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Foods of Pigeons and Doves in Fragmented Landscapes of Subtropical Eastern Australia

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Summary

We report dietary items of pigeons and doves from northern New South Wales and southern Queensland, obtained from opportunistic sampling of the gut contents of dead birds and observing foraging birds. Most records were from fragmented rainforest habitats, which now support abundant invasive fleshy-fruited plants. The fruits and seeds of invasive plants, particularly Camphor Laurel *Cinnamomum camphora*, formed the dominant food of several of the species sampled, although in some cases these birds appear to destroy most of the ingested seeds in the gizzard, thereby not contributing to weed dispersal. We also describe the first records of White-headed Pigeons *Columba leucomela* eating flowers and Brown Cuckoo-Doves *Macropygia amboinensis* eating flower buds. Camphor Laurel, via flowers, green and ripe fruits, and seeds, provided food for White-headed Pigeons in the Goolmangar district of New South Wales throughout the entire year. Seventy percent of the plant species whose fruits and seeds were recovered from the gut had not previously been recorded as food items for those bird species, illustrating how little is known about the diets of pigeons and doves in fragmented Australian landscapes.

Introduction

The diets of the frugivorous, mostly arboreal, rainforest pigeons, cuckoo-dove and fruit-doves in subtropical eastern Australia have been the subject of several detailed studies (Innis 1989; Date *et al.* 1991; Church 1997), predominantly from areas of extensive native vegetation. Much of the habitat within the ranges of these species has now been heavily modified, and consists of habitat fragments, cleared country and regrowth forest of indigenous and invasive plants. The diets of these birds in these modified habitats have been recorded only opportunistically (Holmes 1987; Higgins & Davies 1996), although it has been suggested that the fruits of invasive plants may now be important for supporting existing populations of some pigeon species (Date *et al.* 1996). In contrast, there have been no detailed studies on the diets of the predominantly terrestrially foraging doves in subtropical eastern Australia, and few food items have even been recorded opportunistically in this region (Higgins & Davies 1996; Rose 2001). Birds are the main seed-dispersal agents for many invasive plant species, although little is known about how birds contribute to the success of plant invasions through their diet, fruit-handling techniques, effects of gut passage on seed viability, and movements (Gosper *et al.* 2005).

The aim of this study was to document the food items of pigeons and doves in subtropical eastern Australia, particularly from areas of fragmented native vegetation and with a high abundance of invasive fleshy-fruited plants. We also specifically focussed on the temporal pattern of use of Camphor Laurel

Cinnamomum camphora as a food source. The data collected would increase our knowledge of the utilisation level of fruits of invasive plants by pigeons and doves, the probable treatment of seeds in the gut, and the other foods that the birds forage in these rarely studied habitats.

Study area and methods

Pigeons and doves that had died were collected, frozen and, at a later date, dissected for dietary analysis. Crop, gizzard and intestine (in those birds that do not destroy seeds in the gizzard) contents were removed. Seeds of each plant species (whole seeds only) were counted and identified by comparison with a reference collection housed at the Alan Fletcher Research Station, Biosecurity Queensland, Brisbane. Other material in the gut was also identified and a description made of the state of seeds at each stage of the gut passage process, to assess whether seeds were likely to pass through the gut intact or be destroyed during the process. Dead birds were collected between 2001 and 2006.

With the exception of one bird (an Emerald Dove *Chalcophaps indica*) collected from suburban Sherwood, Brisbane (27°32′S, 152°58′E), all other birds (total = 11) were collected at Goolmangar (28°43′S, 153°14′E; ~30 m above sea level), near Lismore in northern New South Wales (NSW). The vegetation in this area is a mix of pasture, remnant riparian and dry rainforest and eucalypt forest, with substantial areas of weedy regrowth dominated by the invasive trees Camphor Laurel and Broad-leaved Privet *Ligustrum lucidum*.

Opportunistic observations of food sources used by pigeons and doves in northern NSW were made over the period 1993 to 2005. Only those foods additional to records in Higgins & Davies (1996) and Church (1997) are included here, with the exception of detailed notes made on the usage of Camphor Laurel by pigeons at Goolmangar by one of the authors (DGG) over this period.

