Trends in the foraging behaviour of ladybird beetles (Coccinellidae)

Faculty of Science

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Introduction:

Several factors influence the predation rate of carnivores, one of the most important one is prey density (Ives et al. 1993; Yasuda 1995; Yasuda and Ishikawa 1999). Experiments studying predation rate indicate a positive response of predation to aphid density (Dixon 1959; Sinha et al. 1982; Carter et al. 1984; Rotheray 1989; Ives et al. 1993). Positive relationships between density of the aphids and ladybird activity confirm experiments which are focused on aggregation behaviour of coccinellids (Frazer and Raworth 1985; Evans and Youssef 1992; Iperti 1999; Schellhorn and Andow 2005).

Differences in predatory behaviour are to be expected because males and females have different life history strategies (Hemptinne et al. 1996; Stearns 1989; Stearns 1992). Female have to obtain sufficient energy and above maintain themselves to be able to produce and lay maximum number of eggs (Matsura and Morooka 1983; Muthukrishnan and Pandian 1987). This reveals that the female need to spend more time foraging than the male (Kerr 2008; Muthukrishnan and Pandian 1987). Similarly experimental studies also record a positive effect of prey density on foraging rate of ladybirds (Yasuda and Ishikawa 1999).We hypothesized that foraging activity of the ladybirds should be positively influenced by the density of the aphids.

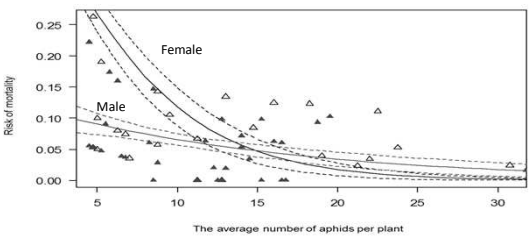

Fig. 1 Differences between the sexes (male = grey line and female = black line) in the risk of mortality (Risk of mortality expressed as total number of kills/ total number of aphids in the pot per study period) vs. average number of aphids per plant. Dashed lines indicate the SE .

Results:

- **We found that above a certain threshold level aphid abundance can negatively affect the ladybirds (defence mechanisms: kicking, alarm pheromone and production of sticky fluid).**
- **Ladybirds stayed a longer time in the patch with higher average density of aphids per plant.**
- **Degree of starvation was the most significant factor, which correlated with residence time.**
- **Turning rate, which indicates predatory activity, was higher in females.**
- **Females appeared to search more effectively than males when there were fewer aphids per plant**

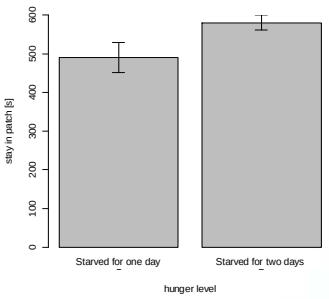

Fig. 3 Amount of time spent in a patch in different hunger levels. The bars show SE.

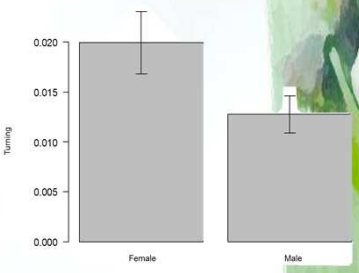

Fig. 4 Turning rates (turning is expressed as a number of turns per study period) recorded for male and female ladybirds. The bars show SE .

Predictions:

- **There will be differences in the behaviour between males and females → different targets (finding a partner for mating and finding food for the egg production).**
- **Increased prey density will positively influence predation rate and duration how long the predator stay in patch**

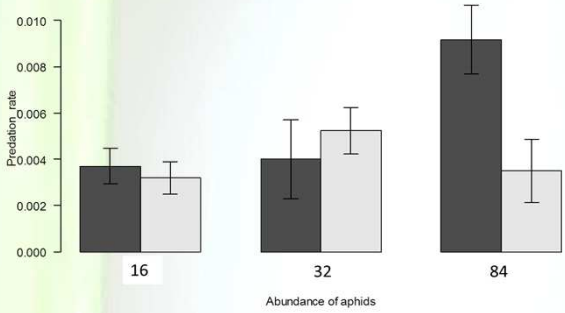

Fig. 2 The numbers of aphids killed (rate of predation) when male or female ladybirds (male = grey color and female = black color) were released on plants infested with one of three different densities of aphids (16, 32 and 84 aphids per pot). The bars show the SE

Matherials and Methods:

Experimental design

This experiment aimed to determine the effect of aphid density on predatory behaviour. Different numbers of aphids (84, 32 and 16) were placed on 4 barley seedlings. Ten barley seeds were planted per pot and latter thinned out so that there were 4 plants per pot. As model species we chose the ladybird *Coccinella septempunctata* as the predator and the aphid, *Rhopalosiphum padi*, feeding on barley, *Hordeum vulgare*, as the prey. There were 20 replicates of each treatment. Each replicate consists of a pot with same number of plants but different numbers of prey. Altogether 60 pots were used per experiment. For each replicate we randomly chose one ladybird which was placed at the base of a randomly chosen plant. Different ladybirds and different plants were used in each replicate to avoid pseudo replication. Ladybirds were then observed for 10 minutes or until they flew away.

Sampling method

We used focal sampling and continuous recording (Grevstad and Klepetka 1992; Clark and Messina 1998), which involved observing one individual for a specified amount of time and recording several different categories of behaviour. We transformed certain types of behaviours in to proportions (Predation rate = *No. of aphids consumed/600s*, Resting = *time spent resting/600s*, Turning = *No. of turns/600s*, Average aphids per plant = *total No. Of aphids per pot/number of plants per pot*, Risk of mortality = *total No. of aphids killed / total No. of aphids per pot*). The behaviours that can be specified as events (behaviour of short duration) were recorded as number of events per unit time. The states that are behaviour patterns with a long duration were measured as proportion of time spent performing the activity.

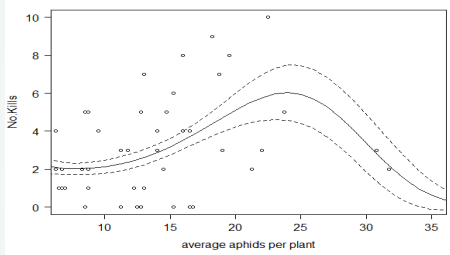

Fig. 5 Effect of abundance of aphids on number of kills. Dashed lines reprezent SE.

Conclusion:

Predation rate was positively influenced by increasing prey densities. Therefore, the timing of the release of ladybirds as a biological control agent should be done when aphid densities are high. Caution then needs to be taken since there can be a negative effect of prey density on predation rate beyond a certain threshold of aphid densities. In addition, the results confirm that the predation rate of the sexes of ladybirds differ significantly. Aphids are at a greater risk of being eaten when females are foraging on a plant and this may be associated with their cost of reproduction. Our findings generally are consistent with the results from the more realistic conditions like the greenhouse or the field. In biological control designs, both the gender of ladybird and positive and negative effect of prey densities on the predator should be considered.

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