

Gang-gang Cockatoo diet as assessed by camera images and written records

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The diet of the endangered Gang-gang Cockatoo *Callocephalon fimbriatum* has not been well documented. The aim of this investigation was to collate and synthesise information from electronic and written sources to fill this knowledge gap and thus provide information that could assist in the species' conservation. Four thousand one hundred and thirty five feeding records from across the species' range were collated from image-based records posted on social media and citizen science platforms, and from the written records of bird observer clubs and bird group databases. There were 275 different food items recorded in these feeding records. Gang-gangs fed on seven main food groups: eucalypt nuts and flowers (43% of all feeding events); berries with relatively large seeds but a small pulp mass (21%); green cones of mainly the Pinaceae and Cupressaceae families (10%); wattles, almost exclusively in spring – early summer and on plants with green pods (8%); soft pods mainly of Liquidamber *Liquidamber styraciflua* (7%); nuts, mainly walnuts *Juglans sp.* and oak acorns *Quercus sp.* (3%), and invertebrates, mainly sawfly *Pergidae sp.* larvae and lerps *Pysllidae sp.* (1%). The Gang-gang's diet varies across its range and this seems to largely reflect the particular food species that are available locally (both planted or indigenous to certain areas). However, there are both regional and overall food preferences. Just twelve taxa accounted for 54% of all feeding events, whilst most other food items were only recorded as being eaten once or twice. Twenty-six percent of the plant species eaten are exotic, which suggests that Gang-gangs can adjust to new food sources. Gang-gangs' diet is broad and flexible and their food is abundant.

Keywords: Gang-gang; diet; image-based records; feeding preferences; food availability

INTRODUCTION

The Gang-gang Cockatoo *Callocephalon fimbriatum* (Cacatuidae) is a small (230-334 g), stocky cockatoo of forests, woodlands and urban areas in cool-temperate south-eastern Australia. It is most closely related to the Galah *Eolophus roseicapilla*, but unlike this predominantly ground-feeding bird, the Gang-gang almost exclusively feeds in the tree and shrub canopy.

Higgins (1999) summarised Gang-gang diet information from 61 papers and three personal communications; his review identified 54 plant and five insect food items, including components of 23 species of *Eucalyptus*, seven *Acacia* species and 14 exotic plants. Higgins (1999) concluded that food mainly consisted of seeds of native and introduced trees and shrubs, especially eucalypts, acacias and hawthorns *Crataegus*, as well as berries, fruits, nuts and insects and their larvae. Most of the reviewed literature consisted of written observations of one or a few Gang-gang feeding events or lists of species on which Gang-gangs had been seen feeding. There has been no comprehensive study of Gang-gang diet. The relative importance of different food items and how diet may change across the seasons or the Gang-gang's range are largely unknown.

Technological advances in photographic image capture, collection and storage provide a new and relatively comprehensive data source for such information. Many hundreds of people are now recording their Gang-gang observations as images on

social media or citizen science platforms such as Naturemapr, iNaturalist or eBird. It must be acknowledged that this is a biased sample, as images tend to be from locations where Gang-gangs are most readily encountered (urban and peri-urban) and are less likely to include records from remote areas or from tall trees where birds are difficult to see and photograph. The images may also over-represent males, as their bright red head makes them more visible and photogenic. Despite these biases, the images can still tell us much about what Gang-gangs are eating.

DAWE (2022) recently listed the Gang-gang as endangered, largely because of a perceived 69% decline in numbers from 1999-2019. The aim of the present study was to provide a better understanding of the species' diet which will aid in identification of critical habitat, may lead to better understanding of the key identified threats of fire and land clearance and could guide habitat restoration.

METHODS

Feeding records of Gang-gangs were compiled from 2,787 on-line image records and 1,348 written records. Projects seeking images of feeding Gang-gangs were created or adapted within the electronic Naturemapr and iNaturalist platforms. Both platforms operate over the total Gang-gang range and allow posting of at least five images of a single feeding event. A feeding event was defined as the number of Gang-gangs in an image or written record multiplied by the number of days over which the feeding event was recorded. However, most of