Results

White-headed Pigeon *Columba leucomela*

Five dead White-headed Pigeons were collected at Goolmangar and dissected (Table 1). The only plant material present in any of the guts was fruits and/or seeds of Camphor Laurel. Specimen 1 was an immature, collected beneath a stand of Camphor Laurel on 8 September 2004, that had died of unknown causes. Its crop contained only Camphor Laurel fruits and seeds. The fruits were old, brown and dried, and some remained attached to the pedicel. The seeds were free of pulp and no fruit pulp was found in the crop.

Specimen 2 was a fledgling (approximate age of 22 days, inferred from an incubation period of 19–20 days: Frith 1982), found dead on 12 March 2005 at the nest-site. The fledgling had left the nest 2 days earlier, roosted overnight ~3 m from the nest, but was observed back on the nest again during the day before it was found dead. Specimen 3 was a nestling (approximate age inferred at 14 days), which was found dead on 7 April 2005 at the nest-site. The crops of both these birds (probably killed by predators) contained only pigeon-milk, a cream-coloured, curd-like substance. Both gizzards contained Camphor Laurel seed(s) and seed fragments.

Specimen 4 was found freshly dead beside a road on 2 April 2006. The head and much of the flesh and feathers of the body had been removed by a predator/scavenger, although the actual cause of death was unknown. The crop was found intact ~30 cm from the body. This bird was judged to be a recently fledged juvenile on the basis of the remaining feathering and wing-length (187–193 mm, as compared with 219–248 mm for adult White-headed Pigeons: Higgins & Davies

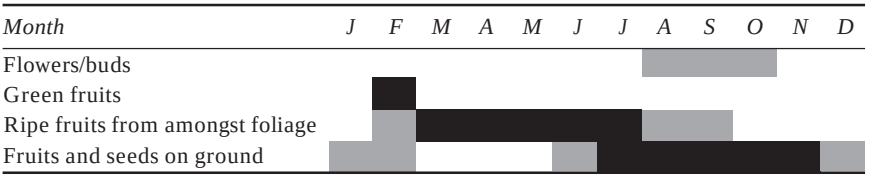
Table 1

Food items identified from the gut contents of pigeons and doves. [1]WhP = White-headed Pigeon (5 specimens); ED = Emerald Dove (5 specimens); BD = Bar-shouldered Dove; RF = Rose-crowned Fruit-Dove; [2]introduced plant species.

Plant species		*Plant part*	*WhP*[1]					*ED*					*BD*	*RF*
			1	*2*	*3*	*4*	*5*	*1*	*2*	*3*	*4*	*5*		
Acacia	*Acacia* sp.	seed							1					
Camphor Laurel[2]	*Cinnamomum camphora*	fruit (seed + pulp)	50+			22	50+							2
		seed		2	1			1	21	7	5			
Cheese Tree	*Glochidion ferdinandi*	arillate seed								65				
Macaranga	*Macaranga tanarius*	seed									76		1	
Cockspur Thorn	*Maclura cochinchinensis*	seed											3	
Cork Passionflower[2]	*Passiflora suberosa*	fruit (seeds + pulp)										3		
Coral Berry[2]	*Rivina humilis*	fruit (seed + pulp)										3		
Native Peach	*Trema tomentosa* var. *viridis*	seeds							5	2				
Grain[2]		seeds											50+	
Unknown species (no. of seeds)		seeds							2(5)	1(2)		1(2)		

Table 2

Periods of the year during which reproductive parts of Camphor Laurel provide food for White-headed Pigeons at Goolmangar, NSW. ■ = major food, ■ = minor food or food in some years only.



1996). Camphor Laurel fruits were the only food type present, with clean fresh seeds, pulp and skin in the crop. The gizzard contained intact Camphor Laurel seeds, and seed pieces of various sizes, and the interior surface of the gizzard was stained mauve.

Specimen 5 was an adult found dying in the grounds of Goolmangar Public School (date not recorded) before this study. Its crop contained Camphor Laurel fruits and seeds.

The gizzards from all of the the White-headed Pigeons had thick muscular walls and were ridged on the inside surface. Small rock fragments were occasionally present, and the bulk of the content of the gizzards was broken-down fragments of seeds.

A single new fruit food of the White-headed Pigeon was recorded opportunistically. On 5 April 1994, a single bird was observed consuming the fruits of Malletwood *Rhodamnia argentea* in Booyong Recreation Reserve, near Clunes in northern NSW. Ripe fruits were picked from amongst the foliage and swallowed whole.

