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Arthropods and fire: studies in a southeast Australian heathland

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ARTHROPODS AND FIRE:
STUDIES IN A SOUTHEAST AUSTRALIAN HEATHLAND

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from

THE UNIVERSITY OF WOLLONGONG

by

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BSc (ANU), BSc For (ANU), Grad Dip Res Man (CCAE)

DEPARTMENT OF BIOLOGICAL SCIENCES
1996
Declaration

This thesis is submitted in accordance with the regulations of the University of Wollongong in fulfilment of the requirements of the degree of Doctor of Philosophy. The work described in this thesis was carried out by me and has not been submitted to any other university or institution.

Patrick Marie Tap
February 1996.
Abstract

The studies described in this thesis were aimed at unravelling the relationships between fire and arthropods. This has been investigated in a number of studies in the literature. Some studies reported finding fewer arthropods in burned than in unburned sites, others reported finding more, and still others found no difference. Factors that may help to explain this variety of outcomes include differences in arthropod taxa and habitat type, time since fire, and methods and duration of sampling. I analysed the frequencies of studies reporting fewer, equivalent or more arthropods in collections from burned compared to unburned sites for eight categories (i.e. taxon, taxonomic group, trophic level, habitat type, season of fire, censusing method, time since fire and duration of sampling) and found some support for the hypothesis that differences between burned and unburned sites are taxon-dependent. However, few of the studies examined had an experimental design of sufficient power to allow a critical analysis of responses to fire. Most studies were short-term (i.e. < 1 year) and lacked knowledge of pre-disturbance conditions. Few studies had sufficient replication or adequate controls. Furthermore, few studies investigated the mechanisms underlying described changes.

I sought to overcome these methodological problems via studies of arthropod communities in heathland located within Barren Grounds Nature Reserve, near Kiama, NSW. The studies comprised: (i) an initial comparison of a site burned by a wildfire in January 1983 and an unburned site, with one set of prefire and 34 sets of postfire samples collected between October 1982 and March 1985, analysed to assess differences between sites; (ii) subsequent reburning of half of one of these sites in March 1985, with a further 13 sets of postfire samples collected between the time of the experimental burn and January 1987, analysed to assess differences between sites; and (iii) a replicated manipulative experiment (i.e. particular combinations of burning, slashing, mowing and vacuuming) initiated in December 1985, with four sets of post-treatment samples collected between January 1986 and January 1987 analysed to assess treatment effects. In all three studies, arthropods were sampled using pitfall traps (larvae not examined) and data for major groups analysed using Analysis of Variance.

In the first field study, 21 taxa were identified among 15,883 macroarthropods collected from the burned and unburned sites. The majority of individuals comprised Formicidae (72%), Araneae (8%), Diptera (7%), Orthoptera (3%), Coleoptera (4%) and Opiliones (1%). In addition to the macroarthropods, Collembola (12,752) and Acarina (8,233), referred to as microarthropods, were counted for eight dates. Comparisons of the mean numbers of individuals trapped at each sample date revealed the following postfire differences between
burned and unburned sites: (a) Overall, significantly more Acarina, 'total macroarthropods', Formicidae, Orthoptera, Coleoptera, but fewer Collembola and Diptera, and equivalent numbers of Araneae were trapped in the burned than in the unburned site; (b) For all groups except Araneae, there was a significant interaction between site and sample date with each macroarthropod group showing a consistent pattern of peaks in numbers of captures in warm periods of the year and troughs during cool periods; (c) The taxa also differed in the timing of the differences between sites with captures of Formicidae, Araneae, Coleoptera and Acarina peaking soon after burning (within 5 to 48 days); and Collembola, Diptera and Orthoptera peaking much later after burning (around 190, 380 and 700 days, respectively). For all major macroarthropod groups except Araneae, differences in captures between sites were still apparent at 2 years after burning.