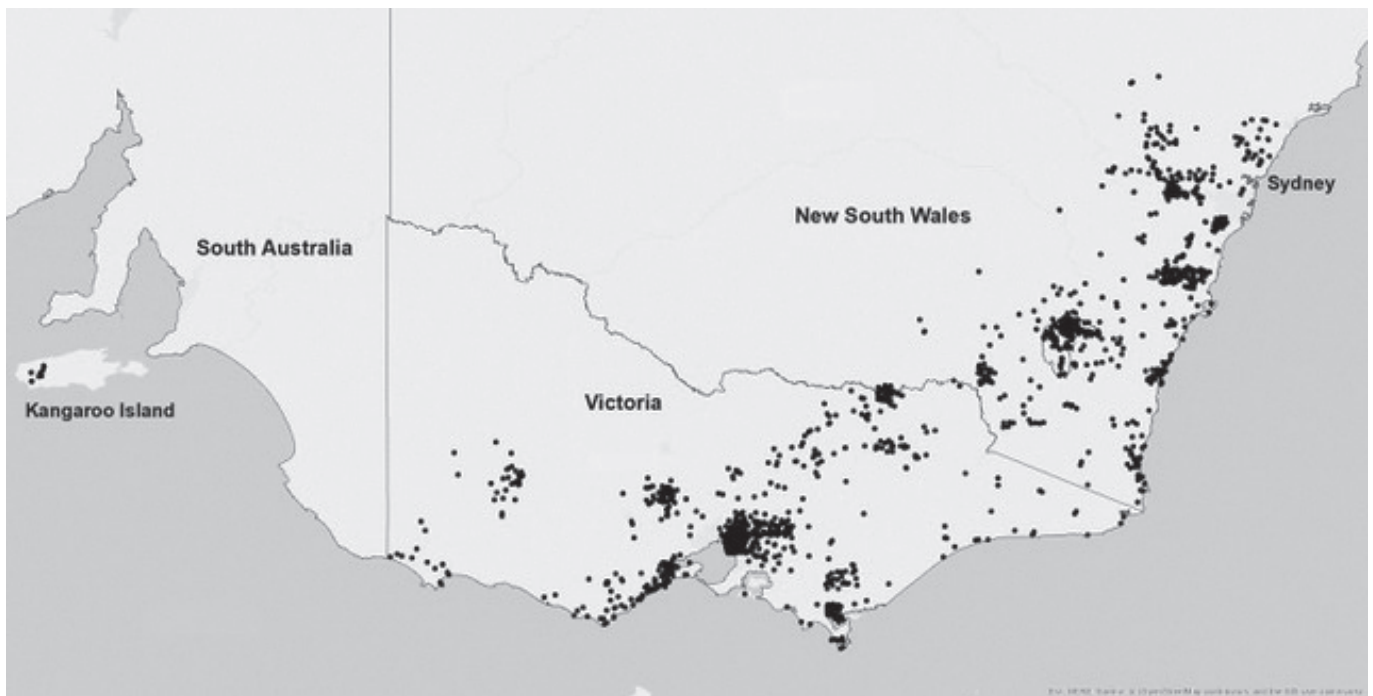


Figure 1. Distribution of collated Gang-gang feeding records.

the records were of feeding on one day only. The people who posted images were also asked to provide the date and location of the observation, the number and sex of birds observed and to describe what item they were consuming. The Naturemapr platform received 429 feeding sightings, whilst 858 were lodged via iNaturalist. eBird provided 310 records with images of feeding Gang-gangs and a further 449 written-only records.

The Facebook pages of about 75 bird, nature conservation and wildlife photography groups operating across the Gang-gang's range were searched using the key words "gang" "Gang-gang Cockatoo" or "*Callocephalon*". The latter two keyword searches were also utilised to locate Gang-gang images in other major social media platforms. In total, Facebook provided 530 feeding images, Flicker 376, Instagram 202 and Twitter 23. Duplicate records posted across platforms were excluded, as were lowest count second sightings of Gang-gangs made by different observers at the same location on the same day.

Non-electronic, written location records containing Gang-gang feeding information were requested and provided by the Canberra Ornithologists Group (625 records), Blue Mountains Bird Observers (139 records) and the New South Wales Far South Coast Bird Observers Club (2 records). A further 85 records came via emails to the senior author, whilst a literature review provided an additional 55 records. Records analysed were obtained between 1910 and August 2022; however, 92% of records were collected after 2012 and thus most of the records in this analysis post-date the review conducted by Higgins (1999).

The Euclid eucalypt (Slee *et al.* 2020), wattle (Maslin 2018) and HortFlora (Royal Botanic Gardens 2018) keys were utilised to confirm the identification of plant food items in the image records. Google Streetview was used to identify some urban plants where Gang-gangs were recorded foraging on an unidentified urban tree or shrub. Where identification was

uncertain in images posted on the Naturemapr or iNaturalist platforms, online messages or emails seeking further information were sent to the reporters. In some instances, plants could only be identified to genus and some insects only to family level. For example, the identifying feature distinguishing English Hawthorn *Crataegus laevigata* from Hawthorn *C. monogyna* is the number of nutlets in the fruit; this is not obvious in a photograph and so these two species were combined in analysis.