At Goolmangar, White-headed Pigeons use Camphor Laurel as a food resource throughout the year (Table 2). Green fruits are taken from amongst the foliage over a brief period in February (first and last dates of observations 16 and 26 February) before fruit ripening, which usually occurs in late February. Ripe fruits are consumed from amongst the foliage up until September (last date 24 September), although in some years most of the fruits will have fallen to the ground by this time. Towards the end of the fruiting season, usually late June to August, there is overlap in arboreal and terrestrial foraging by the birds, sometimes on the same day.

White-headed Pigeons typically commence feeding on the ground beneath Camphor Laurel stands in June to July (earliest date 30 June), with terrestrial foraging peaking between late July and mid November, although there is some variation in timing between years. During 1994, when Camphor Laurel carried ripe fruits into late October, ground foraging was not observed until early December and involved few birds. Loose foraging aggregations of 20–40 birds are common, although groups of around 100 birds have been recorded. Over the period 14 September to 17 October 1997, assemblages of up to 105 birds were recorded feeding under stands of Camphor Laurel in the grounds of Goolmangar and Blakebrook schools in the early mornings and late afternoons. The duration of the peaks in terrestrial foraging is usually only a few weeks, and numbers of White-headed Pigeons in the local area decline thereafter, although small numbers of pigeons forage for Camphor Laurel seeds on the ground until early February

(latest date 8 February). Small numbers of Brown Cuckoo-Doves *Macropygia amboinensis*, Emerald Doves, Wonga Pigeons *Leucosarcia picata*, Australian King-Parrots *Alisterus scapularis* and, in open areas, Crested Pigeons *Ocyphaps lophotes* occasionally joined ground-foraging White-headed Pigeons.

White-headed Pigeons were also observed feeding on Camphor Laurel flowers on several occasions. On 27 September 1996 in the late afternoon (1720 h, with sunset at 1745 h), a flock of 10–12 White-headed Pigeons flew into a flowering Camphor Laurel tree along Goolmangar Creek. The pigeons soon moved to the outer foliage and began pecking at the small flowers and/or unopened flower buds. Subsequent observations on the afternoons of 30 September and 5 October confirmed that flowers/buds were being pecked off and swallowed whole. No evidence was detected of pieces being dropped.

Brown Cuckoo-Dove *Macropygia amboinensis*

Three new food items of Brown Cuckoo-Doves were identified from opportunistic observations of foraging birds. Fruits of Shiny-leaved Stinging Tree *Dendrocnide photiniphylla* were consumed at Booyong Recreation Reserve in December 1993. Fruits of Creek Sandpaper Fig *Ficus coronata* were consumed at Protester's Falls Picnic Area, Nightcap National Park, on 15 January 1995. On 7 January 1999 at Bar Mountain in the Border Ranges National Park, a solitary bird fed on the small flower buds of an unidentified tree overhanging the walking trail. The bird was observed for ~5 minutes, and the buds were picked from among the foliage and swallowed whole.

At Goolmangar, where Brown Cuckoo-Doves are present in low numbers, they have not been observed to take fruit from Camphor Laurels, although they have sometimes been observed foraging on the ground beneath Camphor Laurel stands. Cuckoo-Doves foraged both alone and in loose association with foraging aggregations of White-headed Pigeons.

Emerald Dove *Chalcophaps indica*

Five Emerald Doves were dissected following fatal collisions with windows. Four of these were from Goolmangar, and were collected on the following dates: Specimen 1 on 7 October 1998, Specimen 2 (adult male) on 18 September 2003, Specimen 3 (adult female) on 1 December 2004, and Specimen 4 (adult female) on 20 November 2005. Specimen 5 was an adult female that died in early January 2004 (date not recorded) at Sherwood, Brisbane. All guts contained numerous seeds, either ingested as whole fruits including pulp (Specimen 5 feeding on Cork Passionflower *Passiflora suberosa* and Coral Berry *Rivina humilis*), as arillate seeds (seeds with a fleshy attachment) (Specimen 3 feeding on Cheese Tree *Glochidion ferdinandi*), or bare seeds without pulp (Specimens 2, 3 and 4 feeding on Camphor Laurel, Specimens 2 and 3 on Native Peach *Trema tomentosa* var. *viridis* and Specimen 4 on Macaranga *Macaranga tanarius*) (Table 1). In addition, the crop of Specimen 2 contained three small snails.

