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CONTRIBUTION OF INTRODUCED FRUITS TO THE WINTER DIET OF PIED CURRAWONGS IN ARMIDALE, NEW SOUTH WALES

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Pied Currawong abundance was surveyed in 1988, 1989 and 1990 in Armidale, New South Wales. Pied Currawongs congregated each April and dispersed in the following September. This pattern is consistent with other studies in south eastern Australia and is best explained in terms of a combination of dietary shifts and breeding pressure. The seed dispersal role of Pied Currawongs was assessed in 1989 by collection of regurgitated pellets containing seeds of ornamental plants. Seeds of 22 species of introduced plants were dispersed by Pied Currawongs. *Ligustrum* and *Pyracantha* were the most common genera dispersed by Pied Currawongs. These plants and others such as *Pistacia chinensis* will continue to be dispersed by Pied Currawongs and invade bushland. This may possibly increase numbers of Pied Currawongs, increase nestling predation rates on small birds, and promote invasion by introduced fleshy fruiting plants.

INTRODUCTION

Pied Currawongs *Strepera graculina* have been implicated in nest robbing and predation on small bird species (Mulvaney 1986; Recher and Lim 1990). While this is a natural phenomenon (Frith 1976) there is some suggestion that the Pied Currawong population may be increasing, causing a reduction in the number of small birds in south east Australia (Recher and Lim 1990). The Pied Currawong has therefore been painted as an ecological villain. However little attention has been given to the underlying causes of this villainy. One hypothesis is that the abundance of food provided by introduced fleshy-fruited plants has increased Pied Currawong numbers (Mulvaney 1986; Recher and Lim 1990). However few studies have examined in detail the extent of introduced fleshy-fruiting species in Pied Currawong diets (e.g. Buchanan 1989). Studies of the diet of Pied Currawongs may reveal key plants that are important both as food for Pied Currawongs, and consequently as invaders of bushland.

Pied Currawongs become very abundant in urban areas throughout south eastern Australia during autumn and winter (Roberts 1942; Strong 1966; Readshaw 1968; Wimbush 1969; Vellenga 1980; Bass 1989). They characteristically congregate in large flocks and feed on the fruit of many ornamental garden and street trees. This behaviour has been associated with changing food availability (Readshaw 1968; Wimbush 1969). In summer, invertebrates form a large component of Pied Currawong diets (Buchanan 1989). With the onset of cooler weather, invertebrate abundance falls, and Pied Currawongs switch to fruit as their main food (Buchanan 1989). The Australian flora has a relatively low representation of fleshy-fruiting species: <30 per cent of species in sclerophyll woodland, heaths and alpine communities produce fleshy fruit. This compares to some North American forests (up to 50%), wooded vegetation in New Zealand (up to 56%) and tropical and sub-tropical rain forests which commonly exceed 70 per cent (Wilson *et al.* 1989; see also French 1991). Feeding on large amounts of introduced fruit in winter when other native food sources are less abundant may promote higher over-winter survival of Pied Currawongs (Recher and Lim 1990).

After ingesting fruit, Pied Currawongs usually fly to a perch and process their meal with their muscular crop. These perches range from fence posts and telegraph poles to large living and or dead trees. Five to fifteen minutes after eating and processing fruit Pied Currawongs regurgitate pellets containing seeds, fruit skins and partly

digested pulp (pers. obs.). As a consequence Pied Currawongs disperse the seeds of many introduced ornamental plants (Buchanan 1983; Mulvaney 1986; Bass 1989, 1990) promoting the extensive and continued modification of regional floras by the naturalization of introduced plants in south eastern Australia (Smith 1985, 1988).

An earlier study documented the influx of Pied Currawongs into Armidale in northern New South Wales during winter (Bass 1989). Subsequently Bass (1990) reported a diurnal pattern of Pied Currawong movements between communal roosts outside of Armidale and feeding areas in Armidale during winter. Both studies documented the role of Pied Currawongs as dispersal agents of some introduced fleshy fruiting plants, especially species of *Ligustrum* and *Pyracantha*. What is not fully known is the extent of Pied Currawong facilitated seed dispersal of other fleshy-fruiting species and how this relates to the potential for invasion by introduced species in Armidale. This study provides a longer record of seasonal patterns of Pied Currawong abundances in Armidale and examines in detail the role of Pied Currawongs in the dispersal of introduced fleshy fruiting plants and the ecological implications of this in the Armidale region.