A Gang-gang was considered to be feeding if it held the item in its beak or foot, or if the reporter specifically stated that it was a feeding event. It is likely that some of the sightings are of Gang-gangs sampling an item but not eating it. Gang-gangs bite beak-sized chunks of bark to line the base of tree hollows in which they are nesting (Davey *et al.* 2019); images of Gang-gangs biting bark or with bark in their beaks were not considered to constitute a feeding record. Records of birds at feeding stations or in aviaries were not included. For each sighting the number and sex of birds feeding and observable in the image(s) or recorded by the reporter were obtained.

RESULTS

Diet throughout the species' range

Records were collected from across the Gang-gang's range, including from the introduced population on Kangaroo Island, South Australia. Most records came from the western and coastal edges of the Gang-gang's range, particularly in the vicinity of Canberra and Melbourne. Data were most sparse for the remote, mountainous areas of SE New South Wales (NSW) and NE Victoria.

The feeding records comprised 16,978 feeding events in which 275 different food items were recorded. Seven food groups made up the majority of records (Table 1). Gang-gangs

Table 1
The main Gang-gang food groups identified in the present study.

Food Group (proportion of all feeding events)	Number of species	Main species consumed
Eucalypt flowers, buds, nuts and shoots (43%)	80 <i>Eucalyptus</i> 6 <i>Corymbia</i> 4 <i>Angophora</i>	Blue Gum <i>E. globulus</i> , Sugar Gum <i>E. cladocalyx</i> , Apple Gum <i>E. brigesiana</i> , Snow Gum <i>E. pauciflora</i> , Sydney Peppermint <i>E. piperita</i> , Red Stringybark <i>E. macrorhynch</i> , Silvertop Ash <i>E. sieberi</i> , Yellow Gum <i>E. leucoxydon</i>
Berries with large seeds and small fruits (21%)	36	Hawthorn <i>Crataegus monogyna/laevigata</i> , <i>Cotoneaster glaucophyllus</i> , White Cedar <i>Melia azedarach</i> , Pistachio <i>Pistacia chinensis</i> , Narrow-leaved Geebung <i>Persoonia linearis</i>
Cones, usually green and of Pine and Cypress families (10%)	26	Arizona Cypress <i>Cupressus arizonica</i> , Monterey Cypress <i>C. macrocarpa</i> , Mediterranean Cypress <i>C. sempervirens</i> , Black Cypress Pine <i>Callitris endlicheri</i>
Soft Pods (9%)	12	<i>Liquidambar styraciflua</i> , Conestick <i>Petrophile pulchella</i>
Wattle flowers and mainly green pods (7.5%)	52	Silver Wattle <i>Acacia dealbata</i> , Cootamundra Wattle <i>A. baileyana</i> , Black Wattle <i>A. mearnsii</i> , Sallow or Sydney Golden Wattle <i>A. longifolia</i>
Nuts (2.5%)	10	Walnuts <i>Juglans</i> sp.
Invertebrates (1.5%)	16	Sawfly larvae <i>Pergidae</i> sp., Lerps <i>Psyllidae</i> sp. galls of wattles and eucalypts

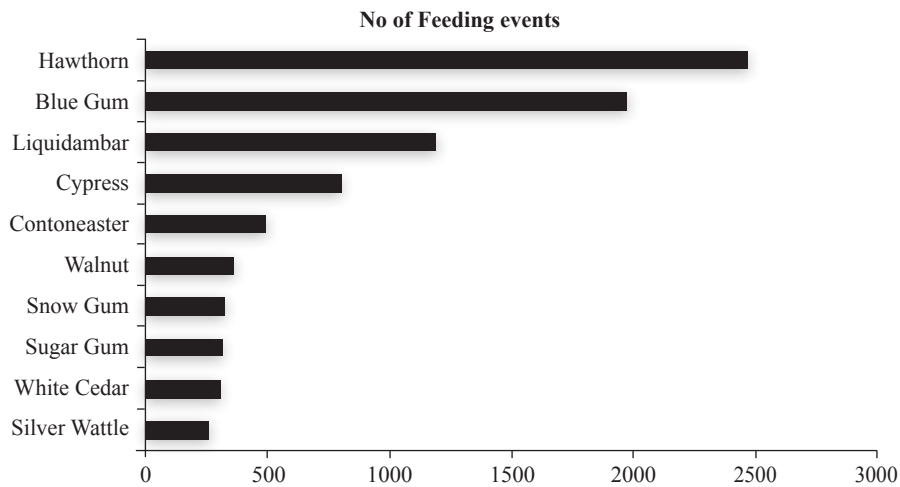


Figure 2. Number of feeding events recorded for the 12 plant taxa most commonly consumed by Gang-gangs.

