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Do exotic birds dominate feeding at garden food stations in Melbourne in winter?

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Deliberate feeding of wild birds is common in urban Australia and supposedly has both costs and benefits for the birds and the humans that feed them. If urban domestic garden food stations are dominated by common exotic species, they may ultimately not promote, or even reduce, urban native bird species diversity. However, too few investigations have been conducted in Australia to permit a thorough evaluation of this possibility. Twelve established bird food stations in suburban gardens in Melbourne, Australia were visited in one winter by 18 bird species, five of which were exotic. Introduced Spotted Doves *Streptopelia chinensis*, Common Mynas *Sturnus tristis* and Rock Doves *Columba livia*, together with native Noisy Miners *Manorina melanocephala*, were the most prominent users of stations providing bread. Spotted Doves numerically dominated feeding at stations that provided seed, but three native species were also quite prominent feeders at some such stations. Bread and seed stations were exploited by fairly distinct bird species assemblages. On average, approximately six high-intensity inter-specific agonistic interactions per hour occurred at a food station, involving 20 species combinations overall. However, only one third of encounters were between an exotic and a native bird. Displacement of native birds from food stations by exotic birds was substantially less common than the reverse event. Thus feeding at urban garden food stations was dominated by exotic birds, but some native birds also exploited them substantially and were not disproportionately aggressively displaced from them by exotics.

INTRODUCTION

Supplementary feeding of wild birds is widespread in the Western World, particularly in cities (Robb *et al.* 2008). In Australia, an estimated 38–57 percent of households participate in garden feeding of wild birds, mainly offering bread, meat or seeds (O'Leary and Jones 2006). Stated reasons for feeding birds in urban gardens include: pleasure derived from close contact with birds; a humane concern for birds coping with the highly anthropogenically modified city environment; and, a need to counterbalance human destruction and modification of birds' natural habitats (Rollinson *et al.* 2003; Jones 2011; DuBois and Fraser 2013; Galbraith *et al*. 2014). Potentially this activity can promote wildlife conservation by raising awareness of the need to conserve native biodiversity and making the participants feel more 'connected to nature' (Sterry and Toms 2008; Galbraith *et al*. 2014).

Most people who feed wild birds believe that it benefits the birds, and there are some potentially fitness-enhancing effects for the birds. These include increased survival through periods of food limitation (e.g. Newton 1998), enhanced breeding productivity (e.g. Robb *et al*. 2008), and conservation of declining species (e.g. Chamberlain *et al*. 2005). However, there are also some likely fitness-reducing effects, including causing: over-reliance on unsuitable foods and ultimately an inability to survive on purely natural foods (Orell 1989; Stanley and Siepen 1996; South and Pruett-Jones 2000; O'Leary and Jones 2006); aggregation of wild birds at (often unhygienic) food stations that increases disease transmission (Fischer *et al*. 1997; Rollinson *et al*. 2003; Robinson *et al*. 2010; Galbraith *et al*. 2014); trophic cascades that affect the distribution and abundance of prey and predators (Robb *et al*. 2008; Galbraith e*t al*. 2015); and, lower resistance to species invasions through reducing inter-specific competition among well-fed resident species (Cannon 2010).

These likely costs and benefits of feeding wild birds in urban gardens have stimulated a lively debate on its merits and demerits. The dominant view among Australian and South African, but not New Zealand, wildlife managers, researchers and ornithological organizations is that it is harmful for the birds and should be discouraged (Rollinson *et al*. 2003; Galbraith *et al*. 2014). In contrast, in Western Europe and North America it is officially encouraged. Unfortunately the research necessary to better inform this debate has been limited in Australia and elsewhere (Jones and Reynolds 2008; Jones 2011).