STUDY AREA AND METHODS

Armidale is a township of approximately 23 000 people, situated on the Northern Tablelands of New South Wales, at an elevation of 1 000 m above sea level. It experiences cool to cold winters and warm summers and has an annual precipitation of 789 mm (Smith 1990). The native eucalypt woodland of the region has been extensively modified by clearing and dieback (Curtis 1989) and has been accompanied by a reduction in the abundance of some components of the native avifauna (Ford and Bell 1981). Since the late 1800s the region was planted with many introduced trees and shrubs including deciduous and evergreen genera from Europe and Asia. First among these was *Crataegus monogyna* which was followed later by *Cotoneaster, Pyracantha* and *Ligustrum*. These plants characteristically produce fleshy fruits adapted for ingestion by birds and subsequent dispersal of seeds in bird guts (van der Pijl 1972).

Pied Currawong abundance

Pied Currawong abundance was determined from continuous records kept from March 1988 to September 1990 of birds seen while driving along a 6.8 km route from home to work at the University of New England. The census took approximately 10 min. and all observations were made between 0730 h and 0900 h after birds had flown from overnight roosts (Bass 1990). All birds seen perching, feeding, flying and on the ground were recorded for up to five days each week (Monday to Friday). For each month the total number of birds counted was divided by the total number of observation days. This gave the average number of birds seen per observation for each month. Days that were foggy and for which observation was difficult were removed from calculations of abundance.

Seed dispersal by Pied Currawongs

Seeds dispersed by Pied Currawongs were assessed from 1 April 1989 to 31 August 1989 by the collection of regurgitated pellets at two sites in north Armidale. Site 1 was a water tower forming part of the water supply of Armidale on which Pied Currawongs perched and regurgitated pellets. The pellets either fell to the ground or collected on the roof and later, dislodged by wind or rain, eventually accumulated on a concrete apron around the base of the tower. Pellets were collected by sweeping the apron each Friday. Site 2 was a residential property with a bird bath which received ejecta from Pied Currawongs perched above in a large *Eucalyptus* tree. The bird bath was cleaned each Friday. Seeds collected from the two sites were dried, identified with the aid of a reference collection made during the study, and counted.

Abundance of fleshy fruiting plants

The relative abundance of introduced fleshy fruiting plants in Armidale was estimated by surveying a 6 km north-south road transect through the middle of Armidale in Autumn 1990. A strip ten metres wide on either side of the road was surveyed (total area 12 ha) and the canopy dimensions of all fruiting plants including those identified by the collection of pellets were estimated for later calculation of canopy volume. This sample included individual plants and those growing in hedges, road verges (street trees), residential properties and council gardens. Canopy volume was calculated for the most common species and genera (*Cotoneaster,* mostly *C. glaucophyllus* and *C. pannosus; Pyracantha,* predominantly *P. angustifolia* and *P. rogersiana; Crataegus monogyna; Ligustrum,* mostly *L. lucidum;* and *Pistacia chinensis*). All were shrubs and trees less than 7 m tall. Other less abundant plants were grouped together as 'others' and included *Hedera helix, Rubus* (probably *R. fruticosus*), Rosa (mostly *R. rubiginosa*), *Malus, Prunus* (mostly *P. cerasifera* 'nigra') and *Lonicera.*

RESULTS

Pied Currawong abundance

Figure 1 shows the trend in Pied Currawong abundance in Armidale for 1988, 1989 and 1990. Pied Currawongs congregated in Armidale each March. Between April and June abundances were up to 16, and commonly around 10 times higher than summer. The May 1989 peak in abundance was due to a flock of 32 Pied Currawongs seen flying along a creek line near the University of New England. During August and September the number of Pied Currawongs declined markedly to less than one bird per day by October.

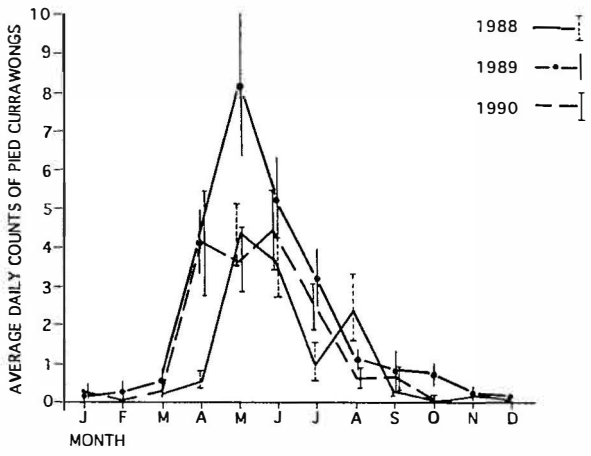

Figure 1. *Mean abundance (± S.E.) of Pied Currawongs in 1988, 1989 and 1990 at Armidale New South Wales.*