were also recorded feeding on items from eight other food groups not listed in Table 1. These items included: herb leaves (159 events), large fleshy fruits (119), nuts of Myrtaceae species other than eucalypts (101), buds of new shoots (68), winged seeds (62), flowers (42), a bird carcass (1) and fungus (1). However, together these items accounted for only 3% of feeding events. Of the food items recorded, 26% were components of exotic plants, which suggests that the cockatoo has an ability to adjust to and utilise ‘new’ food resources.

In more than 98% of records, Gang-gangs were feeding in trees or shrubs. They occasionally descended to the ground to eat herbs (particularly Water Milfoil *Myriophyllum* sp.) or

fallen and partly broken-up nuts, such as acorns of *Quercus* sp. or hazelnuts *Corlyus* sp. This pattern is consistent with earlier findings that Gang-gangs are predominately canopy feeders and only occasionally feed on low shrubs (Loyn 1985; Recher and Holmes 1985). The most unusual dietary items were Parsley *Petroselinum crispum* eaten by one bird in a Canberra backyard and freshly killed Australian Magpie *Gymnorhina tibicen* roadkill in the Geelong area (Swan 1977).

The numbers of feeding events recorded for the twelve most commonly consumed species/species groupings across the Gang-gang’s entire range are shown in Figure 2. Just three plant taxa accounted for a third of all of the feeding events; these were

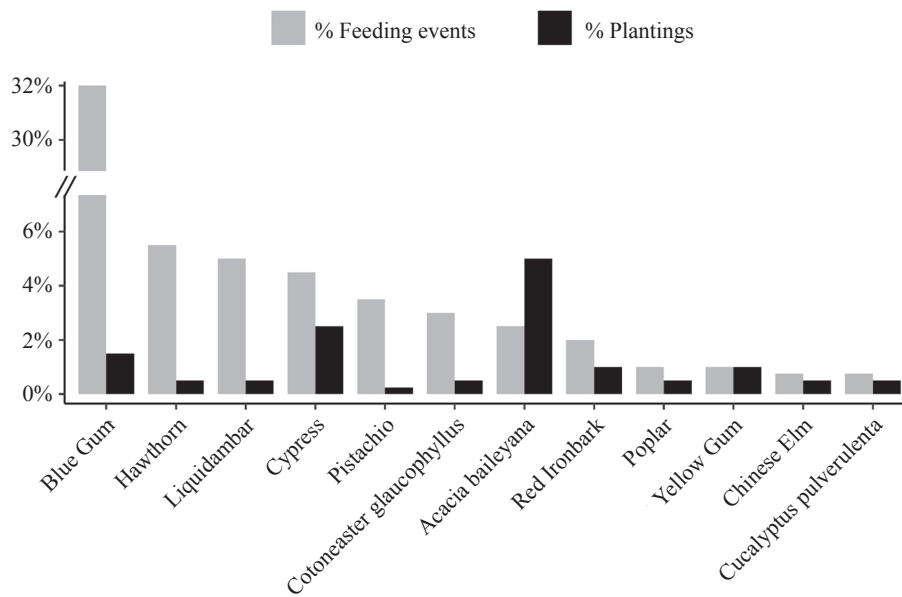


Figure 3. Percentage of Canberra Gang-gang feeding events in which the 12 most frequently recorded plants were observed and their percentage abundance in plantings. Note the break in the vertical axis for visual clarity.