Gizzards from the Emerald Doves had thick muscular walls and were ridged on the inside surface. Small rock fragments were present in two of the five gizzards, and the bulk of the content of the gizzards was broken-down fragments of seeds. Most of the intact seeds were recovered from the crops of the birds.

At Goolmangar, Emerald Doves were often observed foraging under larger stands of Camphor Laurel.

Bar-shouldered Dove *Geopelia humeralis*

A single Bar-shouldered Dove was dissected after being collected on an unknown date at Goolmangar (cause of death not recorded). Over 90% of the seeds in the crop and gizzard were of grain (possibly commercial chicken feed), although seeds (without pulp) of the native Macaranga and Cockspur Thorn *Maclura cochinchinensis* were also present (Table 1). The gizzard was muscular, ridged on the inside surface and contained several small rock fragments. The bulk of the gizzard content was broken-down seed fragments.

Rose-crowned Fruit-Dove *Ptilinopus regina*

A single Rose-crowned Fruit-Dove was dissected: a subadult male that had been killed in a collision with a window at Goolmangar on 7 September 2001. The only food items in the gut were fruits of Camphor Laurel (seeds and pulp) (Table 1). The gizzard from this specimen was less muscular than in the other species examined, and had a lumpy inner surface. Seeds in the gizzard were intact, but mostly separated from the fruit/pulp.

Rose-crowned Fruit-Doves were observed feeding on four food items that have not been previously recorded. Fruits of Oliver's Sassafras *Cinnamomum oliveri*, Three-veined Cryptocarya *Cryptocarya triplinervis* and *Guilfoylia monostylis* were seen to be consumed at Booyong Recreation Reserve on 5 January, 1 February and 5 April 1994 respectively. Fruits of Scrub Turpentine *Rhodamnia rubescens* were consumed at Rocky Creek Dam, near Dunoon in northern NSW, on 28 November 1993.

Rose-crowned Fruit-Doves occur at Goolmangar in low numbers throughout most of the year (Gosper & Holmes 2002), and have been observed feeding on Camphor Laurel fruits in May and June, plus September for the dissected specimen (with other observations in the district in July and September). The nest of a Rose-crowned Fruit-Dove in a small Rough-leaved Elm *Aphananthe philippinensis* tree near Goolmangar Creek was monitored for 11 days in June 2002, with a large nestling being visible by 12 June. On 15 June (at 0915 h) the two adults and fledgling were disturbed from a perch in an overhanging Camphor Laurel ~2 m above their empty nest. The birds dispersed a short distance (<6 m) in different directions, with the adults landing in adjoining trees. The fledgling could not be relocated. Shortly after, both adults returned to the canopy of the original tree and commenced feeding on Camphor Laurel fruits. The ground below the nest had fresh faeces and the fresh skins of several Camphor Laurel fruits. Notes made at the time did not record whether the faecal material contained the skins or whether these were separate.

Topknot Pigeon *Lopholaimus antarcticus*

A single new food record for the Topknot Pigeon was recorded: fruits of Rose Maple *Cryptocarya rigida* were consumed near Minyon Falls, Whian Whian State Forest (now part of Nightcap National Park) (date not recorded).

Topknot Pigeons visit Goolmangar annually to feed on Camphor Laurel fruits. Flock size is typically in the order of 40 to 100 birds, but more than 250 were recorded in visiting flocks in 1993, 1996 and 1997. The first flocks regularly appear in March or April, but departure times and the length of time that the birds stay in the area are less consistent, with the birds leaving as early as May or as late as November (Table 3). Most foraging occurs in larger stands of Camphor Laurel,

Table 3

Dates that the first and last flocks of Topknot Pigeons were recorded at Goolmangar, NSW, and duration of stay over the period 1993–2005.