The focus of the present investigation is on another very important potential problem with urban garden food stations, which has received less research attention. If these stations are dominated by common, exotic birds (Parsons 2006), they may ultimately not promote, or even reduce, the species diversity of urban native birds (Fuller *et al*. 2008; Galbraith *et al*. 2015) and generate heightened, costly aggression among them (Jones 2011; Wojczulanis-Jakubas *et al.* 2015). Our study examined whether garden food stations providing bread or seeds in winter in suburban Melbourne, Australia were dominated by common urban exotic species and whether inter- and intra-specific aggression occurred frequently and with negative consequences among wild birds visiting these stations. We predicted that exotic species would dominate feeding at these food stations because: they are the most common streetscape birds in

Melbourne (White *et al*. 2005) and correspondence between abundance in streetscapes and attendance at garden food stations has been recorded elsewhere (Cannon *et al*. 2005); and, innovative exploitation of food inadvertently and deliberately provided by humans is a key to successful urban colonization by many exotic bird species (Sol *et al*. 2011). We also predicted that aggressive interactions would be frequent at food stations in winter because natural food resources are seasonally diminished (Woinarski and Cullen 1984) and bird aggregations at point food sources typically generates aggressive interference competition, unless food is superabundant (Wojczulanis-Jakubas *et al.* 2015). It thus seemed likely that aggressive dominance of native by exotic bird species would play a role in affording the latter greater access to the food provided at garden feeders.

METHODS

Study area and food stations

The study was conducted in eastern suburban Melbourne (37.47˚S 144.58˚E) from March–July, 2012, a time of year when mean daily minimum and maximum ambient temperatures in the study area are 10.3˚C and 20.0˚C in autumn and 6.1˚C and 13.6˚C in winter. Twelve established food stations in private gardens 0.6 to 28 kilometres apart were investigated. Gardens varied in the number of trees greater than five metres in height from 0–15 (mean 4) and trees and shrubs less than five metres in height from 2–14 (mean 8). The food stations were elevated 0–197 centimetres (mean 95) above ground level and the amount of food provided daily varied from 58–700 grams. These physical attributes of stations had no influence on station use by birds and consequently are not discussed further. Stations had been operating continuously for 1–20 years and half of them provided bread and half a commercial seed mix. Seed was usually presented in a bowl, whereas bread was scattered by hand. Stations were recruited for the study by word-of-mouth and advertising on ornithological internet web sites. There were no selection criteria other than location in the eastern suburbs, agreement of the owner and obtaining equal numbers of bread and seed stations. Observations were made in the morning, starting 1.5 h after civil twilight.

Measurement of attendance, feeding and agonistic behaviour at food stations

Instantaneous sampling (Choi *et al*. 2007) at 15-second intervals over 15-minute observation periods was used to record the species visiting and feeding at food stations. Attendance and feeding were analysed separately because we reasoned initially that some species might visit the stations, but not actually feed. Birds that visited the vicinity of a station but did not stop there were not scored as 'attending'. Six observation sessions were conducted per station.

Separately, the occurrence of escalated agonistic interactions was recorded during continuous observation for 30-second periods (separated by 15-second intervals) over six or seven 30-minute observation sessions per station. An escalated interaction involved aggressive chasing and/or fighting, resulting in displacement of the 'loser' from the food station and its immediate vicinity. Focusing on escalated interactions meant that it was easy to determine that a bird that left a station did so because of the aggression of the other combatant. For each visiting species, features of its involvement in inter-specific agonistic behaviour recorded were: frequency of participating in interactions; number and identity of species with which it interacted: and, extent to which its members were displaced from the station in interactions. We also recorded each species' proportional contribution to all intra-specific aggressive behaviour observed. Scientific names of the species observed at food stations are given in Table 1 and body sizes in Table 3.

Data analysis

Attendance at food stations by a species was assessed in terms of: the number of stations which at least one species' member visited during the investigation; the percentage of all observation sessions in which at least one species' member attended any station; and, an attendance index (AI), which was the mean number of attendances by the species per 15-minute observation session per station × 100. An 'attendance' was the presence of a species' member at a station irrespective of whether it was/was not feeding. The AI thus gave an indication of the magnitude of a species' attendance at food stations, despite individuals usually not being recognisable throughout an observation session or among sessions. Similarly, feeding at food stations by a species was expressed as a feeding index (FI), which was the mean number of feeding events by the species per 15-minute observation session per station × 100. A 'feeding event' comprised a species' member feeding at a station at a particular sampling interval. Like the AI, the FI indicated the magnitude of feeding by a species at food stations, despite individuals not being recognisable. Although we calculated win: loss ratios for species' involved in inter-specific interactions at food stations, we did not subject them to significance testing because the number of separate individuals involved was unknown.