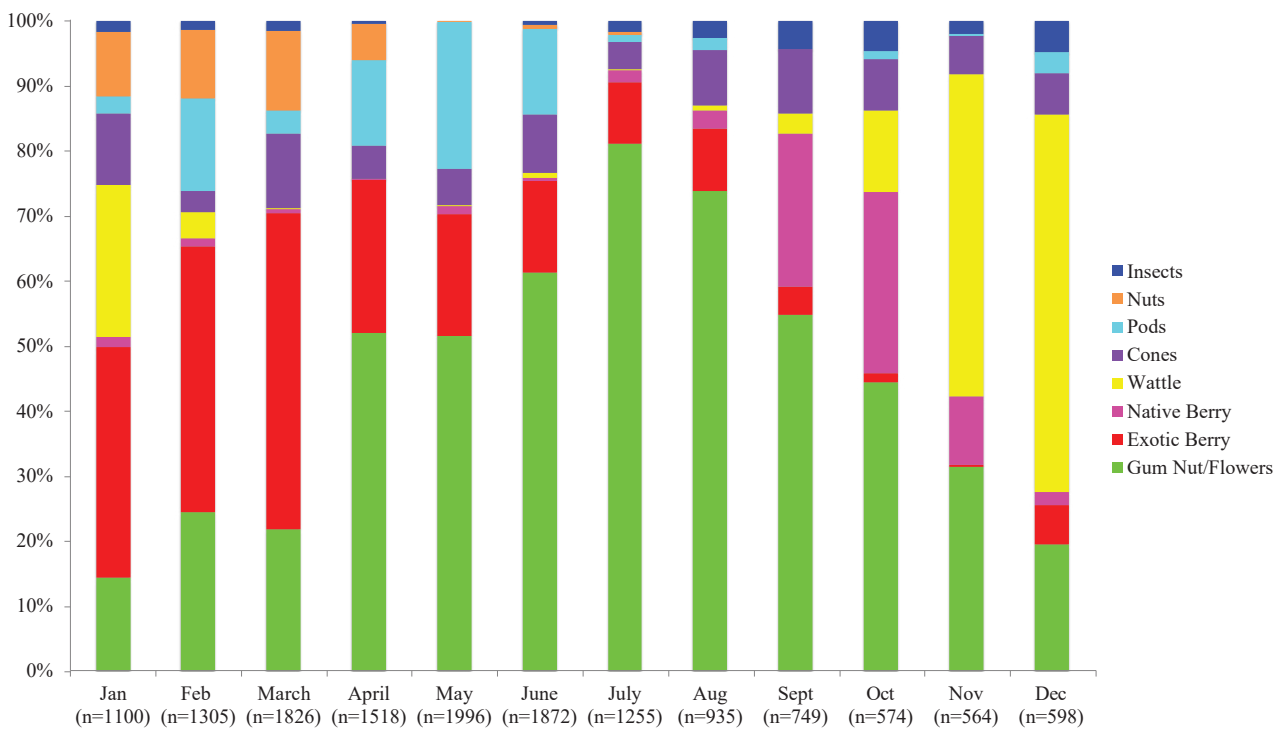


Figure 4. Percentage consumption of Gang-gang food groups across the year (% feeding events).

Hawthorn (14% of all records), Blue Gum *Eucalyptus globulus* (including four of its subspecies *bicostata*, *globulus*, *maidenii* and *pseudoglobulus*) (12%), and *Liquidambar styraciflua* (7%). The 12 most commonly observed species/species groupings accounted for 54% of all feeding events. For 143 (53%) of the food items identified, Gang-gangs were only reported consuming them once or twice. Thus Gang-gangs appear to consume a wide range of foods, but the bulk of their feeding is focused on a few species.

Food preference versus availability

Whilst the feeding data indicate the proportions that particular food groups or species comprise of Gang-gangs’ diet, it is uncertain whether these proportions are the result of the birds exercising preferences or just reflect the relative abundances of the foods that they encounter. Some insight into this question can be gained by reference to the research of Mulvaney (1991). This author collated over two million

Table 2

Diet parameters at three locations and overall across the Gang-gang's range.

	National	Blue Mountains	ACT	Greater Melbourne
No. of feeding events	16,798	1,743	6,893	1,431
Number of food items	275	67	144	55
No. of food items only recorded once	110 (40%)	32 (48%)	62 (43%)	20 (36%)
% top 3 taxa contribute to total feeding events	31%	47%	40%	53%
10 most commonly fed-on species – in order of number of feeding events	<i>Crataegus</i> sp. <i>Eucalyptus globulus</i> <i>Liquidamber styraciflua</i> <i>Juglans</i> sp. <i>Cotoneaster glaucophyllus</i> <i>Eucalyptus pauciflora</i> <i>Eucalyptus cladocalyx</i> <i>Melia azerdarach</i> <i>Cupressus arizonica</i> <i>Acacia dealbata</i>	<i>Juglans</i> sp. <i>Liquidamber styraciflua</i> <i>Eucalyptus piperita</i> <i>Petrophile pulchella</i> <i>Eucalyptus sieberi</i> <i>Eucalyptus racemosa</i> <i>Corymbia gummifera</i> <i>Crataegus</i> sp. <i>Rosa</i> sp. <i>Allocasuarina littoralis</i>	<i>Eucalyptus globulus</i> <i>Liquidamber styraciflua</i> <i>Pistacia chinensis</i> <i>Eucalyptus bridgesiana</i> <i>Cupressus sempervirens</i> <i>Eucalyptus macrorhyncha</i> <i>Acacia baileyana</i> <i>Crataegus</i> sp. <i>Cotoneaster glaucophyllus</i> <i>Eucalyptus sideroxylon</i>	<i>Crataegus</i> sp. <i>Eucalyptus cladocalyx</i> <i>Cotoneaster glaucophyllus</i> <i>Eucalyptus goniocalyx</i> <i>Corymbia citriodora</i> <i>Eucalyptus leucoxydon</i> <i>Melia azerdarach</i> <i>Acacia mearnsii</i> <i>Liquidamber styraciflua</i> <i>Eucalyptus botryoides</i>

