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Age and distance effects on the canopy arthropod composition of old-growth and 100-year-old *Eucalyptus obliqua* trees

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Abstract

Despite the anthropogenically-induced changes to forest tree demographics, few studies have examined the differences in arthropod species composition between the crowns of trees of different ages. We tested for differences in the taxonomic composition of the canopy arthropod faunas of 100 y.o. and old-growth trees, using eight pairs of trees in an *Eucalyptus obliqua* tall open-forest with a rainforest understorey in the Warra Long Term Ecological Research Site in southern Tasmania and compared these differences to those related to geographic distances. Sticky traps, hanging flight-intercept traps and bark funnel traps were used to sample the canopy arthropods in different placement situations. There were no significant differences between 100 y.o. and old-growth trees at the tree level, but several at the trap and placement levels. Ordination analyses and correlation analyses indicated that high inter-pair variability related to the geographic distance between trees was partially masking tree age effects. The age of *E. obliqua* does influence canopy arthropod species composition, but this effect was weaker than the geographic effect that was evident in a relatively uniform forest with a maximum distance between trees of only 324 m. This implied high beta diversity in the forest type has implications for the planning of conservation reserves. Further work is needed to see if age effects are stronger in forests of the ages created by silvicultural treatment.

Keywords: Canopy arthropods; *Eucalyptus obliqua*; Forest entomology; Geographic distance; Tree age; Tasmania; Invertebrate trapping

1. Introduction

Arthropod biodiversity reaches its greatest levels in forest ecosystems (Erwin, 1995), and Australian *Eucalyptus* forests harbour a globally significant number of species (Majer et al., 1994). Harvesting and replanting alters the structure and demographics of native *Eucalyptus* forests (Lindenmayer et al., 2000). In Tasmania, clearfelled wet eucalypt forests are replanted for potential future harvest on a rotation of 80–90 years. This will result in a reduction in the numbers of old-growth (or veteran) trees, those 110 years or older (Franklin et al., 2002; Lindenmayer et al., 1997). While there are some data on changes in canopy arthropod biodiversity related to the impact of harvesting (Schowalter, 1995; Winchester and Ring, 1996; Chey et al., 1998; Floren and Linsenmair, 2001), and host plant age (Banerjee, 1981; Abbott et al., 1992; Basset, 2001), very little is known about the arthropod biodiversity of old-growth *Eucalyptus* trees in relation to younger trees (Majer et al., 1997). For *Eucalyptus*, the only published study on age-related changes in arthropod communities compares juvenile and sapling *Eucalyptus marginata* (Abbott et al., 1992). No previous research has investigated the differences in arthropod communities between the canopies of mature and old-growth *Eucalyptus* trees.

Previous researchers have found distinctions in the faunal communities between forests, trees, or foliage of different ages. Schowalter (1995) distinguishes a characteristic old-growth forest community on the foliage of western American coniferous forests. In Scandinavian boreal forests, Martikainen et al. (2000) and Sippola and Kallio (1995) found a distinct saproxylic beetle community in older forests when compared to younger managed forests. Waltz and Whitham (1997) found the herbivore arthropod communities within *Populus* crowns to be different between mature and juvenile branches.

Geographically related differences in the arthropod taxon composition of individual trees of the same species and age can occur over relatively short distances. For example, Richardson et al. (1999) showed that differences between the arthropods on individuals of *Melaleuca* occurred systematically over

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0–20 km. Burgman and Williams (1995) found spatial patterning in the foliage arthropod faunas of *E. marginata* trees that became evident at distances of greater than 20 km.

The degrees to which tree age and distance between trees influence arthropod taxon composition in canopies is highly relevant to forest conservation planning, yet there are few data on the subject. The present study uses paired 100-year-old ("100 y.o.") and old-growth (>350 years, "old") trees of *Eucalyptus obliqua* L'Herit. trees. These pairs were distributed over 4 km^2 of tall open-forest with a closed rainforest understorey, at the Warra Long Term Research Site in southern Tasmania, Australia. This design enables the testing of the relative and singular roles of tree age and geographic proximity in influencing canopy arthropod species composition.

