Chapter 22
Islands in a Sea of Foliage: Mistletoes as Discrete Components of Forest Canopies

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Bullet Points

1. Mistletoes and their dependent insects, such as butterflies, moths, and psyllids, are sensitive indicators of disturbance regime and overall forest integrity.
2. The health of the whole forest ecosystem is important for maintaining populations of insects in the canopy because different insect life stages depend on different types of plants.
3. Herbivorous insects and mammals, along with fire, help to regulate mistletoe abundance.

Summary

This chapter focuses on the ecological interactions between mistletoe plants and their invertebrate inhabitants (insects and spiders), drawing on our own empirical research in southeastern Australia and several other studies conducted worldwide. Our research on box mistletoes and their host eucalypt trees in remnant woodlands was the first direct comparison of invertebrate fauna inhabiting mistletoes and their host plants (Burns 2009; Burns et al. 2011). We discovered the occurrence of

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distinct assemblages of insects on mistletoes, which are dependent on mistletoes for their entire lives. Spiders were found to be generalists on mistletoes and their host trees. These invertebrates represent important components of the food web in forest and woodland canopies.

1 Introduction

Mistletoes are a functional category of plants, defined as shrubby, aerial hemiparasites which depend on their host plants for water and mineral nutrition. Although three aberrant species (all in monotypic genera) are root parasitic, mistletoes are stem parasites, attaching to their hosts via specialized organs called haustoria. Mistletoes belong to the order Santalales and are arranged in the families Loranthaceae, Viscaceae, Misodendraceae, and Santalaceae, with the great majority of species belonging to the first two families (Nickrent 2001; Nickrent et al. 2010). Although some species regularly parasitize lianas and other mistletoes, most species are dependent on trees and shrubs as principal hosts. The more than 1,500 species worldwide live in diverse habitats from rainforest to semiarid woodlands and are absent only from habitats devoid of woody hosts (e.g., polar, alpine and desert environments). Mistletoes are an important food source and nesting site for many birds and mammals (Cooney et al. 2006; Mathiasen et al. 2008; Watson 2001) and have a positive effect on the diversity and distribution of vertebrate animals in a range of habitats (Mathiasen et al. 2008; Watson 2002). By comparison, the ecological interactions between mistletoes and invertebrates—particularly arthropods—are poorly known. Unlike birds and mammals—long-lived and highly mobile animals that visit mistletoes periodically—many insects live their entire lives within mistletoe clumps, completely dependent on them for food and shelter. In this contribution, we summarize recent research on mistletoe-dependent arthropods, contrasting the extreme specialism exhibited by herbivorous groups, with lower substrate specificity (and greater dependence on structural complexity) displayed by predatory taxa. Rather than simply a subset of the biota found in the host canopy, we demonstrate that arthropods in mistletoes represent discrete and complementary assemblages, hitherto overlooked islands within a sea of forest and woodland treetops. Finally, we consider these findings in terms of the threats facing many forested systems, demonstrating the utility of mistletoe-dependent arthropods as sensitive indicators of overall forest health and ecosystem integrity.

2 Diversity of Invertebrates on Mistletoes

The recorded diversity of invertebrates occurring on mistletoes includes more than ten orders of arthropods including beetles (Coleoptera); bugs (Hemiptera); wasps, ants, and bees (Hymenoptera); butterflies and moths (Lepidoptera); thrips (Thysanoptera); flies (Diptera); bark lice (Psocoptera); cockroaches (Blattodea); praying mantis

(Mantodea); grasshoppers (Orthoptera); lace wings (Neuroptera); mites (Acari); and spiders (Araneae) (Anderson and Braby 2009; Baloch and Mohyuddin 1969; Burns et al. 2011; French 2004; Robertson et al. 2005; Room 1972; Tassone and Majer 1997; Whittaker 1982). Some of the animals in these groups are herbivorous, feeding on the foliage, flowers, fruit, or stems; others are predators of insects or scavengers that feed on fungi or dead plant matter. Thus, some invertebrates on mistletoes are specialists that particularly seek out these plants and are dependent on them for their survival, while others are canopy generalists, occurring on mistletoes haphazardly or opportunistically for food and/or shelter. Some examples of specialist and generalist invertebrates inhabiting mistletoes are examined in detail below.

