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Semi-natural habitat contribution to Carabid beetle diversity and biocontrol potential in apple production

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Abstract

Understanding natural predator-prey dynamics is key to developing effective biological control strategies for IPM. The overall aim of this study was to gain knowledge of the epigeic predator species contributing to pest control in apple orchards. Several pest species, including the codling moth, Cydia pomonella, spend parts of their life cycle on the orchard floor, making them vulnerable to ground living predators including Carabid beetles. This study investigated the carabid community across a distance gradient from semi-natural habitats into the orchards. Results reported here are from the 2024 growing season (May-August). Over 1143 carabids were collected in pitfall traps and 59 carabid species were identified. Species composition, diversity and functional traits were assessed. Both diversity and abundance were significantly higher closer to the semi-natural habitat, with diversity decreasing by approximately 46 % from the semi-natural habitat to the furthest distance. Seasonal patterns were evident, with a decline in diversity and abundance toward the centre of the orchard later in the season. The findings support the theory that semi-natural habitats enhance diversity and contribute to ecosystem services such as biological control. This short communication presents results from the first of two years of sampling.

Keywords: Biocontrol, natural enemies, semi-natural habitats, ground-dwelling predators, pest control.

Introduction

Natural enemies play a key role in regulating pest species in agricultural systems. Among them, Carabid beetles (Coleoptera: *Carabidae*) are important generalist predators, contributing to pest suppression from ground level. Semi-natural habitats such as meadows, orchard edges, and hedgerows provide resources and overwintering sites for a wide range of arthropods, supporting functional biodiversity among predatory insects (Tscharntke et al., 2012; Rischen et al., 2022). Diversity in predator taxa and functional traits is associated with ecosystem stability and enhanced biocontrol potential (Snyder et al., 2008). Understanding the spatial and seasonal dynamics of carabids is therefore essential for optimising integrated pest management (IPM). This study investigates how semi-natural habitats affect the carabid diversity and abundance within orchards across the season and with increasing distance from the seminatural habitat.

Material and Methods

Field sampling and laboratory analyses were used to investigate the composition and functional diversity of ground-dwelling predators in Norwegian apple orchards. Three field collections were conducted from May 14th to August 12th (2024), in three orchards located in south-eastern Norway. Two of the orchards were managed organically, with every other row of grass cut at three weeks interval, and roto tillage under trees every 3-4 weeks, while the third was under conventional management, with IPM. At each location pitfall traps were placed at four distances: 1) in the adjacent semi-natural habitat, 2) in row 1, 3) in row 3 and

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4) in row 5 parallel to the semi-natural habitat. The distance between tree rows was 3,5 meters, leaving 14 meters between row 1 and 5. Distance between adjacent semi-natural habitat and row 1 varied between 3,5 and 5 meters. At each distance, three replicate pitfall traps were installed. In each orchard, the sampling area started 10 meters from the end of the rows and extended along a row of 66 trees also allowing a buffer zone in the other end of the orchard.

Results and Discussion

This study showed clear seasonal and spatial variation in carabid beetle diversity, highlighting the dynamic nature of biological control. Despite different management, no differences in diversity or abundance were found between orchards. Overall, carabid abundance remained relatively stable, indicating species specific seasonal patterns, rather than large fluctuations in total predator numbers. Distinct patterns emerge when considering sample date and distance from the semi-natural habitat (*Figure 1*). Diversity decreased in a gradient towards the middle of the orchard, while the abundance at the furthest distance was highest early and mid-season, suggesting that carabids exploit resources further into the orchard early in the season. Later, predator numbers declined within the orchard, likely reflecting movement toward semi-natural habitats for overwintering (Pywell et al., 2005; Holland et al., 2016). These spatial patterns support the spillover effect (Rand et al., 2006; Schneider et al., 2016), where edge habitats serve as reservoirs for beneficial arthropods in adjacent agricultural systems. The observed diversity reduction with increasing distance could reflect variation in mobility and dispersal capability of certain species. This theory corresponds to significant variations in functional traits and species composition between distances.

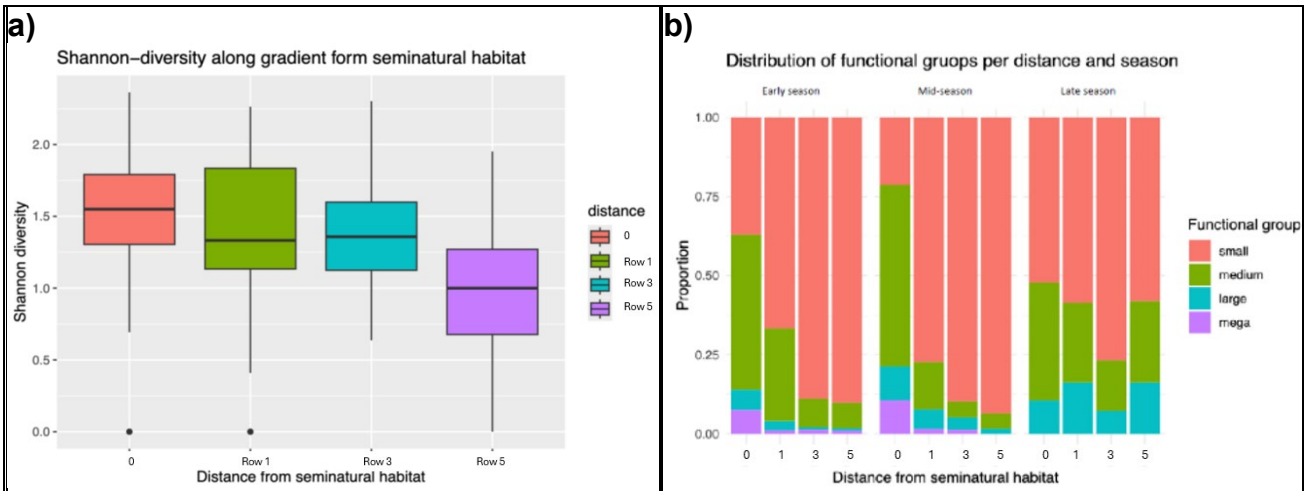

Figure 1: **a)** Shannon diversity index (H´) along a gradient of three distances (row 1, 3 and 5) from semi-natural habitat (0) and towards the middle of the apple orchard (row 5). Diversity decreased significantly with increased distance from the semi-natural habitat, and row 5 had significantly lower diversity compared to all other distances ($p < 0.001$). **b)** Relative distribution of carabid functional groups (body size) across distances. Size classes: small (<9 mm), medium (9-13 mm), large (13-21 mm), and mega (21-40mm). Data was collected in apple orchards three times during the growing season; early, mid and late season.

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