5 ± 3.9 | 13.2 ± 13.9 | 9.3 ± 10.9 |
collected on June 11 in Großschirma – was 639 (415 eggs, 171 larvae, 53 post-larvae). The average number of larval and post-larval stages was highest at the second collection in June on both sites. Even in June, a high number of eggs was recorded. In the third survey fewer eggs were found at Großschirma but more at Sorno.

Simple linear regressions were calculated for male and female beetles to predict number of mites per host based on beetle length and weight, but no significant regression equations were found.

Impact on longevity and reproductive traits of female *Chrysomela populi*

Dissection of the genitals of dead individuals showed that eight beetles in the control group and 10 beetles in the parasitized group were incorrectly sexed. Therefore, only 27 parasitized females and 25 females in the control group were used for further analysis.

The seeding of female *C. populi* with *L. coccinellae* was successful. Development took place on all infested adults. The first mite eggs were observed after 1 week, the first larvae after 2 weeks, and the first post-larval stages after about 3 weeks (Figure 2). The number of post-larvae slightly decreased after 4 weeks, possibly by a host change of the first adult mites, infecting the male *C. populi*. The maximum number of mite eggs per beetle was 260, the maximum number of larvae was 171, and the maximum number of post-larvae was 395. The maximum total number of stages found at the same examination was 419 individuals.

No significant influence of *L. coccinellae* on longevity and various reproductive traits of *C. populi* was found (Table 2) despite the high number of mites in the infested group (compare Figure 2). Infested and control beetles lived equally long (mean ± SD = 40.6 ± 9.8 vs. 41.2 ± 9.8 days; Mann–Whitney U test: W = 315, P = 0.68; Table 2). The survival probability of adults of *C. populi* with and without parasitization by *L. coccinellae* was similar, as indicated by the Kaplan–Meier curves and the median survival times (Mparasitized = 39 days, Mcontrol = 41 days; Figure 3).

The mean time between emergence of the beetles and the day when we could find the first eggs of *C. populi* (pre-oviposition period) was 14.0 days for both groups (Table 2; Mann–Whitney U test: W = 350, P = 0.82).

![Figure 2](image)

**Figure 2** Mean (± SD) number of eggs, larvae, and post-larvae (protonymph, tritonymph, and adult) of *Linobia coccinellae* per female adult of *Chrysomela populi* seeded with five adult mites 5 days after emerging, at 5 weekly intervals, that is, on average 1–41 days after seeding.

| Development stage | No. mites |
|-------------------|-----------|
| Eggs              | 0 ± 0     |
| Larvae            | 8 ± 0.9   |
| Post-larvae       | 16 ± 0.8  |
|                   | 24 ± 0.7  |
|                   | 30 ± 1.4  |
|                   | 41 ± 8.7  |

Table 2  Mean (± SD) longevity (days) and reproductive traits of females of *Chrysomela populi* parasitized with *Linobia coccinellae* or unparasitized (control group)

|                | n  | Longevity (days) | Pre-oviposition period (days) | Oviposition period (days) | Lifetime egg production (no. eggs) |
|----------------|----|------------------|------------------------------|--------------------------|-----------------------------------|
| Parasitized    | 27 | 40.6 ± 9.8       | 14.0 ± 1.7                   | 14.5 ± 14.5              | 358.7 ± 182.8                    |
| Control        | 25 | 41.2 ± 9.8       | 14.0 ± 2.0                   | 18.1 ± 10.4              | 393.8 ± 153.1                    |

There are no significant differences between treatments (Mann–Whitey U test: P > 0.05).
found eggs) of infested vs. control females was 14.5 ± 10.5 vs. 18.1 ± 10.4 days (W = 255.5, P = 0.14). During the first 24% of the number of eggs laid was almost identical (mean ± SD cumulative number of eggs laid after 24 days, infested females: 272 ± 114; control females: 299 ± 109). After this, control females laid slightly more eggs than infested females. The total number of eggs laid did not differ between the two groups (t-test: t = −0.7, d.f. = 50, P = 0.46; Table 2).