records of the non-local tree and shrub plantings in Canberra up to 1985, which at that time was thought to represent about 17% of the city's total plantings. Whilst this planting record is from 40 years ago, most of the trees and shrubs will have survived to the present time and be mature and fruit/seed producing, and most of the plantings would have been in the inner Canberra area where over 90% of the city's Gang-gang feeding sightings were recorded. In Figure 3 the proportion that a plant species contributes to the overall Canberra feeding event record is compared to the proportion that it comprises of the city's plantings as determined by Mulvaney (1991). If feeding was purely a matter of what Gang-gangs encounter, then the two proportions should be roughly the same.

The comparison shows that Gang-gangs are not simply feeding on species in proportion to their occurrence in the city. The top 12 most consumed plant species/species groupings account for 63% of all Gang-gang feeding events but for only 19% of Canberra's plantings. The distribution is uneven among the 12 food plants: Blue Gum, Liquidamber, Pistachio *Pistacia chinensis* and Hawthorn make up 47% of all feeding events, but account for only 3.3% of Canberra's planting, whereas Cootamundra Wattle *Acacia baileyana* and Cotoneasters *Cotoneaster* sp. account for 5.5% of all feeding events and make up 9.5% of all plantings. Nonetheless, overall there is a significant difference between the occurrence of these 12 food plant species in Gang-gang feeding events and their relative proportions in Canberra plantings ($\chi^2 = 6,841$, d. f. = 11, $p < 0.001$). Assuming equal planting of trees and shrubs, the former, being larger, are likely to be encountered more commonly by Gang-gangs, which may partially account for the observed results. Nevertheless, actual Gang-gang diet at least in Canberra seems to be a result of both the birds' preferences and what happens to be available.

Seasonal diet changes

There are major changes across the year in both the feeding reporting rate and what is eaten (Fig. 4). These changes not

surprisingly seem in part to be related to what food items are available at a particular time, but there also seems to be an element of Gang-gang food selection involved. For example, gum nuts and buds are available throughout the year but feature in a much greater proportion of feeding events in winter than in spring and summer. Wattles are the main food plants in November and December and remain a major food item in January, but exotic berries (or small fruits) become the main item in February and March. Gum nuts and flowers are the major food item from April to October; they peak in constituting the major proportion of the overall diet from May to August. Exotic berries, largely of Hawthorn, Chinese Pistachio and *Cotoneaster glaucophyllus*, are mainly eaten from January to June. Native berries, such as those of Geebung *Persoonia* sp. and White Cedar *Melia azerdarach*, are targeted in September and October, largely within the Sydney Basin and NSW South Coast. Cones are the item with fewest monthly differences in consumption rates, featuring in 5-12% of food events in each month. Mediterranean Cypress *Cupressus sempervirens* and Snow Gum *Eucalyptus pauciflora* are the only food items that were recorded as being eaten in every month.

Gang-gang pod eating includes both bits of the pod and the seeds inside. The timing of pod eating seems to be largely related to the ripening of *Liquidamber styraciflua* pods. Feeding on this species mainly occurs from April to June and peaks in May. Nut feeding records largely come from walnut farms in the Blue Mountains and are at their highest level in February. Peak insect consumption occurs in September in the early stages of the cockatoo's breeding season, which usually occurs between September–February.

May and June yielded nearly three times as many feeding events as were recorded for the months of October, November and December. These figures are probably indicative of larger, more obvious, feeding flocks being observed during autumn and winter than at other times of the year. The figures also reflect the observations of Mulvaney *et al.* (2022) that Gang-gangs

Table 3

Number of feeding events recorded on the various food groups at three locations and overall across the Gang-gang's range.