Seed dispersal by Pied Currawongs

Site 1 (Fig. 2) yielded 20 576 seeds from 20 species. The temporal pattern of fruit ingestion suggested by occurrence of seeds in Pied Currawong ejecta may have been affected by variation in seed retention times on the water tower as evidenced by a weathered *Prunus cerasifera* seed found in mid-winter whereas fruit of this species should be

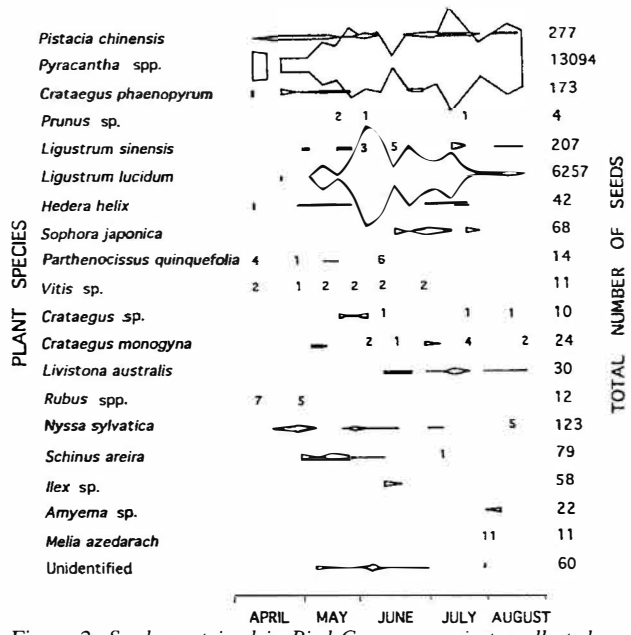

Figure 2. *Seeds contained in Pied Currawong ejecta collected at site 1 (water tower) in 1989. The size of the envelope is proportional to the total number of seeds collected at the site. Numbers are actual seed numbers.*

available only in summer. Site 2 (Fig. 3) yielded fewer seeds (N = 13 949) and fewer species (N = 16) compared to site 1. Site 2 probably provided a better indication of temporal patterns in fruit ingestion and subsequent seed dispersal by Pied Currawongs as there was no contamination of the bird bath by extraneous material. The pattern of fruit ingestion closely reflects the progression of fruit ripening in Armidale (pers. obs.).

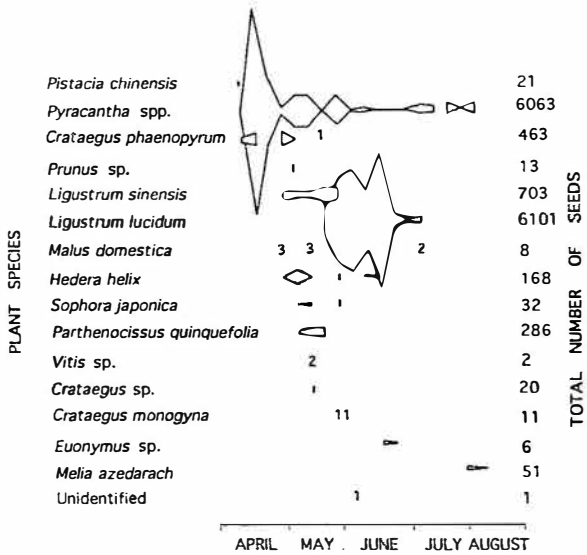

Figure 3. *Seeds contained in Pied Currawong ejecta collected at site 2 (bird bath) in 1989. The size of the envelope is proportional to the total number of seeds collected at the site. Numbers are actual seed numbers.*

The most commonly collected seeds from the two sites were from species of *Pyracantha* and *Ligustrum*, together accounting for more than 92 per cent of all seed collected. Significant numbers of seeds were also collected of *Pistacia chinensis, Crataegus phaenopyrum* and *Nyssa sylvatica* from site 1 and *C. phaenopyrum, Hedera helix* and *Parthenocissus quinquefolia* from site 2 which accounted for approximately 5 per cent of all seeds collected. All seeds collected from the two sites were intact and showed no signs of damage from ingestion by Pied Currawongs.

Abundance of fleshy fruiting plants

Figure 4 shows the proportion of canopy volume for each introduced plant group in Armidale.