2. Methods

2.1. Study area

The study area is on a steep, south-facing slope, between 100 and 300 m above sea level, composed of Jurassic dolerite colluvium overlaying and intermixed with lime-rich Permian sediments. Precipitation approximates 1275 mm per annum with a winter maximum, but no month has an average less than 50 mm. The mean temperature of the warmest month, February is 13.3 °C, and of the coldest, August, is 5.78 °C. The tallest stratum is composed solely of *E. obliqua* trees up to 80 m tall. These have two distinct size classes, which are closely intermixed. The smaller trees date from regeneration after fires between 1898 and 1906 (Hickey et al., 1998). These 100 y.o. trees have crowns of healthy original branches. The old-growth trees are of indeterminable age, but are estimated to be between 350 and 450 years (Hickey et al., 1998). Some of the old trees have a secondary crown of epicormic branches triggered by the fire that enabled the establishment of the younger cohort, while others have a senescing primary crown of original branches (Jacobs, 1955). Beneath the eucalypts is a floristically distinct temperate rainforest canopy 10–30 m tall, dominated by *Atherosperma moschatum* Labill. and *Nothofagus cunninghamii* (Hook.) Oersted.

2.2. Tree pair selection

Eight pairs of *E. obliqua* trees were selected for sampling using the criteria of accessibility and safety for direct rope access into the crown (Dial and Tobin, 1994). Trees in a pair consisted of an old-growth tree and a 100 y.o. tree, and were no more than 50 m apart. All pairs were within a 4 km^2 region. The old-growth trees were selected first, care being taken not to select highly decayed trees that were obviously dangerous for climbers.

2.3. Sampling methods

The canopy arthropod biodiversity of the 16 study *E. obliqua* trees was sampled using three types of trap. Mobile arthropods on the exterior of the tree were targeted. Fourteen trap placements were set within the crown of each tree: two sticky traps, six funnel traps, and six hanging flight-intercept bottles.

The trap design criteria were: broad collection of taxa, low cost, durability in the conditions of the treetops, and portability. Sessile arthropods, and arthropods living within the tree, were poorly sampled by these traps. One sticky trap, composed of a compact disk case coated with Tanglefoot® glue (125 mm × 140 mm), was placed in each of the upper and lower crown of each tree. Funnel traps, composed of the neck of a 1 l soda bottle and a collecting bottle, were nailed to: the upper trunk, the lower trunk, an upper crown dead branch, a lower crown dead branch, an upper crown live branch, and a lower crown live branch. Two 10 mm × 10 mm × 1 m strips of closed cell foam served as drift fences for each funnel trap. For each of the hang traps, an upper and lower bottle collected arthropods intercepted by a plastic panel assembly (200 mm × 120 mm). One hang trap was suspended in each of the lower, middle and upper canopy of each tree.

Traps were active for approximately 60 days between January and April 2004, and collected only once. The upper crown trapping region was approximately 40–45 m high in the 100 y.o. trees, and 55–60 m in the old trees. For the lower crown traps, the region was 20–25 m in the 100 y.o. trees, and 25–30 m in the old trees.

2.4. Arthropod processing

Adult arthropods were identified to distinguishable morphospecies or Recognizable Taxonomic Units (hereafter "RTU") and assigned as best as possible to a taxonomic group (Oliver and Beattie, 1996; Pik et al., 1999; Baldi, 2003; Basset et al., 2000). Voucher holotype specimens for each RTU were photographed to aid in identification and archived. Araneae (spiders), Acarina (mites), and Hymenoptera-Formicidae (ants) were counted, but not sorted to morphospecies. Coleoptera (beetles) were pinned and identified, when possible, to named species in the Tasmanian Forest Insect Collection (TFIC), Forestry Tasmania, Hobart, Australia. Araneae were lodged at the Queen Victoria Museum (Launceston, Australia) and Diptera (flies) at the Australian Museum (Sydney, Australia). All other voucher specimens, photo catalogues, and computer CD archives of raw and processed data, are lodged at the TFIC. Digital photographs of each RTU holotype are available for viewing online (http://www.geog.utas.edu.au/yoav/pho/voucher/vouchergallery.htm).

2.5. Data analysis

At the tree level, the independent sampling entity was considered to be a single tree. The entire collection from each of eight 100 y.o. trees was compared to that of each of eight old trees. An assumption was made that the loss of traps was random and unbiased across the two age classes. At the trap level, each trap was considered as a sampling unit and the pool of traps was divided into those from 100 y.o. trees, and those from old trees. Because the individual tree was the subject of consideration, this was a pseudo-replicated approach. Trap level analysis was only used for multivariate community analyses in