We used non-metric multidimensional scaling (NMDS) plots (Quinn and Keogh 2002) to examine visually whether the composition of the assemblages of bird species visiting food stations was influenced by the type of food offered (bread or seed). Analysis of Similarity (ANOSIM) and Similarity Percentage (SIMPER) procedures in PRIMER v. 6 (Clarke and Warwick 2001) were used to establish which species accounted for similarities within and dissimilarities between the bird species assemblages visiting bread and seed stations. Non-parametric Spearman rank correlation tests were conducted in R (R Development Core Team, 2011) to examine the relationship between attendance at food stations and involvement in agonistic interactions.

RESULTS

Attendance and feeding at food stations

Eighteen bird species visited the 12 food stations (Table 1), of which 15 (five exotic and ten native) actually fed there. The suite of bread stations was visited by 12 species, the suite of seed stations by 11 species and seven species visited both types of station. During the study, individual bird species (i.e. at least one species member) fed at up to eight stations (mean = 2.5 per species) and the number of bird species feeding at a particular station ranged from 1 to 8 (mean = 4). Native species feeding at bread stations comprised Sulphur-crested Cockatoos *Cacatua galerita*, Rainbow Lorikeets *Trichoglossus*

Table 1

Mean attendance index is the number of bird attendances per observation session per station × 100 and mean feeding index is number of feeding events per observation session per station × 100. Blank cells indicate a complete absence of attendance or feeding. * indicates exotic species.

Species	Percent sessions present (Number stations attended)		Mean attendance index		Mean feeding index	
	Bread	Seed	Bread	Seed	Bread	Seed
Rock Dove* *Columba livia*	14.3 (2)		23.8		5.1	
Spotted Dove* *Streptopelia chinensis*	28.6 (4)	45.2 (5)	8.5	137.7	5.9	82.5
Crested Pigeon *Ochyphaps lophotes*		4.8 (1)		1.2		1
Little Corella *Cacatua sanguinea*		21.4 (2)		32.1		28.1
Sulphur-crested Cockatoo *Cacatua galerita*	2.4 (1)	9.5 (3)	10.4	19.2	0.9	3.8
Rainbow Lorikeet *Trichoglossus haematodus*	2.4 (1)	7.1 (1)	1.1	8.2	0.4	14.1
Crimson Rosella *Platycercus elegans*		2.0 (2)		13.8		15.5
Laughing Kookaburra *Dacelo gigas*		2.4 (1)		0.8		
Common Blackbird* *Turdus merula*	2.4 (1)		0.7		0.1	0.5
Red Wattlebird *Anthochaera carunculatus*	21.4 (3)		3.2		2	
Noisy Miner *Manorhina melanocephala*	35.7 (3)		58.9		4.1	
Common Starling* *Sturnus vulgaris*	21.4 (3)	4.8 (1)	4.8	0.8	1.1	0.3
Common Myna* *Sturnus tristis*	50.0 (6)	11.9 (3)	24.4	2.4	5.3	0.6
Magpie-lark *Grallina cyanoleuca*	9.5 (3)	2.4 (1)	0.6	1.4	0.2	1.1
Pied Currawong *Strepera graculina*	4.8 (1)		0.8		0.3	
Pied Butcherbird *Cracticus nigrogularis*	2.4 (1)		0.1			
Australian Magpie *Cracticus tibicen*	7.1 (1)	2.4 (1)	1.3	0.2	0.1	0.1
Little Raven *Corvus mellori*		2.4 (1)		0.1		

haematodus, Magpie-larks *Grallina cyanoleuca*, Australian Magpies *Cracticus tibicen*, Red Wattlebirds *Anthochaera carunculatus*, Noisy Miners *Manorina melanocephala* and Pied Currawongs *Strepera graculina*; those feeding at seed stations included the first four of these species, plus Crimson Rosellas *Platycercus elegans*, Little Corellas *Cacatua sanguinea* and Crested Pigeons *Ochyphaps lophotes* (Table 1).