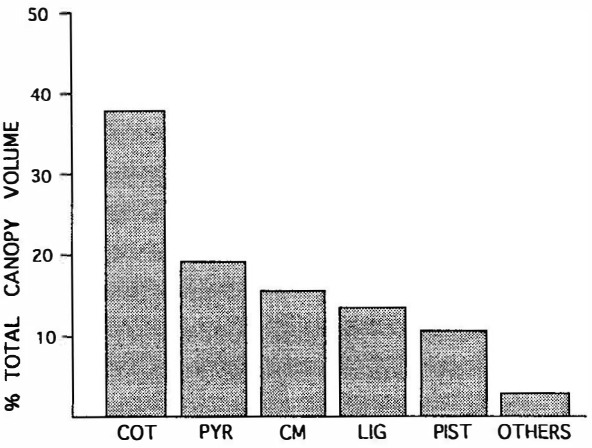

Figure 4. *Relative abundance of fleshy fruiting species planted in Armidale expressed as a percentage of total canopy volume. COT = Cotoneaster, PYR = Pyracantha, CM = Crataegus monogyna, LIG = Ligustrum, PIST = Pistacia chinensis and OTHERS = other species (see text for details).*

Cotoneaster accounted for >38 per cent of canopy volume with *Pyracantha, Crataegus monogyna, Ligustrum* and *P. chinensis* accounting for 10 to 20 per cent. All plants, except *P. chinensis* were predominantly found in residential and public gardens. *P. chinensis* was only recorded as a street tree planted by the Armidale City Council. The species identified in the canopy survey were also found growing within 200 m of both sites 1 and 2.

DISCUSSION

The regular autumn-winter concentration of Pied Currawongs in Armidale revealed by this study is consistent with other studies throughout south eastern Australia (Readshaw 1968; Wimbush 1969; Vellenga 1980 and others) and is probably best explained by a shift in diet, followed by spring dispersal associated with breeding activities (Frith 1976; Recher 1976).

This study revealed a large range of fruits of introduced plants ingested and their seeds dispersed by Pied Currawongs. There were two occurrences of native mistletoe (*Amyema* sp.) seeds (N = 22) recovered from Pied Currawong ejecta at site 1 suggesting that ingestion of native fruit is rare during winter in Armidale. The seed rain is dominated by a 'key' group of ornamental garden trees and shrubs comprising of *Pyracantha* and *Ligustrum* which account for >90 per cent of all seeds collected from Pied Currawong ejecta. A smaller (c. 5%) but significant component of the seed rain was comprised of a secondary group of *Crataegus phaenopyrum, Pistacia chinensis, Nyssa sylvatica, Hedera helix* and *Parthenocissus quinquefolia*. Seeds of a third group of 'rarely ingested' plants consisting of the balance of species in Figures 2 and 3 (e.g. *Melia azaderach, Crataegus monogyna, Sophora japonica, Euonymus, Ilex* sp., *Schinus areira*) accounted for <1 per cent of seeds, are occasionally dispersed by Pied Currawongs. A fourth group of plants characterized by *Cotoneaster* were not found to be ingested by Pied Currawongs in Armidale.

The dominance of *Pyracantha* and *Ligustrum* in Figures 2 and 3 is also reflected in the large numbers of *Pyracantha* and *Ligustrum* seedlings growing in the Armidale State Forest approximately 6 km to the north-east of Armidale which have resulted from Pied Currawong facilitated seed dispersal from Armidale along regular winter diurnal flightpaths (Bass 1990). *Pyracantha* and *Ligustrum* are key genera which provide winter food resources for Pied Currawongs in Armidale. As a consequence these genera will also continue to dominate the invasion of bushland near Armidale. Other plants from the secondary group are dispersed in fewer numbers but may gradually increase in importance as dispersed plants mature and produce fruit. Rarely ingested species are not likely to invade bushland to the same extent as plants from the first two groups.

The role of other bird species in the dispersal of introduced plants in Armidale is unclear. Silvereyes *Zosterops lateralis* and Starlings *Sturnus vulgaris* are likely to be important dispersers for some plant species. However, the winter seed dispersal shadow generated by Pied Currawongs is likely to dwarf that of other birds due to high Pied Currawong abundance, their larger body size and subsequent greater number of fruit ingested per feeding event at this time.

The occurrence of ornamental fruiting plants in residential gardens and the inclusion of their fruit in Pied Currawong diets is well documented (Mulvaney 1986; Buchanan 1983, 1989; Bass 1989, 1990). However the inclusion of fruit of street trees in Pied Currawong diets is also important. Of note are *P. chinensis, N. sylvatica* and *C. phaenopyrum* from the secondary group of plants. Local councils which plant ornamental street trees that produce fruit can expand the

range of ornamental species already dispersed by Pied Currawongs. Some of these street trees are at an early stage of invasion as evidenced by many *P. chinensis* seedlings now established and growing well in bushland away from Armidale (Borgis 1993; J. M. B. Smith, pers. comm.; and pers. obs.). Pied Currawong facilitated seed dispersal will continue to promote invasion by these species and lead ultimately to changes in regional floras.

