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Influence of seminatural habitats and management practice on arthropod biodiversity and pest control in Danish apple orchards

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Abstract

*Sustainable fruit production is balancing requirements of high yield, quality, and ecological sustainability. Achieving this balance depends on the interplay between orchard management practices, surrounding seminatural habitats, and the landscape orchards are embedded in. This study investigates how semi-natural habitats and orchard management affect arthropod natural enemy abundance and functional biodiversity, and their potential impact on major apple pests; the Apple sawfly (*Hoplocampa testudinea *Klug), the Rosy apple aphid (*Dysaphis plantaginea *Pass.), and the Codling moth (*Cydia pomonella *L.). We conducted visual observations and beating samples in 15 Danish apple orchards. Furthermore, we compared data from apple tree rows in the centre of the orchard with apple tree rows in orchard edges to assess local effects of semi-natural habitats. Overall, pest infestations were low in the investigated orchards, while variations seemed to depend on pest species dynamics. Results of overall arthropod diversity as well as natural enemy diversity indicated that orchard management rather than distance to semi-natural habitat supported the diversity of arthropod communities within the orchards.*

Keywords: Functional biodiversity, conservation biocontrol, natural enemies, predators

Introduction

Functional agrobiodiversity can potentially enhance ecosystem services such as natural pest regulation by supporting the presence of natural enemies such as predators and parasitoids. The concept encourages implementation and conservation of seminatural habitats, such as hedgerows and similar ecological infrastructures, to provide varied food resources, reproduction sites and shelter for overwintering of arthropod (Holland et al., 2016). Three major pest species in Danish apple orchards are the Apple sawfly (*H. testudinea*), the Rosy apple aphid (*D. plantaginea*), and the Codling moth (*C. pomonella*). Studies on the interactions between management practice and agroecological structures on natural enemy communities are of current relevance, both in terms of developing sustainable agricultural practices that support biodiversity, as well as the pest regulation potentially obtained by a higher functional diversity (Happe et al., 2019). Particularly the latter needs to be addressed in more depth within crop production (Holland et al., 2016). The aim of this study was to investigate effects of hedgerows and management practice on arthropod biodiversity and pest control in Danish apple orchards.

Material and Methods

Arthropod diversity was assessed by beating samples from apple trees, while pest infestation was assessed by visual observations of three major pest species. Assessments were conducted in 15 apple orchards located on Funen and Zealand, Denmark, in the

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growth season of 2024. In each orchard, assessments were done in one tree row in two different edges (2nd row from the edge) and in two tree rows adjacent, in the centre of the orchard. The orchards were selected based on criteria of orchard size, management practice (organic (n=7); conventional (n=8)), presence of hedgerows, and immediate landscape diversity surrounding the orchard. Visual observations were conducted by assessing the symptoms of each pest species on 10 apples per tree, in 20 trees per row. Observations of the Rosy apple aphid was conducted at young fruit development (BBCH 72), of the Apple sawfly before the second fruit fall (BBCH 74-76), and of the Codling moth before harvest (BBCH 80). Beating samples were conducted two times in the season: in the end of May after flowering and in the beginning of July after the second fruit fall. Beating samples were done by beating one branch per tree on a total of 33 trees in each row. Botanical surveys of spontaneous herbaceous and perennial vegetation within and around orchards were also conducted and will be considered in subsequent analyses of vegetation and arthropod diversity. The diversity of arthropods from the beating samples was calculated by the Shannon-Wiener diversity index and analysed by a Kruskal-Wallis test.

Results and Discussion

Overall, pest infestations were low across the 15 orchards investigated in 2024, while indicating higher infestations of the apple sawfly and the Apple codling moth in the organic compared to the conventional orchards, and for the Apple sawfly with higher infestation in the centre than in the edge of the orchards (Table 1). The opposite trend was observed for The Rosy apple aphid, that despite overall low infestation, indicated higher infestations in the edge than in the centre of the orchard (Table 1). Despite assessments done in the second row from the edge, the latter is likely a reflection of an edge effect, as aphids are often more abundant in edges than further into orchards (Howard et al., 2024; Jacobsen et al., 2022).

Table 1: Proportion of pest damage (%) by the Rosy apple aphid, the Apple sawfly, and the Apple codling moth, in conventional and organic, and in the centre and edge, of 15 Danish apple orchards. Overall damage represents data across management and locations of all orchards. ±StDev.