(1) Bread stations

Bread stations were visited by four predominantly nectarivorous, three granivorous, three omnivorous, two insectivorous and one carnivorous species. Feeding was predominantly by exotic Spotted Doves *Streptopelia chinensis*, Rock Doves *Columba livia* and Common Mynas *Sturnus tristis* (FIs 5.1 to 5.3) and native Noisy Miners (FI 4.1), but only the Common Myna fed at all bread stations (Table 1). At least one exotic Common Myna, Common Starling *Sturnus vulgaris* and Spotted Dove and one native Noisy Miner and Red Wattlebird visited the bread station under observation in more than 20 percent of sessions (Table 1). However, the Red Wattlebird and Common Starling were not abundant at such stations and had low AIs and FIs there. Thus overall, three exotic and one native species dominated feeding at bread stations.

(2) Seed stations

Seed stations were visited by five predominantly granivorous species, three omnivores, one nectarivore, one carnivore and one insectivore. Feeding was predominantly by exotic Spotted Doves (FI 82.5) and native Little Corellas, Crimson Rosellas and Rainbow Lorikeets (FIs 14.1 to 28.1) (Table 1). Attendance and feeding regimes of these species at seed stations varied considerably. Spotted Doves fed at five of the stations and at least one dove was present at a seed station in 45 percent of observation sessions. One or more Little Corellas visited the seed station under observation in 21 percent of sessions, but this species only fed at two seed stations during the investigation (Table 1). Overall, Crimson Rosellas and Rainbow Lorikeets were relatively prominent consumers at seed stations, but they only fed at a few such stations and were present for only two percent and seven percent of observation sessions, respectively (Table 1). Thus exotic Spotted Doves dominated feeding at seed stations, but three native species fed at them quite substantially.

Distinctness of bird species assemblages at bread and seed stations

There was marked clustering of stations in an NMDS plot of species assemblage composition as a function of food type offered (Fig. 1 shows AI-based plot). ANOSIM confirmed this distinctness (global R = 0.507 [P =0.001] and 0.259 [P = 0.007] for presence/absence and mean abundance data, respectively). SIMPER analysis indicated that exotic Spotted Doves and Common Mynas and native Noisy Miners and Little Corellas were most responsible for the similarities in assemblage composition among stations offering each of the two food types; these species, plus the native Crimson Rosella and Rainbow Lorikeet, were most responsible for the dissimilarities in bird assemblage composition between bread and seed stations (Table 2).

Agonistic behaviour at food stations

The overall rate of occurrence of intra- plus inter-specific agonistic interactions at food stations was 3.5 ± 0.7(s. e.) (range 0–33) per 30-minute observation session.

Table 2

Percentage contributions of species to Bray-Curtis similarity within and dissimilarity between bird assemblages at bread and seed stations from SIMPER analysis. Upper row for each species is derived from species presence/absence data and lower row in parentheses from presence data scaled for species' attendance rates. Contributions < 5% were excluded.

Bird species	Percentage contributions		
	to similarity within		to dissimilarity between
	bread stations	seed stations	bread and seed stations
Spotted Dove	12.2	64.9	14.3
	(35.7)	(61.5)	(31.8)
Common Myna	62.3	11.8	20.7
	(47.2)		
Sulphur-crested Cockatoo		7.5	
Crimson Rosella		6.6	6.5
			(11.3)
Noisy Miner	11.2		8.9
	(8.1)		
Common Starling	5.1		6.9
Little Corella			7.9
		(22.9)	(19.3)

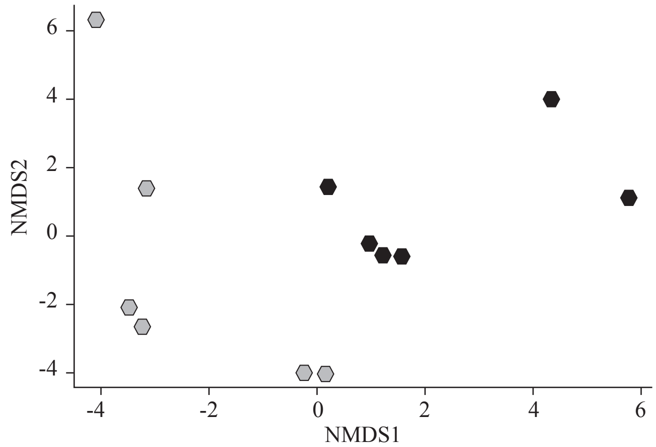

Figure 1. *NMDS plot of bird species assemblage composition at food stations as a function of food type offered at the station. Plot based on species attendance indexes. Black circles are bread stations; grey circles are seed stations.*