2.1 Specialists: Psyllids

Also known as lerp insects, these sap-sucking bugs (in the order Hemiptera) resemble small cicadas but are more similar in size to aphids (1–10 mm in length). The name "lerp" refers to the shell-like covering produced by the developing insects of some species (Fig. 22.1a), which acts as a shelter and may help maintain a humid microenvironment. These structures consist of sugar compounds excreted by the larvae and come in many shapes and sizes, some with elaborate decorations, which can be diagnostic tools for identification of species (Hollis 2004). Both the lerps and larvae inside them are a food source for birds (Lockwood and Gilroy 2004; te Marvelde et al. 2009). These insects can occur in outbreak proportions and cause severe foliar damage, which is particularly detrimental to the host plants' health in drought conditions (Clark and Dallwitz 1974; Semple and Koen 2007).

These insects are also known as jumping plant lice or psyllids that belong to the superfamily Psylloidea (suborder Sternorrhyncha). More than 3,000 species have been identified to date, worldwide, and they are very host-plant specific; most occur on one or a few closely related plant species and can only complete their whole life cycle on plants of those species (Hollis 2004). Accordingly, the species that occur on mistletoes are different from those that live on the mistletoes' host plants. Three psyllid species have been identified inhabiting species of *Amyema* mistletoes in Australia (Taylor 1999). In our study comparing the insect communities on box mistletoe, *Amyema miquelii*, and some of its host *Eucalyptus* species (Burns 2009; Burns et al. 2011), we found completely different assemblages of psyllids on the two plant types. While two species (*Acizzia loranthaceae* and *A. amyemae;* see Fig. 22.1b) were found to inhabit box mistletoe across the whole study area, 17 species inhabited the three eucalypt species.

Psyllid species that inhabit mistletoes are more closely related to those inhabiting *Acacia* than *Eucalyptus* species (Taylor 1999; Yen 2002). This may indicate an ancient radiation of psyllids from *Acacia*, which are mostly understory plants, to mistletoes on *Acacia* and thence to mistletoes in the canopy of *Eucalyptus* trees (Taylor 1999), potentially coinciding with the spread of eucalypts throughout Australia as rainforests retreated (White 1994).

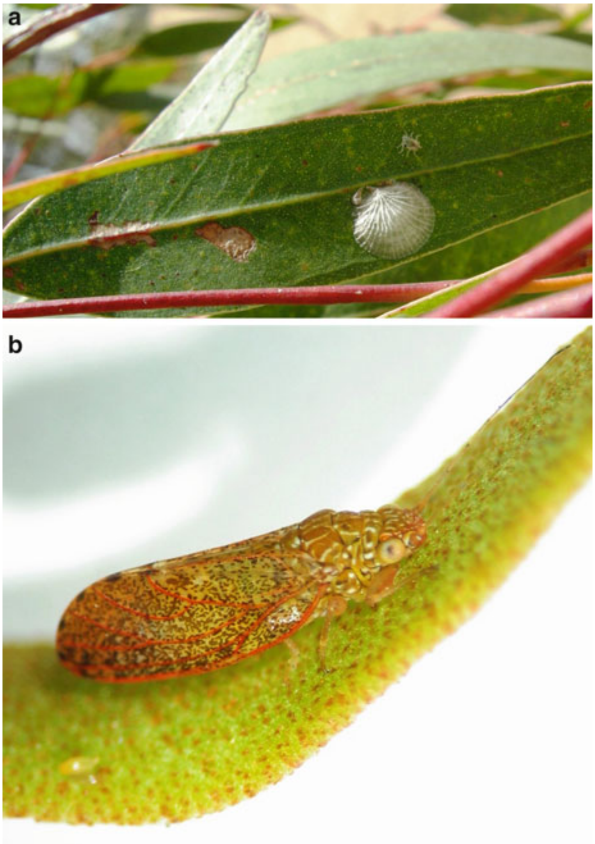

Fig. 22.1 (**a**) Lerp of a psyllid species on a *Eucalyptus* leaf. (**b**) An adult psyllid of *Acizzia amyemae* on a box mistletoe (*Amyema miquelii*) leaf (Images: Anna Burns)

