Understanding earwig phenology in top fruit orchards

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Abstract

Earwigs, Forficula auricularia, *are key generalist predators to a variety of orchard pests. However, numbers of earwigs have declined in both organic and IPM orchards in recent years. Both Integrated and Organic fruit growers have tried to re-establish earwig populations, thus far with little success. To understand earwig population dynamics and to find measures to increase natural orchard populations, we conducted a detailed phenological survey of earwigs in orchards. Earwigs were sampled while sheltering during daytime in artificial refuges. They move into the trees from the third nymph stage onwards. In most orchards, a small second brood is produced in summer, and this has a positive impact on population size in fall. We see only minor differences in phenology between apple and pear orchards, mainly caused by differences in alternative hiding places. Earwigs show an inexplicable reduction in numbers at the timing of moulting into adults. When earwig phenology is correlated with pest phenology in apple and pear, its use for pest control of major pests is clear.*

Keywords: *Forficula auricularia*, biological control, population dynamics, apple, pear

Introduction

The common earwig, *Forficula auricularia,* is a generalist feeder that survives on plant material, mosses or fungi, but, given the chance, preferentially consumes small arthropods (Phillips 1981). A number of lab studies focussing on specific orchard pests demonstrated earwig pest consumption ability of scale insects (Karsemeijer, 1973; McLeod & Chant, 1952), aphids, (Buxton & Madge, 1976; Noppert et al., 1987; Phillips, 1981), spider mites (Phillips 1981), and Psyllids (Lenfant, et al. 1994; Phillips, 1981). Only for four of these orchard pests, some studies attempted to demonstrate efficacy in more practically relevant semi-field or field trials. The best documented predatory effect of earwigs is that toward the woolly apple aphid *Eriosoma lanigerum*, a major pest in apple orchards with integrated or organic pest management. Both a study in Holland (Mueller et al. 1988) and in Australia (Nicholas et al. 2005) demonstrated a direct effect of earwig exclusion on woolly apple aphid proliferation, and a negative correlation between degree of aphid infestation and the number of earwigs present on the trees. Also in the highly abundant pear pest *Cacopsylla pyri*, a semifield test showed consumption of large numbers of eggs by earwigs confined to sleeves on pear branches (Lenfant et al., 1994). Field control of three more pest species was not clearly demonstrated: the same research team found contradictory results in controlling the green apple aphid *Aphis pomi* (Carroll & Hoyt, 1984; Carroll et al., 1985), while a small scale field study on the apple-grass aphid *Rhopalosiphum insertum* and the spider mite *Panonychus ulmi* could not demonstrate any effect of earwig presence (Phillips 1981).

Earwigs are univoltine. Males and females form pairs in fall and hibernate in underground nests. Once the female lays eggs in late winter or early spring, she expels the males and provides broodcare to eggs and the first nymph stage.

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Females abandon the nests when nymphs become second instars, these nymphs will disperse shortly thereafter and move to weeds, shrubs or trees. Especially around early summer (end of june, early july) abundance of late instar earwigs is present in orchard trees. Although the general life cycle of earwigs is well understood, most quantitative studies on earwig presence in orchards are limited to summer occurrence only, as earwigs are most abundant in July. To understand what limits the presence of earwigs in orchards, we conducted a detailed survey of earwig presence covering the whole season. To manage a univoltine species such as *F. auricularia* a good knowledge of its life history is required. The species was recently identified with molecular techniques as a complex of at least two sibling species, named species A and B (*sensu* Wirth et al., 1998). These species have distinct life history strategies, having either a single or two broods, and likely a slightly different timing of onset of egg-laying in winter.

Material and Methods

As earwigs are nocturnal, they readily hide in artificial refuges during the daytime. Providing two shelters in each of 10-20 trees per orchard allowed assessment of earwig numbers. Shelters consisted of corrugated cardboard rolls inserted in a Styrofoam coffee cup for rain protection and attached horizontally to a strong branch with iron wire. For earwig counts, cardboard rolls were opened and all earwigs collected in a tray. Nymphal stages were differentiated by size and antennal segments; male and female adults based on sexual dimorphism in cerci. Once counted, earwigs were released on the assessed tree and the shelter was returned to the same location within the tree. Earwigs were counted at least once a week, starting upon appearance in the trees (start of June) until adults migrate to the soil (end of October). Sampled orchards were a mix of IPM and organic orchards.