(1) Intra-specific interactions

At all food stations combined, 167 escalated intra-specific agonistic interactions occurred during the investigation. The overall mean number of interactions per 30-minute observation was 2.3. The highest mean number of interactions per station per session was 9.3, and 12 species (four exotic and eight native) engaged in such interactions. If we consider just species that were present at stations in more than three aggression observation sessions and visited at least two stations, the proportional contributions to the total number of intra-specific agonistic interactions observed ranged from zero percent (Magpie-lark and Australian Magpie) to 22 percent (Little Corella) (Table 3). These species' contributions were not significantly correlated with the percentage of observation sessions in which species visited the food stations (r_s = 0.045, P>0.05, N = 12). Among native species, four psittacines made the greatest proportional contributions to overall levels of intra-specific aggression and the Spotted Dove made the greatest proportional contribution by an exotic species. Little Corellas and Spotted Doves were among the most frequent visitors to food stations, but Crimson Rosellas, Rainbow Lorikeets and Sulphur-crested Cockatoos were not.

(2) Inter-specific interactions

Only 66 escalated inter-specific agonistic interactions (mean 2.8 per 30-minute observation session) occurred at all food stations combined during the study. Four exotic and nine native species (i. e. 72% of the species attending the stations) were involved in these interactions. Interactions occurred between 20 species combinations (Table 3), eight percent involving two exotic species, 34 percent an exotic and a native species and 58 percent two native species. The greatest involvement was by native Magpie-larks (41% of total encounters) and Crimson Rosellas (42%), but this was attributable to a very high number of encounters between these two species at one food station on just two days, possibly involving just a few individuals. The exotic Spotted Dove was more consistently involved at a high rate in inter-specific agonistic behaviour, participating in 27 percent of all such interactions, at five of the 11 stations where such behaviour was measured, and against seven, mostly native species. The other three exotic species that engaged in inter-specific aggression at food stations also interacted predominantly with native species, but at very low frequencies (Table 3). Considering just species that visited at least two stations, there was no correlation between the percentage of sessions in which a species attended a food station and its level of involvement in inter-specific encounters (r_s = 0.073, P>0.05, N=12).

Focusing on just those inter-specific interactions resulting in the 'loser' being at least temporarily completely displaced from a food station, three species (all native) 'won' all such interactions in which they were involved, three (two native and one exotic) 'lost' all of them and seven (four native and three exotic) experienced both 'winning' and 'losing' against a given species (Table 3B). Interestingly, two of the species that were always displaced from food stations in these highly escalated interactions were: the exotic Spotted Dove, which had high AIs and FIs (particularly at seed stations) and a high level of involvement in inter-specific agonistic interactions at food stations (Tables 1 and 3); and, the native Noisy Miner, which aggressively dominates many bird species in other contexts. If the aberrant Magpie-lark × Crimson Rosella interaction frequency is scored as 1 (see explanation above), exotic species displaced exotic and native birds from food stations equally and native species behaved similarly. The percentages of this adjusted number of interactions won by the larger (53.5%) and smaller (46.5%) combatant were similar (Binomial probability 0.109).

Table 3

Outcome of escalated inter-specific agonistic interactions at garden food stations. Data in each cell are numbers of agonistic interactions for all observation sessions at all food stations in which members of a particular species (in bold) displaced members of another species (in italics) from a station. Win: loss ratio is ratio of displacing to being displaced from food stations. Thus RD displaced RW once, NM twice and CM once (=4), and were displaced once by CM (=1). Interactions without a clear outcome are excluded. Boxed numbers on diagonal are percentages (rounded) of all intraspecific agonistic interactions contributed by the various species.