Food Group	National	Blue Mountains	ACT	Melbourne
Gum nuts and flowers	7,079 (43%)	603 (34%)	2,777 (61%)	519 (36%)
Berry	3,948 (21%)	89 (5%)	631 (14%)	723 (50.5%)
Wattle	1,208 (7.5%)	70 (4%)	278 (6%)	112 (8%)
Cone	1,630 (10%)	271 (15.5%)	425 (10.5%)	22 (1.5%)
Pod	1,290 (7.5%)	301 (17%)	273 (6%)	29 (2%)
Nut	444 (2.5%)	313 (18%)	24 (0.5%)	8 (0.5%)
Insect	244 (1.5%)	10 (0.5)	81 (2%)	16 (1%)
Large fleshy fruit	259 (1.5%)	86 (5%)	28 (0.5%)	2 (0%)

are much more secretive during the breeding season and do a lot of their feeding early in the morning, meaning that even though they may be present they are much less likely to be seen, captured in a photographic image and reported.

Local diet variation within the Gang-gang's range

To gauge the level of regional variation that may occur in the Gang-gang's diet, the feeding sightings recorded in the Blue Mountains, Australian Capital Territory and greater Melbourne areas were compared. The overall structure of the diet is fairly similar among these regions in that Gang-gangs in all three areas eat a wide variety of food items, but focus predominantly on just a few plant species (see Table 2). However, there are large regional differences in actual diet content. Only two species, Hawthorn and Liquidamber, are amongst the top ten species consumed in all three areas. The regional differences seem largely to reflect disparities in the abundances of food items among the areas. Thus, in the Blue Mountains locally dominant Sydney Peppermint *Eucalyptus piperita* and Silvertop Ash *E. sieberi* are amongst the most commonly eaten food items, whilst in Canberra and Melbourne the eucalypts eaten are a mixture of the commonly planted exotic species in those localities, such as Blue Gum *E. globulus* and Sugar Gum *E. cladocalyx*, and abundant native eucalypts, such as Apple Box *E. bridgesiana*, Long-leaved Box *E. goniocalyx* and Red Stringybark *E. macrorhyncha*.

Table 3 indicates that the proportion that each food group constitutes of the total number of feeding events observed varies among the three regions ($\chi^2 = 2,815.6$, d. f. = 14, $p < 0.001$). Gum nuts and flowers feature in a much higher proportion of the ACT's observed Gang-gang feeding events than they do in the other two areas. Berries feature in more than half of Melbourne's feeding events, but are a relatively small proportion of such events in the other two areas, particularly in the Blue Mountains. Gang-gangs were much more likely to be observed feeding on cones and pods in the Blue Mountains than in the other areas, particularly in Melbourne. The Blue Mountains also had a much higher proportion of recorded feeding events on nuts and large fleshy fruits than did the other two areas.

Feeding flock sizes and locations

Large flocks of feeding Gang-gangs were only rarely reported. On only 134 occasions (3% of total sightings) were flocks of 15 or more birds reported. Only 35 of the 4,135

sightings analysed had 25 or more individual birds in the report or image(s).

Large feeding flocks can occur at any time of year, but reach a peak in May and more generally in the late autumn – early winter period. The 35 large flocks recorded were feeding on 14 different plant species, of which Hawthorn (13 recorded flocks), Liquidamber (6) and Snow Gums (4) were the most numerous. Flocks of 100 and 50 have been recorded feeding on Liquidamber at Palmdale to the north of Sydney, and flocks of 70, 60 and 53 birds were recorded feeding on Hawthorn at Heywood, Banyule Flats and Wodonga, respectively. The only other record of a feeding flock of 50 or more birds was in a walnut plantation in the Blue Mountains.

The larger flocks recorded tended to be feeding on particular food species/ species groupings at particular times of the year. Unless specific locations are stated below, these flocks were recorded from multiple widespread locations. Amongst the recorded flocks of fifteen or more birds were:

- 56 flocks on eucalypts from January – October
- 31 flocks on Hawthorns from January – August
- 13 flocks on Liquidamber from April – June, mainly at Palmdale on the NSW Central Coast
- 11 flocks on wattles from November – January
- 3 flocks on White Cedar in Kangaroo Valley from September – October
- 3 flocks on a walnut farm in Blue Mountains from January – February
- 3 flocks on Conesticks *Petrophile* sp. in the Blue Mountains from March – June

Fifty-three (40%) of the large flocks were recorded at a location at which large flocks had been recorded previously, with multiple sightings of large flocks over a number of years occurring at a number of locations, including Palmdale (on Liquidamber), Pambula Wetlands, Lithgow, Banyule Flats (in eastern Melbourne), Heywood (regional Victoria) and Hoskinstown (regional NSW), all feeding on Hawthorn.