Interpretation of the role of fire in producing differences reported in the first study was limited by two main constraints: (i) paucity of prefire data for each site, and (ii) lack of replication of treatments. The first of these two problems was addressed in the second field study when half of the 'unburned site' from the first study was experimentally burned. Data obtained from trap grids in the burned and unburned halves were compared to the data collected in the site during the 29 months prior to treatment. Most taxa present before burning, were present after burning. Overall, after the experimental fire, 16 taxa were identified among 2816 macroarthropods trapped from burned and unburned halves. The majority of macroarthropods comprised Formicidae (68%), Araneae (13%), Diptera (8%), Opiliones (3%), Orthoptera (3%) and Coleoptera (2%). Comparisons of the mean numbers of individuals of the major taxa trapped at each sample date revealed the following patterns: (a) Overall, as in the first study, significantly more 'total macroarthropods', Formicidae, Orthoptera and Coleoptera were trapped in the burned than in the unburned half of the study site, numbers of Araneae trapped in each half of the site were not different, but unlike the first study, the same was also true for Diptera; (b) Prior to burning there were no groups for which significant differences between half-sites were detected; (c) For all groups except Araneae and Coleoptera, there was a significant interaction between half-site and sample date for the period following the experimental fire; (d) The taxa differed in the timing of the differences between half-sites. For example, captures of Araneae, Diptera and Formicidae peaked soon after burning (i.e. within 1 to 5 days) while Orthoptera peaked much later (481 to 644 days). For all major macroarthropod groups, differences in captures between sites were still apparent at 1.8 years after burning.

The second constraint of the wildfire study (i.e. lack of replication of treatments) was addressed in a manipulative experiment that evaluated the role of vegetative cover in the postfire response. The following eight treatments were established in a study area comprised
of 64, 5 x 5m plots (i.e. 8 replicates per treatment). The treatments were: (i) Control; (ii) Burned only; (iii) Burned then vacuumed; (iv) Burned, vacuumed then covered with slashed vegetation; (v) Scorched (approximately one-third of plot area burned); (vi) Slashed then most cuttings removed; (vii) Slashed, mown, then all cuttings removed; and (viii) Slashed then all cuttings left. The data analysed were from collections undertaken at 16, 77, 242 and 403 days after initiation of the treatments. Overall, 18 taxa were identified among 60,952 macroarthropods trapped. The majority comprised Formicidae (90%), Araneae (4%) and Diptera (2%). The additional examination of the effects of burning, by comparing Burned only and Control plots, confirmed the general patterns observed in the first two studies.

Comparisons of the data from each of the eight treatments revealed the following general patterns: (a) Significant differences among the eight treatments were found for all the taxa tested excepting Hemiptera; (b) Differences were significant at all four dates for 'total macroarthropods', Orthoptera and Formicidae; at three dates for Diptera and Hymenoptera (other than Formicidae); and at two dates for Araneae, Thysanoptera and Coleoptera; (c) For some groups, most individuals were trapped in treatments where vegetative cover was removed (i.e. by burning or slashing), and least in treatments where cover was partially removed or added after burning; this pattern was apparent at all four dates for 'total macroarthropods', Orthoptera and Formicidae; and at two dates for Thysanoptera; the reverse was true, at one date, for Coleoptera; no particular pattern was apparent for Araneae, or Diptera; (d) Comparisons within modes of disturbance (e.g. 'burned vs. other burned', 'slashed vs. other slashed') showed that differences between plots occurred most often where levels of surface cover were very different (e.g. Burned only vs. Burned, vacuumed then covered with slash); (e) Comparisons between modes of disturbance generally showed that there were few differences for partial removal of cover, but for substantial or complete removal of vegetation cover, they differed in only half the comparisons.

The studies outlined in this thesis confirm various patterns that have been reported in the literature on the relationships between fire and arthropods. That is: (i) there is not an elimination of arthropods; (ii) many taxa are trapped more readily after fire; (iii) for some taxa this increase occurs soon after burning (e.g. Araneae and Formicidae); and (iv) for other taxa, the increase occurs some time later (e.g. Orthoptera, Diptera). Patterns and directions of differences between burned and unburned areas were also found to vary between taxa, thereby adding additional weight to the hypothesis that fire responses are taxon-dependent. Details of the mechanisms behind observed differences are more difficult to resolve. The randomised block burning-and-slash study suggested that, for Formicidae and Orthoptera, the presence or absence of vegetative cover, as much as burning per se, is an important variable that influences the postfire environment.
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