Displaced species	Displacing species: RD	SD	CP	LC	SCC	RL	CR	RW	NM	CS	CM	ML	AM
RD	1										1		
SD		17	2	3	3	3	1	1			4		
CP			0										
LC				22	2								
SCC				4	10								
RL						14							
CR						1	17				1		
RW	1							7					
NM	2								7	2	1		4
CS								1		1	1		
CM	1										5		1
ML							24					0	2
AM													0
Win:Loss ratio	**4:1**	**0:17**	**2:0**	**7:2**	**5:4**	**4:0**	**25:2**	**2:1**	**0:9**	**2:2**	**8:2**	**0:26**	**7:0**

Species key (and total lengths in mm from Pizzey and Knight 2012)): RD, Rock Dove (330-340); SD, Spotted Dove (315); CP, Crested Pigeon (305-355); LC, Little Corella (355-395); SCC, Sulphur-crested Cockatoo (455-510); RL, Rainbow Lorikeet (250-320); CR, Crimson Rosella (320-370); RW, Red Wattlebird (335-360); NM, Noisy Miner (240-275); CS, Common Starling (210); CM, Common Myna (230-255); ML, Magpie-lark (260-300); AM, Australian Magpie (370-440).

DISCUSSION

Bird species using the garden food stations

Thirteen of the 18 species attending the food stations were native. However, the exotic Spotted Dove was the most prominent attender and feeder at both types of station, but particularly at bread stations. Galbraith *et al*. (2015) also found that the Spotted Dove particularly benefitted from supplementary feeding on urban properties in Auckland, New Zealand. The exotic Common Myna and Rock Dove and native Crimson Rosella and Rainbow Lorikeet were also prominent visitors to, and feeders at, bread but not seed stations, although they attended a more restricted number of such stations than Spotted Doves. Native Little Corellas were prominent seed consumers, but only at a small number of stations. In contrast to the situation in Auckland, New Zealand (Galbraith *et al*. 2015), the House Sparrow (*Passer domesticus*), a common exotic urban species, did not feed at the suburban food stations, perhaps because it is more common in, although not confined to, the inner city. Overall, our prediction that exotic species would dominate feeding at the food stations was fairly true of bread, but not seed, stations.

Exotic Spotted Doves and Common Mynas are two of the most common birds in Melbourne streetscapes and native Rainbow Lorikeets (mean FI at seed stations 14.1) and Noisy Miners (mean FI at bread stations 4.1) are also amongst the more common streetscape residents (White *et al*. 2005). Correspondence between abundance in streetscapes and attendance at garden food stations has also been recorded in Great Britain (Cannon *et al*. 2005) and echoes Fuller *et al*.'s (2008) finding that garden supplementary feeding simply seems to subsidize and perpetuate the dominance of the already common city species, many of which are exotic (Daniels and Kirkpatrick 2006). However, in our study there were some exceptions to this pattern. Native Australian Magpies are very common streetscape birds throughout Melbourne (White *et al*. 2005), but did not visit food stations often. Native Crimson Rosellas (mean FI at seed stations 15.5) were prominent feeders at seed stations, but are not among the most common street birds in the city.

In contrast to what has been reported in Brisbane and Sydney (Rollinson *et al*. 2003; Parsons *et al.* 2006; Ishigame and Baxter 2007), birds visiting suburban Melbourne garden food stations were not predominantly large, aggressive, carnivorous species, such as magpies, butcherbirds, currawongs, kookaburras and corvids. The reason may be that none of the stations that we studied offered meat, whereas 32 percent of Brisbane and many Sydney stations did, and many of the Brisbane station operators deliberately targeted these large, carnivorous species and even actively discouraged other species. There was otherwise a considerable commonality in the species assemblages visiting Brisbane and Melbourne food stations, allowing for differences in species' geographic distributions. Parrots and doves featured prominently as visitors in both cities. Interestingly, Red-browed Finches (*Neochmia temporalis*), frequent visitors to Sydney gardens containing seed stations (Parsons *et al*. 2006), were absent from Melbourne food stations, despite occurring in some areas of suburban Melbourne (A. Lill, personal observation).