Proportion pest damage (%)	**Orchard management**		**Orchard location**		
	Conventional	Organic	Centre	Edge	Overall
Rosy apple aphid	**0.1** ±0.1	**0.5** ±0.2	**0.05** ±0.07	**0.6** ±0.3	**0.3** ±0.2
Apple sawfly	**0.3** ±0.2	**2.1** ±0.5	**1.7** ±0.4	**0.9** ±0.3	**1.3** ±0.4
Apple codling moth	**0.3** ±0.2	**1.1** ±0.7	**0.7** ±0.3	**0.6** ±0.3	**0.7** ±0.3

Management type (conventional vs. organic) rather than orchard location (centre vs. edge) defined differences in the diversity (Shannon-Wiener, H) of arthropods identified from the beating samples. Considering both, all arthropods identified, as well as the arthropods categorized as natural enemies, no differences in diversity indices were found between centre and edge of the orchards ($p=0.06$ and $p=0.47$ respectively). On the contrary, there was a higher diversity of all arthropods ($p<0.001$) as well as a higher diversity of natural enemies ($p<0.001$) in organic compared to conventional orchards (Fig. 1). Potential positive effects of seminatural habitats, such as hedgerows, on arthropod biodiversity and pest control, can depend on seasonal, spatial, functional, and managerial factors among others, as well as variations between sites and studies. While no differences were found in the preliminary results of the present study, other studies have found positive correlations between hedgerows and natural enemies (Bishop et a., 2023; Happe et al., 2019).

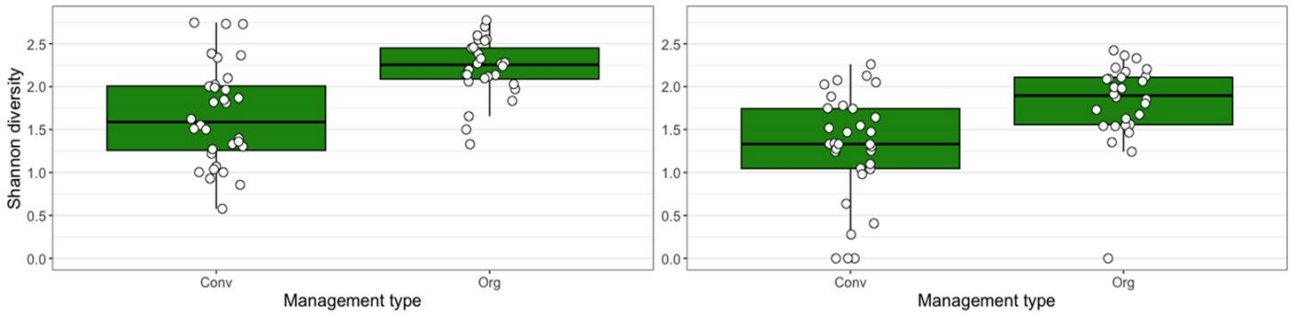

Figure 1: Boxplot of Shannon Diversity Index of all arthropods (left) and of arthropod natural enemies (right) from beating samples in conventional (conv) and organic (org) apple orchards. Each dot represents one sample, box limits indicate upper and lower quartile of data, and midline the median.

The results showed a higher arthropod diversity in organic compared to conventional apple orchards. This aligns well with similar studies showing positive effects of management on natural enemy abundance and biodiversity (Happe et. al., 2019; Schnerch et. al., 2025). The preliminary results presented highlight the impact of management, both on overall biodiversity, as well as of the functional group of natural enemies. We expect that further analyses, with an additional year of 2023 included, and more in-depth interpretation of functional groups, will provide knowledge on the composition of specific functional groups, e.g. spiders, as found by Schnerch et al. (2025), as an effect of management, but also of proximity to hedgerow, seasonality, and annual variations.

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References

Bishop, G.A., Fijen, T.P.M., Desposato, B.N., Scheper, J. & Kleijn, D. (2023). Hedgerows have contrasting effects on pollinators and natural enemies and limited spillover effects on apple production. *Agriculture, Ecosystems & Environment* **346**: 108364.

Happe, A.-K., Alins, G., Blüthgen, N., Boreux, V., Bosch, J., García, D., Hambäck, P.A., Klein, A.-M., Martínez-Sastre, R., Miñarro, M.,… & Modya, K. (2019). Predatory arthropods in apple orchards across Europe: Responses to agricultural management, adjacent habitat, landscape composition and country. *Agriculture, Ecosystems & Environment* **273**: 141-150.

Holland, J.M., Bianchi, F.J., Entling, M.H., Moonen, A.-C., Smith, B.M. & Jeanneret, P. (2016). Structure, function and management of semi-natural habitats for conservation biological control: a review of European studies. *Pest Management Science* **72**: 1638-1651.

Howard, C., Fountain, M.T., Brittain, C., Burgess, P. J. & Garratt, M. P. D. (2024). Perennial flower margins reduce orchard fruit damage by rosy apple aphid, *Dysaphis plantaginea* (Homoptera: Aphididae). *Journal of Applied Ecology* **61**: 821–835.

Jacobsen, S.K., Sørensen, H. & Sigsgaard, L. (2022). Perennial flower strips in apple orchards promote natural enemies in their proximity. *Crop Protection* **156**: 105962.

Schnerch, B., Bucher, R., Djoudi, E.A., Hossain, M., Niyibizi, I.A.B. & Birkhofer, K. (2025). Growth stage, management and habitat influence the taxonomic and functional composition of arthropod communities in apple orchards. *Agriculture, Ecosystems & Environment* **394**: 109901.

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