Australian Field Ornithology 2016, **33**, 121–124
http://dx.doi.org/10.20938/afo33121124

Do Spotted Doves need to forage extensively in food-rich urban environments?

Alan Lill[1]* and Beth Geraldene[2]

[1]Department of Ecology, Environment and Evolution, School of Life Sciences, La Trobe University, Bundoora VIC 3086, Australia
[2]School of Biological Sciences, Monash University, Clayton Campus, Clayton VIC 3800, Australia
*Corresponding author. Email: A.Lill@latrobe.edu.au

Abstract. Many 'urban exploiter' birds have access to much more abundant food resources than their exurban counterparts and so potentially may not have to allocate much time to foraging. Exotic Spotted Doves *Streptopelia chinensis* in Melbourne, Victoria, spent a mean of only 17% of 'off-nest' daytime in foraging. Factors emerging from this and previous studies that might permit this small proportional time allocation to foraging include: (1) a rapid rate of food acquisition (1 item per second of continuous feeding), (2) energetically inexpensive foraging behaviour, and (3) a negligible level of intra- and interspecific interference competition for food. To some extent, a foraging strategy comprising many, brief, highly productive foraging bouts, and consequently a small daily proportional time allocation to foraging, may also be dictated by Spotted Doves' digestive physiology.

Introduction

Understanding the ecology of urban birds is important for biodiversity conservation, pest management, educational and aesthetic reasons (Platt & Lill 2006). One striking feature of cities is that food abundance and predictability for birds is much greater than in exurban environments, particularly for species that can innovatively exploit supplementary food deliberately or incidentally provided by human city-dwellers (Schochat *et al*. 2006; Anderies *et al*. 2007; Møller 2009). Therefore, many urban birds may be able to meet their daily energy and nutrient requirements with a relatively small time allocation to foraging, but this interesting issue has rarely been explored.

The Spotted Dove *Streptopelia chinensis*, an 'urban exploiter' (Blair 2001), was deliberately introduced and released in Melbourne, Victoria, in the 1860s–1870s (Long 1981). It is now abundant in the city, attaining mean densities of 0.1–2.63 individuals per ha (Mulhall & Lill 2011) or higher (e.g. Fitzsimons *et al*. 2011) across a wide range of habitats, from bushland remnants to streetscapes. It has colonised many other conurbations in eastern, southern and south-western Australia and also occurs in some rural, agricultural areas (Pizzey & Knight 2012). In Melbourne, Spotted Doves obtain their food mainly by gleaning on the ground, their diet comprising the attached and fallen seeds of exotic wild grasses and herbs, but also seeds clearly sourced from stock-feed or garden-feeders (Frith *et al*. 1976; Geraldene 2004; Mulhall & Lill 2011). Ruwandeniya & Lill (in press) showed that Spotted Doves were prominent winter visitors to garden-feeders providing either bread or a commercial seed mix. In Melbourne, the species therefore fits the prescription alluded to above of an innovative feeder on abundant anthropogenic food sources. Our investigation's aim was to determine whether, during the breeding season, the Spotted Doves in Melbourne spent only a relatively small proportion of their 'off-nest' daylight hours in foraging, despite the heightened energy and nutrient requirements of breeding (Williams 2012). We did this by measuring their proportional time allocation to foraging (PFT) and their feeding rate. We predicted that the high urban food abundance would permit breeding Spotted Doves to allocate just a small proportion of 'off-nest' time to foraging compared with that spent by species with less abundant food resources.

Methods

Study area

The study was conducted in the eastern suburbs of Melbourne (37°48′S, 144°59′E) over a 5-month period covering the spring and summer of 2004. Twenty-four well-spaced study sites were sampled in an area extending 30 km from Frankston in the south to Mount Waverley in the north. Sites were chosen without any prior knowledge as to whether they were inhabited by Spotted Doves and irrespective of the type of terrestrial habitat that they contained. If, on inspection, a site yielded no Spotted Doves after considerable searching, it was discounted as a sampling location and a replacement site was surveyed instead. Distances between adjacent sampling sites ranged from ~2 to 8.5 km. Sites were in residential gardens, streetscapes, car parks and parklands. Up to three visits spaced at least 2 weeks apart were made to each site, and observations were made in all weather conditions except heavy rain and high wind.