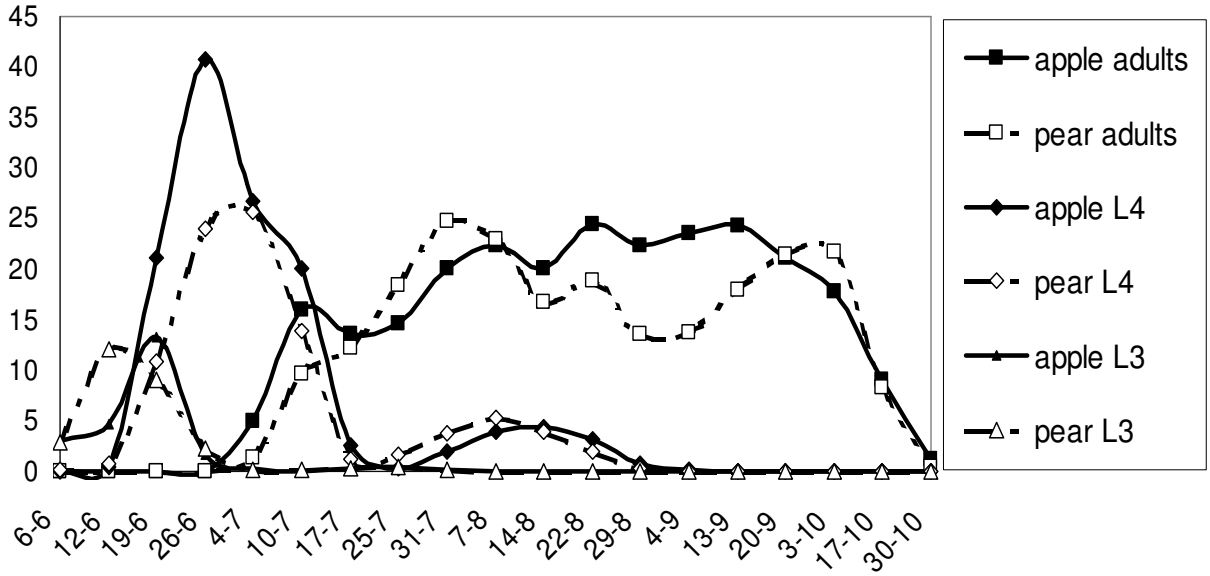

Figure 1: Average numbers of 3rd and 4th instar nymphs and adults in apple and pear orchards in Belgium

Results and discussion

Earwig larvae appear in the fruit trees from the end of May onwards. We observed very few L2 nymphs in the cardboard shelters (an average maximum of 1.57 in apple and 0.5 in pear, early june). From the third nymphal stage upwards, earwigs gradually became more abundant in the trees (Figure 1). The discrepancy between the peak of 3rd and 4th nymphal stages suggests that younger nymphs still dwell on the ground. Addition of shelters on the soil indeed enhanced the capture of 3rd instar nymphs.

Earwig numbers were greatest at the 4th nymphal stage. In both apple and pear orchards, a sharp decline in numbers was observed at the timing of moulting of L4 into adults, around mid July. We are currently testing several hypothesis as to what might cause this effect. In most orchards, earwigs produce a second brood, with a rather limited numerical contribution to the earwig population. In apple, the adult population observed in the shelters remains at a rather constant level, with a small increase when a second brood is present. In contrast, we observe a progressive decline of the adult population in pear in August, with a considerable increase in fall, after harvest. The pattern in pear is likely due to a sampling artefact, i.e. the reduced necessity for earwigs to use artificial shelters when pear clusters grow, offering numerous alternative hiding places. Once these hiding places are removed at harvest, the population again moves into the artificial refuges. The presence of a second brood has a positive effect on the population size in fall, a few orchards lacking a second brood show a gradual decline towards fall. The latter orchards clearly have a single species (the one with the single brood), but it is as yet unclear whether the other orchards have a mixture of both subspecies or solely the “two-brood” subspecies.

To estimate the predation potential of earwigs on the main orchard pests, we roughly correlated earwig phenology with pest phenology as was observed at the Gorsem research station for the past 50 years (Table 1). The phenology of earwigs is ideal to help control summer and fall generations of *E. lanigerum* in apple and *C. pyri* in pear. Exclusion experiments in apple orchards indeed showed that these pests increase when earwigs are absent (Mueller et al., 1988; Nicholas 2005). Earwigs are also likely to assist in controlling summer generations of leafrollers and various Lepidopteran pests. The potential earwig impact on codling moth (*C. Pomonella*) will be minor, as only eggs and recently hatched larvae are exposed. Once the codling moth larvae penetrated the fruit skin, it is well protected from earwig predation within the fruit, and be only at risk again in a late stage when the bore hole is large. Earwigs come to late in the trees to control most aphids, but might in some years assist in cleaning up colony remnants in June. This explains the variability in earwig control of green apple aphids described from successive field trials (Carroll & Hoyt, 1984; Carroll et al., 1985). Even when earwigs can consume red spider mite eggs (Phillips 1981), we believe the impact of earwigs on that pest to be minor compared to its control with predatory mites, the most proliferate beneficial in the majority of belgian apple orchards.

In sum, though earwigs will play a role in control of a variety of pest insects, their main contribution to biological control in top fruit will be against woolly aphid in apple and *Psylla* in pear. As Psyllid adults are highly mobile, earwig control will be restricted within a season. In contrast, earwig control of the fall population of *Eriosoma* will likely contribute to a reduction in numbers at the onset of the next season.

Table 1: The control potential of *F. auricularia* for major top fruit pests in Belgium, estimated by linking earwig and pest phenologies.

Main Top Fruit Pest species	Presence of damaging stage	Potential Forficula control	
Adoxophyes orana	1st generation: April	no	Earwigs still underground
	2nd generation: August	yes	Presence of adult earwigs, low numbers of nymphs
Dysaphis plantaginea	March to May	no	Earwigs still underground
Cydia pomonella	May to August	weak	Presence coincides but likely only eggs and recently hatched larvae can be reached by earwigs
Eriosoma lanigerum	Resume activity: March	no	Earwigs still underground, unknown whether they feed on root colonies
	Main migration: Mid May	no	Earwigs come too late to prevent migration
	Summer population	yes	Earwigs assist *Aphelinus* in controlling *Eriosoma* by mid July and throughout August
	Fall population	yes	Earwigs are main natural enemy at this point
Various aphids	March to June	weak	Nymphs (L3) might assist cleaning up colony remnants in June
Lepidosaphis ulmi	Year-round, migration May	likely	Migration is too early, but earwigs can likely feed on settled scales
Cacopsylla Pyri	2nd generation: May-June	weak	Earwigs are too late to prevent massive egg-laying and hatching, but L4 can feed on later larval stages
	3rd generation onwards	yes	Earwigs can feed on eggs and eclosed larva until October

Acknowledgements

This research was funded by IWT Agronomic Research grant N° 04-667. We acknowledge collaborating fruit growers, the fruit cooperatives and the Belgian organization for organic farming BELBIOR.

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