The temporal pattern of fruit consumption mirrored the observed pattern of fruit ripening in Armidale. Plants that ripen fruit coinciding with the early influx of Pied Currawongs into Armidale will benefit from reduced interspecific competition for dispersal by Pied Currawongs. *P. chinensis* and *C. phaenopyrum* are two of the first species to ripen fruit and consequently dominated the seed rain in April. From May through to July the balance of fruiting species have ripe fruit and Pied Currawongs broadened their diet: consequently interspecific competition for attraction of seed dispersers must have been intense. However, the seed rain remains dominated by *Pyracantha* and then later by *Ligustrum* suggesting that these fruits are either more attractive to Pied Currawongs and/or more abundant than other species. Where patterns in fruit consumption diverged (e.g. the continued dominance of *Pyracantha* at site 1 through to August compared with reduced consumption at site 2), local factors may have come into play. There was considerably more *Pyracantha* near site 1 which provided fruit for Pied Currawongs over the entire winter period whereas at site 2 the fewer number of *Pyracantha* shrubs were almost entirely stripped of fruit by early June.

The complete absence of *Cotoneaster* from Pied Currawong ejecta collected during the course of this study was despite a much greater relative abundance (Fig. 4) and apparently suitable size and colour of fruit (van der Pijl 1972). Mulvaney (1986), in feeding trials conducted on caged birds, also found low ingestion rates of *Cotoneaster* fruit by Pied Currawongs. It is possible that not only does ripening schedule play a role in fruit selection by Pied Currawongs but also non-random selection based on nutritional status of fruit may come into play (Nakanishi 1991) i.e. that there may be some biochemical component of *Cotoneaster* fruit which make them unpalatable or of negligible nutritional value.

Central to understanding the impact of Pied Currawongs on small native birds is the need to collect data on predation by Pied Currawongs and survival rates of the nestlings of small birds. If Pied Currawong predation on small birds is widespread (Mulvaney 1986; Recher and Lim 1990) and it is a result of a larger Pied Currawong population due in part to the introduction of fleshy fruiting plants, a number of management options are suggested. 1) Identify key introduced plants (e.g. *Pyracantha* and *Ligustrum* in Armidale) and replace these with natives. Without a corresponding decrease in Pied Currawong numbers this may increase predation rates on small birds in the short term. 2) Develop ornamental plants which produce infertile seeds thereby reducing invasion by these plants. There are however many 'wild' plants that produce fertile seeds and are foci for continued invasion. This option does little to tackle current Pied Currawong food resources. 3) Intensively cull Pied Currawongs. This is relatively easy to accomplish when Pied Currawongs congregate in urban areas during autumn and winter and use predictable flight paths (see Bass 1990). This represents an effective short-term measure but fails to address the under lying cause. Integration of the three approaches outlined above may provide a compromise of both short- and long-term management objectives.

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MANAGEMENT OF RIVER RED GUMS FOR WATERBIRD NESTING

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In order to breed, waterbirds require appropriate sites for their nests. Most nests of waterbirds (families Pelecaniformes, Ciconiiformes) in River Red Gum wetlands were in clumps of live, mature trees next to open water. Often these Red Gums had branches leaning over the water. Retention of these nest trees is essential for waterbird conservation. The Red Gum wetlands of the Murrumbidgee River, which contain more mature trees than the Millewa and associated Red Gum wetlands of the Murray River, provide extensive and valuable breeding habitat for waterbirds.

INTRODUCTION

To breed successfully waterbirds require: (i) suitable places in which to build their nest; and (ii) appropriate water regimes in feeding areas at the nest site or nearby. The aim of this paper is to describe the characteristics of River Red Gums *Eucalyptus camaldulensis* in which waterbirds in the families Pelecaniformes and Ciconiformes construct their nests. Specifically, the paper: (i) reports our observations on the characteristics of Red Gums in which waterbirds nested along the middle section of the Murrumbidgee River; (ii) synthesizes our results and those of others (Vestjens 1975; Chesterfield *et al.* 1984; Kahl 1988; Maher 1988, 1990; Lowe 1989; Magrath 1992) on the characteristics of Red Gums used as nest trees by waterbirds in the Murray Darling basin; and (iii) derives recommendations for managing River Red Gums for nesting waterbirds. Recommendations for managing water regimes in River Red Gum wetlands for waterbird