Year	*First date*	*Last date*	*Duration (days)*
1993	14 March	22 May	69
1994	28 June	10 November	135
1995	17 March	10 May	54
1996	16 March	4 July	110
1997	14 April	2 July	79
1998	1 April	10 November	223
1999	8 March	20 June	104
2000	23 April	No data	-
2001	19 April	10 July	82
2002	27 April	30 June	64
2003	No data	No data	-
2004	19 March	8 August	142
2005	5 April	4 July	90
Mean			104.7

such as along Goolmangar Creek, and isolated trees in more open situations are largely avoided. Topknot Pigeons appear 'nervous' when foraging in this largely cleared landscape, and are easily disturbed by human presence. Flocks arrive during the morning and leave in the evening, heading in a north-westerly to westerly direction presumably to roost in forests farther up the Goolmangar Creek catchment.

Discussion

White-headed Pigeon

The state of Camphor Laurel fruits and seeds recovered from the dissected guts of the White-headed Pigeons indicates that these birds foraged on the ground and/or in the foliage. Bare seeds of Camphor Laurel are abundant on the ground beneath stands at Goolmangar, through the foraging activities of Scaly-breasted Lorikeets *Trichoglossus chlorolepidotu*s (Gosper & Gosper 1996), defaecated seeds from other frugivores, and probably the weathering of dislodged or shed fruits. Bare seeds were present in the gizzards of the nestling and fledgling. Both these birds died over the period when most observations of feeding White-headed Pigeons were of them taking ripe fruits from amongst foliage. It is unknown if the parent birds ate bare seeds from the ground (thus indicating that this food type is used throughout the year), or if whole fruits were consumed and the seed and pulp became separated in the gut of the parent before the seed was fed to their offspring.

Camphor Laurel fruits and/or seeds were detected in each of the five guts examined, and were the only plant matter present. This finding suggests that the fruits and seeds of this invasive plant are an important food for White-headed

Pigeons locally, as suggested by Date *et al.* (1996). The gizzard of each specimen contained mostly seed fragments, indicating that White-headed Pigeons destroy most ingested Camphor Laurel seeds and are unlikely to be a significant dispersal agent. Corlett (2005) suggested that consumption of seeds by Spotted Doves *Streptopelia chinensis* might be influencing the ability of Camphor Laurel to naturalise in Hong Kong. The role of White-headed Pigeons (and other seed-grinding species such as Emerald Doves) in rendering Camphor Laurel seeds incapable of germination and thus limiting the recruitment of new Camphor Laurel trees in the study area is unknown, but certainly this species destroys substantial quantities of seeds.

Two juvenile birds contained pigeon-milk in the crop. There is little information on the length of time that this milk is fed to juvenile Australian pigeons, with Higgins & Davies (1996) indicating only that crop-milk is fed exclusively for the first few days. These records of milk being fed to juveniles at around 14 and 22 days of age are consistent with the length of time that other frugivorous pigeon species feed crop-milk to their young (del Hoyo *et al.* 1997). Milk has been recorded in the crop of the White-crowned Pigeon *Columba leucocephala* and Band-tailed Pigeon *C. fasciata* for up to 20 and 30 days after hatching, respectively (del Hoyo *et al.* 1997). In the present study, seeds of Camphor Laurel had also been fed to these juveniles by their parents, as the juveniles had died before leaving the natal shrub.

As far as we are aware, we describe the first record of White-headed Pigeons consuming flowers or buds. Few Australian pigeons have been recorded consuming flowers, although some pigeons overseas frequently consume them (e.g. New Zealand Pigeon *Hemiphaga novaeseelandiae* and Common Woodpigeon *Columba palumbus*: Higgins & Davies 1996; del Hoyo *et al.* 1997). Although not present in the gut samples in the present study, green Camphor Laurel fruits were seen to be consumed by White-headed Pigeons at Goolmangar, in addition to whole ripe fruits and bare seeds. Thus, White-headed Pigeons use each of the reproductive stages of Camphor Laurel (flowers, green and ripe fruit, and bare seeds) as food. This habit represents a remarkable flexibility in diet and foraging behaviour in using the complete spectrum of Camphor Laurel's reproductive resources. Although we do not know if White-headed Pigeons use any indigenous flowers as food, the possibility exists that Camphor Laurel is now providing a food type for the pigeons that was not previously used.

The temporal pattern of occurrence of White-headed Pigeons at Goolmangar differed from that reported by Innis (1989) from areas with Camphor Laurel in south-eastern Queensland. At Goolmangar, at least small numbers of White-headed Pigeons are found throughout the year, not just during the Camphor Laurel fruiting season (although the local abundance for the species peaks in the latter part of the fruiting season and shortly afterwards).