Distinctness of bird species assemblages at bread and seed stations

Although seven of the 18 species recorded at food stations visited both bread and seed stations, species assemblages using the two types of station were fairly distinct. The Spotted Dove, Common Myna and Little Corella were the most important species generating this distinctness. The species that fed exclusively at seed stations are naturally totally or partially granivorous, but those feeding exclusively at bread stations are more varied in their natural diets (including granivory, carnivory and omnivory). Five of the species that fed at both types of station ate more seed than bread, although only one of them (Spotted Dove) is naturally largely granivorous.

Consumption of low quality food

Most species that fed at the garden stations were consuming foods that were 'unnatural' for them to varying degrees, although some commercial seed mixtures now available may provide a reasonably balanced diet for natural granivores (Jones 2011). It might potentially be more worrying that 12 species consumed bread, four of them quite substantially. Heavy consumption of this highly processed, nutritionally unbalanced food at bird food stations is common worldwide (Chace and Walsh 2006). However, in our investigation any concern about bread consumption should be directed more towards the birds' wellbeing than the effect on native biodiversity conservation, because three of the significant bread consumers were common, urban, exotic birds.

Agonistic behaviour of birds at food stations

The mean number of intra-specific agonistic interactions at food stations per hour was only about five. The exotic Spotted Dove and four native members of the Psittaciformes had the greatest relative involvement in intra-specific agonistic encounters at food stations. However, level of attendance at stations did not strongly influence proportional involvement in such behaviour; the Spotted Dove and one of the psittacine species were among the most common visitors to stations, but the other three psittacine species were not.

The mean number of inter-specific agonistic encounters per hour was approximately six, only slightly higher than that for intra-specific interactions. Again, there was no overall association between a species' attendance level at food stations and its involvement in inter-specific agonistic interactions. Although most exotic species recorded at food stations had high AIs (Table 1), only about 33 percent of inter-specific agonistic interactions were between exotic and native birds. Introduced Spotted Doves were among the most consistent visitors to food stations and involved in more than 25 percent of all inter-specific interactions, but they were always displaced from food stations by other species in highly escalated interactions. Despite this species' long residence history in Melbourne and other eastern Australian cities (Long 1981), species' members appear to be less bold than many other co-habiting urban birds, as also indicated by their reactions to human proximity in the urban environment (Gendall *et al*. 2015). The other three exotic species involved in inter-specific agonistic interactions both 'won' and 'lost' encounters against particular exotic or native species. Overall, larger and smaller species were equally likely to displace each other from food stations (cf. Wojczulanis-Jakubas *et al*. 2015). Thus our predictions that inter-specific agonistic interactions would be frequent and that exotic birds would generally displace natives from the food stations were not really borne out (see also Sol *et al*. 2012). However, conceivably just the passive presence of some exotic species may directly and indirectly reduce feeding rates of native birds at garden food stations (Peck *et al*. 2014).

Low level of aggression by Noisy Miners visiting food stations

Highly aggressive, inter-specific territorial defence by Noisy Miners transforms diverse assemblages of insectivorous and nectarivorous birds into simpler assemblages with fewer species of mostly large, sedentary birds (Mac Nally *et al*. 2012; Maron *et al*. 2013). However, although Noisy Miners were prominent exploiters of bread (but not seed) at garden food stations in our study, they were only involved in nine escalated inter-specific agonistic interactions (14% of total), in all of which they were displaced from the food station by Australian Magpies or exotic birds. Noisy Miners are particularly effective in territorially excluding species smaller than themselves (Maron *et al*. 2013), and almost all the other species attending food stations, and most of those that displaced Noisy Miners there, were as large as, or larger than, the miners. It is likely that the Noisy Miners had aggressively excluded most species smaller than themselves from food station areas prior to the commencement of our observations.

CONCLUSIONS

Feeding at Melbourne's domestic garden food stations that provided bread in winter was dominated by exotic birds, but one exotic and three native species dominated feeding at seed stations. Therefore to a considerable extent the food stations potentially aided the survival of exotic species that are the most common streetscape birds in Melbourne, and consequently they may have had only a modest role in promoting urban native bird species diversity. However, agonistic behaviour was not very common at food stations and the dominance of feeding at stations by exotic birds was not size-related or achieved primarily through aggressive displacement of natives. This 'snapshot' study was limited to one autumn/winter in one Australian city, and extension of research to other seasons, years and cities, and to food stations providing meat, would be valuable.

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