**Discussion**

The results revealed a high occurrence of *L. coccinellae* on *C. populi* collected at two poplar SRC sites in Germany on various dates. Up to 97% of the collected adults in the field were parasitized by the mite with densities of up to 639 individuals (all development stages) on a single host. On average, female beetles were colonized with 97.4 ± 126.1 mites, males with 28.0 ± 43.5. Unfortunately, the number of collected beetles was very low at Sorno on 12 June because the chemical pesticide Karate Forst flüssig had been applied on 21 May. However, due to the limited area of application (0.7 out of 6 ha), it is very unlikely that the insecticide had an impact on the third sampling. After the efficacy of the product had diminished (approximately 4 weeks after application), the beetles were able to re-colonize the plantation from the surrounding areas. The proportion of adult *C. populi* parasitized by *L. coccinellae* increased during the course of the year and females usually exhibited a higher density of infestation. Mites of the family Hemisarcoptidae, to which *L. coccinellae* belongs, have shown a preference for female hosts, presumably because fertilized females look for a more varied and richer diet to guarantee optimal development for their eggs and larvae (Gerson et al., 2003). Also, females of *C. populi* are bigger than males, have a pronounced abdomen and, hence, have more hemolymph available for the individuals of *L. coccinellae*.

A high rate of infestation would suggest a negative effect on the individuals of *C. populi* in some way. However, as Eickwort (1983a) noted, it seems that the feeding of parasitic mites on phytophagous insects is too harmless to kill their host. Besides, it is not in the interest of the mite to kill the host before the completion of its own life cycle (Eickwort, 1983a). In our survey, an impact of *L. coccinellae* on the fecundity and longevity of *C. populi* could not be detected, even though beetles might have experienced high levels of stress when held under laboratory conditions, had food of lower quality, and were checked for mites regularly. Although the number of five mites as initial density was chosen in accordance with observations in the field and the number of mites in the laboratory experiment was very similar to that in the field, it cannot be excluded that this initial number was too low to have an impact on the host. A repetition of the experiment with higher initial densities would help to gain further insight.

The negative results of this study do not exclude any other possible indirect effect on the beetles, especially when they are exposed to natural conditions in the field. The effect of parasitism on a host is not necessarily evident in increased mortality, but may be found in various indirect impacts such as decreased fecundity, reduced success in mating, or increased mortality through a higher exposure of individuals to other stresses (Crawley, 1992). For instance, *L. decemlineata* was less able to fly when infested with *C. labidomerae* (O’Neil et al., 2005). In addition, there might be an effect on *C. populi* by individuals of *L. coccinellae* from a different location and population. A high rate of close inbreeding between the mites led to local co-adaptation with *C. labidomerae* as their host (Eickwort, 1983a). This could increase the success of locally different mite populations, having a negative effect on the host due to
different genetics in the target populations of *C. labidomerae*. Evidence of this conjecture was found in Mexico, when in the recent past a population of *C. labidomerae* was found on *L. decemlineata*, with mites morphologically identical to those of *L. clivicollis*, their usual host in North America. Unlike with *L. clivicollis*, the pathogenic effect on *L. decemlineata* was found to be significantly greater (Eickwort, 1983a).

This study showed that the mite *L. coccinellae* occurs regularly and in high densities on *C. populi* in poplar short-rotation coppices. Five female mites seeded artificially on female adults of *C. populi* did not have any significant influence on longevity and reproductive traits of their hosts. These results disprove the categorization of *Linobia* by Eickwort (1983a) as a family of mites that deserves immediate evaluation or implementation, due to its significant impact, which he based on findings of others. A possible explanation would be a too low initial density of mites in our laboratory study. To be able to make final statements for the potential use of *L. coccinellae* as biocontrol agent in an IPM program, further research is needed. A question still to be answered is whether mites have an impact on the survival of overwintering beetles. Furthermore, it is not clear whether the mites increase the beetles’ susceptibility to other biotic and abiotic factors. Thus, based on the present data it is impossible to exclude a potential impact of *L. coccinellae* on *C. populi*. With regard to the literature and our own observations in the field, we would expect a minor effect by *L. coccinellae* on the beetles with higher initial densities of mites as well as on beetles with additional stress factors.

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