Brown Cuckoo-Dove

As far as we are aware, we describe the first record of Brown Cuckoo-Doves feeding on flower buds.

Emerald Dove

Few food items have been recorded for the Emerald Dove in eastern Australia

(Higgins & Davies 1996), with all those reported in the gut of the sampled specimens being previously unrecorded, except for Camphor Laurel. Birds fed on either fleshy fruits (seeds with pulp or aril) or bare seeds. The gizzard of each specimen contained mostly seed fragments, indicating that Emerald Doves destroy most ingested seeds. In particular, seed fragments of Camphor Laurel and Cork Passionflower were identifiable, and Emerald Doves are thus unlikely to be a significant dispersal agent for these invasive plants.

Snails were identified in the crop of one of the Emerald Doves, as they have been previously (Higgins & Davies 1996). It is possible that the bird accidentally ingested these animals when picking up seeds from the forest floor, as one of the snails was still attached to a Camphor Laurel seed.

Bar-shouldered Dove

Few food items have been recorded for the Bar-shouldered Dove in eastern Australia (Higgins & Davies 1996), with the seeds of each of the native plant species present in the gut of the sampled specimen being previously unrecorded.

Topknot Pigeon

The length of stay and departure dates for Topknot Pigeons at Goolmangar varied considerably between years, much more than did the time of arrival. Innis (1989) reported similar movement patterns in south-eastern Queensland, with initial arrival of Topknot Pigeons in Camphor Laurel stands usually in April to May, and with a variable length of stay. It is possible that departure movements at Goolmangar occur in response to the availability of Camphor Laurel fruits, the main food item at this site. In one of the years (1994) when departure was very late (10 November, the latest date recorded at this site: DGG pers. obs.), ripe Camphor Laurel fruits were available in trees up until 29 October. The timing of the arrival of Topknot Pigeons matches the end of the Bangalow Palm *Archontophoenix cunninghamiana* fruit crop (Frith 1957; Holmes 1987), which stimulates widespread dispersal movements in Topknot Pigeons and dietary switching to Camphor Laurel (Frith 1957; Innis 1989).

Conclusion

The fruits and/or seeds of invasive plants made up a significant proportion of the gut contents of the birds dissected in this study. Camphor Laurel seeds or fruits were the only plant matter in the gut of the five White-headed Pigeons and the single Rose-crowned Fruit-Dove, and were also present in the four Emerald Doves from Goolmangar. Camphor Laurel is well known as a food source for pigeons and doves (Innis 1989; Date *et al.* 1996), with one of the most interesting aspects of the current study being the length of time that it provides food to the terrestrially foraging species. Camphor Laurel provides fruit from February through to June or July (and October or November in peak years) (Holmes 1987; Innis 1989; DGG pers. obs.), but is capable of providing food for Emerald Doves through to at least December and for White-headed Pigeons to February in the form of seeds on the ground.

There is debate about the importance of Camphor Laurel fruits for frugivore populations. Date *et al.* (1991, 1996) regarded Camphor Laurel fruits as providing an important food source for rainforest pigeons, and Camphor Laurel regrowth

as providing 'stepping-stones' of suitable habitat linking remnant areas of rainforest. Friend (2006), however, asserted that some forms of Camphor Laurel (chemotypes) are actually toxic to birds, causing death or leading to infertility, and that continued invasion of Camphor Laurel may threaten these bird species (although this view was not supported by the NSW Scientific Committee 2004). Although the present study provides further evidence of the extensive use of Camphor Laurel fruits and seeds by pigeons and doves, the proposal of direct toxic effects or infertility from the ingestion of Camphor Laurel seeds lacks supporting evidence. The death of all but three birds collected during this study (all White-headed Pigeons) that had fed on Camphor Laurel can be attributed with confidence to either collision with a window or predation. All of the pigeon and dove species reported on (except Topknot Pigeon) have also successfully hatched young at Goolmangar (DGG pers. obs.).

Seventy percent of the food items recovered from gut samples had not previously been recorded as foods for the relevant bird species, including all of the native plant foods recorded. Furthermore, new food types (flowers and buds) were recorded for two species (White-headed Pigeon and Brown Cuckoo-Dove). These findings readily illustrate how poorly known are the diets of native pigeons and doves in fragmented Australian landscapes.

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