DISCUSSION

Given the great variety evident in the Gang-gang's diet, the abundance of many of the food items, and the Gang-gangs' ability to adjust to new food sources and to what is available

locally and seasonally, it seems unlikely that food availability is a major reason for the species' recent dramatic decline. Gang-gangs' dietary flexibility may also be reflected in changes over time. Frith (1976) stated that Gang-gangs could regularly be seen feeding on ornamental pine trees and Firethorn *Pyracantha* hedges in the heart of Canberra, whereas amongst the over 6,500 recent feeding records for Canberra in the present study only one pine feeding event was recorded and none on *Pyracantha*.

Food quality could potentially be an issue for Gang-gangs, as they tend to target mainly just a few food sources. Canberra's Gang-gang population appears to be increasing (Bounds *et al.* 2021), in contrast to the dramatic decline seen elsewhere (DAWE 2021). The diet of Canberra's birds with its high eucalypt content is different to that elsewhere, so regional differences in diet may be worth further investigation. However, given the apparently wide choice of food available at all Gang-gang locations, food quality seems an unlikely cause of the uneven decline among populations.

Davey and Eyles (1976) noted that 27% of all Gang-gang feeding records in Canberra were of human-provided seed. The actual percentage of such supplementary food is likely to be higher, as surveyors did not ask observers if they put out seed, rather this information was volunteered. Sunflower *Helianthus annuus* seeds are a commonly provided food supplement and they are high in fats (>50%) but deficient in calcium, vitamin A and other nutrients (Currumbin Vet 2015). A diet high in supplementary food has been reported to have health impacts on wild birds (e.g. Santo *et al.* 2018) and specifically feeding caged parrots an overabundance of sunflower seeds can lead to malnutrition, infertility and liver and other health problems (Currumbin Vet 2015; StØstad *et al.* 2019). Supplementary feeding was not examined in this study and the amount of such food consumed and the impacts of sunflower feeding on wild Gang-gangs remain unknown. However, given the Gang-gang's propensity to target mainly just a few food sources, it may be of concern.

The diet records analysed in this study were primarily from urban, peri-urban, woodland and dry forest habitats. This limits comparisons of observed feeding preferences with those in tall forests where fewer observations were reported. Nevertheless, the records support the general understanding that Gang-gangs occur primarily in the temperate eucalypt forests and woodlands of mainland south-eastern Australia (Higgins 1999; Cameron 2007; DAWE 2022). Our collation of feeding data also indicates that urban, peri-urban and rural residential habitats provide important food resources for Gang-gangs. These areas often support an abundance and diversity of plants from the main Gang-gang food groups to an extent rarely seen elsewhere, but this habitat is unfortunately often excluded or overlooked in the conservation of the species (NSW Scientific Committee 2008; DAWE 2022). In modelling of climate change impacts on Gang-gangs, woodlands and open forests have also been, perhaps incorrectly, rated as less suitable habitat than tall open forests (OEH and Macquarie University 2021; Rogers *et al.* 2022).

Current wisdom is that Gang-gangs are altitudinal migrants (DAWE 2022) that typically spend summer in heavily timbered, mature wet sclerophyll forests and woodlands in *Eucalyptus*-dominated assemblages which often support a dense, shrubby

Acacia understorey (Higgins 1999). During winter it is thought that Gang-gangs tend to range beyond montane forests to inhabit woodland assemblages at lower, drier altitudes (DAWE 2022). Of the records analysed as part of this study, there were many more observations of Gang-gangs foraging in areas of low elevation, such as Canberra and Melbourne, during autumn and winter than at other times of year. However, it is unclear whether this reflects influxes of birds or just greater visibility of the birds that were already present, or perhaps a mixture of both factors. The data do not support the occurrence of large waves of migratory or nomadic birds; rather, they suggest that Gang-gangs gather annually at a few key foraging locations, and may move in and out of urban areas.

Current Gang-gang habitat restoration advice focuses on planting or allowing the regeneration of local native trees, shrubs and ground layer plants, with an emphasis on acacias and eucalypts (NSW Office of Environment and Heritage 2022). Our study suggests that more nuanced restoration advice is pertinent. Focus should be placed on wattles that bear green pods during the October to January period, as fruits borne outside this period are unlikely to be eaten. Similarly, re-establishment of eucalypts should aim to include at least some species that bear buds or fruits from late autumn to mid-winter. Restoration should also include native species from the other main food groups, including those that have berries with large seeds, and Cypress Pine *Callitris* sp. and/or *Petrophile* for its cones or soft pods.

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