2.2 Generalists: Spiders

Spiders are one of the most abundant and speciose groups of invertebrate animals that occur on mistletoes (Anderson and Braby 2009; Burns et al. 2011; Room 1972), and their occurrence is seemingly opportunistic. Both our study of box mistletoe and its host eucalypts and that by Jennings et al. (1989) of dwarf mistletoes (*Arceuthobium* spp.) and their conifer hosts showed that similar species of spiders inhabit mistletoes and their hosts. Specifically, 50 % of the 42 species of spiders found on box mistletoes and the eucalypts occurred on both mistletoes and their host trees. Most of the spiders in our study were less than 10 mm in size and belonged to six families, including orb weavers (Araneidae), jumping spiders (Salticidae), crab spiders (Thomisidae), comb-footed spiders (Theridiidae), and lynx spiders (Oxypidae; see Fig. 22.2). The spiders and insects were both more abundant on the eucalypts than on mistletoes, indicating that the distribution of spiders was likely influenced by the abundance of potential prey. Habitat structure

Fig. 22.2 A lynx spider protecting its egg sac on box mistletoe (Image: Anna Burns)

is also an important factor that influences the distribution and composition of spider communities (Foelix 1982). Examination of the microclimate and specific substrates within mistletoe clumps, such as the haustorium (connection with the host plant) and folded leaves or other leaf structures, could reveal habitat-specific spiders within mistletoe clumps, similar to the assemblages of spiders that inhabit bromeliads (Romero 2006).

3 Indicators of Forest Health: Butterflies, Moths, and Mistletoes

Butterflies and moths (order Lepidoptera) form associations with mistletoes for food and shelter. Their larvae feed on mistletoe foliage and often live in colonies on mistletoe or its host plant until completion of pupation (Braby 2000, 2004; De Baar 1985). In Australia, 25 species of butterflies (in families Pieridae and Lycaenidae) and at least four species of moths (in families Saturniidae, Agaristidae, Lymantriidae, and Noctuidae; see Fig. 22.3) feed on a range of mistletoe species, either exclusively or as a large proportion of their diet (Braby 2000; De Baar 1985). In the Asian region, 20 species of *Delias* (Pieridae) have been recorded feeding on mistletoes in the families Loranthaceae and Viscaceae (Braby 2006); in Africa, 14 species of *Mylothris* (Pieridae) feed on mistletoes (Braby 2005); and five Lepidopteran species

Fig. 22.3 Caterpillar of mistletoe day moth, *Comocrus behri*, on box mistletoe (Image: Catherine Bach)

feed on dwarf mistletoes in the USA, including the rare Johnson's (or mistletoe) hairstreak (McCorkle 1962; Mooney 2003). Many of these caterpillars are completely dependent on mistletoe as a food source, and thus, as important herbivores, they help regulate mistletoe abundance. Due to their holometabolous life cycle (i.e., complete metamorphosis, with larvae and adults dependent on different food sources), the occurrence and abundance of these insects can act as sensitive indicators of overall habitat health and integrity.

Mammalian herbivores also contribute to regulation of mistletoe abundance, along with fire in some habitats (Kelly et al. 1997; Mathiasen et al. 2008; Parker et al. 2006). It is when these natural disturbances, along with insect herbivores, are eliminated from or reduced in ecosystems that mistletoes can become overabundant and impair the health of their host trees (Mathiasen et al. 2008; Reid et al. 1995). Maintenance of the habitat requirements of herbivores is thus important for sustainable abundance of mistletoes in forests and woodlands (Watson 2011). For example, an adequate supply of the food source of adult moths and butterflies (e.g., understory nectar-bearing plants) is required to maintain healthy populations of hungry caterpillars. However, in modified and degraded landscapes, understory plants often decline. Habitat degradation and fragmentation also affect populations of mammalian herbivores (e.g., possums, koalas, and deer), rendering them less effective control agents, and can alter mistletoe dispersal patterns, leading to overabundance in isolated trees (Reid 1997). On the other hand, when mistletoes become too scarce, many of their dependent animals are affected, often leading to local extinction (McCorkle 1962; Hawksworth and Wiens 1996). Considering these factors, we propose that mistletoes and their dependent arthropods are sensitive indicators of disturbance regime and overall forest health.

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