The impacts of agricultural intensification on arthropod assemblages at global and local scales

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Abstract

Agriculture has often resulted in large-scale habitat loss and simplification of ecosystems and the loss of biological diversity. However, agricultural landscapes can also provide habitat for a wide range of species. Whilst ecological research has tended to focus on natural habitats or native habitat components situated in agricultural systems, there is a growing realisation that production land can play an important role in ecological processes and conservation outcomes. In this thesis I explored a number of questions pertaining to the relationship between agriculture and biodiversity:

1. What drives agricultural change and how have different global patterns of agricultural development impacted upon biological diversity?

2. How do abundance and richness of different arthropod taxa and feeding guilds respond to land-use change globally?

3. How and why do Formicidae populations and assemblages vary among different land uses in a heterogeneous agricultural landscape?

4. Do body-size and morphological features of Araneae, Coleoptera and Formicidae assemblages differ among different land uses in an agricultural landscape?

5. How do arthropod assemblages of crops differ depending on the type of habitat that borders the crop field?

6. Does the rate of pest-predation in cropping vary depending on the adjacent habitat type?

Agricultural land-use change is often driven by an interacting combination of biophysical factors and socio-economic and political factors, and frequently impacts negatively on biodiversity. In this study I identified four broad patterns of how agriculture can impact on biodiversity globally, related to the history of agriculture in a region, and the trajectory of agricultural management intensification.

The impact of agriculture and the utilisation of agricultural land uses by arthropods are of particular importance, given the role that arthropods can play in driving fundamental ecosystem processes and functions upon which healthy
agricultural systems depend. In order to examine global trends in responses of arthropod communities to land-use change, I undertook a series of meta-analyses incorporating data from over 250 studies from the scientific literature. From this I found that arthropod richness declined along a gradient of agricultural intensification from native vegetation to improved pasture, to reduced-input cropping, to intensive cropping. Within feeding guilds, both predators and decomposers exhibited this response, but not herbivores. The decline of arthropod richness was greater between native vegetation and agricultural land than it was between different categories of agricultural land, implying that on average, the retention of native vegetation may be a more effective strategy in maintaining arthropod species richness than wildlife-friendly farming. However, low-intensity agricultural land uses were consistently more biodiverse than their intensive counterparts, indicating that wildlife-friendly farming may also be an effective conservation strategy where retaining native vegetation is not feasible or cost effective, or where native vegetation is already sufficiently protected or managed.

Having identified a range of globally consistent patterns of arthropod assemblage responses to different agricultural land-use and management change scenarios, I examined these in a geographically localised context, in a heterogeneous mixed farming landscape in southern Queensland, Australia. I examined patterns of Formicidae abundance, richness, and assemblage composition in three land-use types (native woodland, grazed pastures and crops) and the interfaces between them. The patterns of richness decline amongst land-use types observed for ants in the field study were broadly similar to those found in the global analyses. However, whilst the native woodland sites were the most biodiverse and the intensively managed cropping was biologically very impoverished, the pasture treatment contributed to landscape-level ant diversity in having a distinctive ant assemblage and several morphospecies restricted to this land-use type. This indicated that not only remnants of woody vegetation, but also elements of the agricultural matrix, should be considered in biodiversity management in agricultural landscapes.

I also examined if assemblages displayed different morphological trait patterns among the land-use types, potentially due to the differing levels of habitat modification and disturbance in the land uses. There were more small-bodied beetles and spiders in intensively managed cropping areas than in pastures and woodlands, and the incidence of highly mobile macropterous beetles was greatest in intensively
managed cropping. This indicates that intensively managed land uses may create suitable conditions for, and confer an advantage on, taxa that have small body size and high degrees of vagility. Such findings could be attributable to a range of factors, such as highly vagile, winged taxa being better able to rapidly colonise crops following disturbance events.

The ecological influence of a land-use type can extend beyond its boundaries. I examined how arthropod assemblages differed in crop fields that were bordered by different habitats, and whether sites at the edge of the field differed in their assemblage to those in the interior. This was tested using pitfall trap stations at crop field edges and crop interiors that differed in whether they were bordered by a patch of native woodland/grassland or a linear grass strip. The richness, abundance and assemblage composition of ants was different at a cropping/woodland edge than it was between the edge formed by cropping and linear strips of vegetation. The ant assemblage in cropping field interiors differed depending upon which habitat type was adjacent to the field. Whilst I found differences in assemblage composition in cropping habitats, depending on whether the adjacent habitat type was native woodland or a linear grass strip, predation rates of *Heliothis armigera* (Lepidoptera: Noctuidae) eggs placed in crops bordered by different habitats did not differ. However, the distance from the edge (regardless of adjacent habitat type) did appear to influence predation rates, with removal of eggs being greater at the edges of crops than in the cropping field itself. This higher rate of egg predation appears to indicate that predator densities may be higher at edge habitats than in crops, and therefore edges may be important sources of predatory arthropods.

This study has contributed to an understanding of how arthropod assemblages are shaped by different agricultural land uses and habitat types in a part of the world where European-style agriculture is a relatively recent introduction (‘frontier’ regions). From this study I conclude that agricultural landscapes in frontier regions have considerable potential to support a range of arthropod groups, providing that they contain remnants of native vegetation, and some relatively low intensity land uses such as pastures. The distinct ant assemblages and treatment-specific taxa found in the pasture systems indicate that mixed-land use farming is likely to have greater biodiversity value than monocultural practices and hence should be encouraged at the policy and on-ground management levels. Furthermore, it appears that relatively low intensity habitat types such as the edges and boundaries of crops and other land-use
types may contribute to maintaining arthropod biodiversity and localised pest control potential. Finally, this study indicates that more attention given to examining the biodiversity attributes of agricultural land uses in frontier regions (where the focus of biodiversity research and conservation is often centred on remnants of native habitat rather than components of the agricultural matrix) may provide important insights into the roles that different farm environments can play in conserving biodiversity and maintaining ecosystem function.
Certification of Dissertation

I certify that the ideas, experimental work, results, analyses and conclusions reported in this thesis are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original, and has not been previously submitted for any other award, except where otherwise acknowledged.

________________________________________________________________________
Signature of candidate
Date

Endorsement:

________________________________________________________________________
Signature of supervisor
Date

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Signature of supervisor
Date

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Signature of supervisor
Date
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