Behavioural measurements

Spotted Doves were observed from a distance at which the researcher's presence did not apparently affect their behaviour, binoculars (10 × 50) being used when necessary. The day (from morning to evening civil twilight) was divided into three equal intervals (D1–3) and observations were spread fairly evenly across these three time intervals. A focal dove was observed only once per observation session per behaviour; the researcher then moved a sufficient distance to ensure that the same individual was not recorded again in that session. Only one member of a flock was observed and scored; it was chosen according to an arbitrary 'rule' that precluded larger or dominant individuals being sampled disproportionately.

Time–activity budgets

Time–activity budgets were measured using instantaneous sampling (Martin & Bateson 2007) in which the focal Spotted Dove's behaviour was recorded at 30-second intervals for a maximum of 15 minutes using an electronic timer. Activities recorded were: foraging—active search for, manipulation and ingestion of food items; resting—perching or standing immobile and silent; resting alert—resting in upright, stretched posture, possibly vocalising; flying—other than in agonistic interactions; social interaction—intraspecific, non-aggressive interactions; maintenance—self-preening, stretching, shaking, scratching, defaecation and bathing; terrestrial locomotion—walking or running on ground other than in foraging. The sample obtained from 41 Spotted Doves was representative in that it was broadly based spatially, evenly spread temporally and exhibited low variance. As observations were made in the breeding season, it was assumed that some individuals were attending nests when not under observation and hence that time allocations to activities were often proportions of 'off-nest' daytime rather than of total daylight hours. As both the male and female incubate eggs and feed nestlings, our sampling was unlikely to have been sex-biased.

Foraging behaviour and feeding rate

Detailed measurements of foraging behaviour were made only during 'steady foraging' i.e. continuous sequences of feeding and walking between feeding sites, uninterrupted except for momentary bouts of maintenance behaviour. Walking was defined as taking five paces without pecking at the substrate. Behaviour was recorded in real time on an audio cassette and later transcribed and timed (± 1 sec.). The linear distance travelled during a foraging bout was estimated visually as: 0–1, 1.1–2 or 2.1–3 m. Distances were nearly always within this range, and a foraging observation typically lasted <5 minutes. Feeding rate was defined as the number of pecks at food items in 15 or 30 seconds of continuous feeding. Most such pecks appeared to result in the acquisition of a food item. Focal birds were sampled up to three times in close succession and the rate averaged.

Data analysis

Data analysis was conducted with Systat (Systat Software Inc., San Jose, California, USA). Diurnal variation in the proportional time allocations to various behaviours and in feeding rate was examined with analyses of variance (ANOVA) after arcsine or square root data transformation.

Results

Time–activity budget

Mean proportions of observation time spent in seven activities were: resting alert (38%), foraging (17%), resting and maintenance both (15%), locomotion (8%), social interaction (5%) and flying (~2%). Proportional time allocations to two of the four most common behaviours varied diurnally. Thus mean PFT decreased from 25% (D1) to 4% (D2) and then increased to 26% (D3) ($F_{(2)} = 3.499$, $P = 0.040$), and mean proportional time spent in locomotion was 4% in D1 and D2, increasing to 22% in D3 ($F_{(2)} = 11.886$, $P < 0.001$). Mean proportional time allocations to resting ($F_{(2)} = 0.634$, $P = 0.536$) and maintenance ($F_{(2)} = 0.668$, $P = 0.518$) did not vary diurnally.

Foraging behaviour and feeding rate

Most foraging observations (75%) were obtained from parkland and particularly streetscape 'nature strips'. Mean length of a 'steady' foraging bout was 112 seconds, 74% of which was spent pecking at food items and 26% walking between feeding sites. During a foraging bout, Spotted Doves on average travelled linear distances of ≤1 m on 55%, 1.1–2 m on 21% and 2.1–3 m on 24% of occasions. Mean feeding rates for 15- and 30-second records were similar (58 ± 30 standard error and 56 ± 27 pecks per minute respectively; $t_{(54)} = 0.437$, $P > 0.05$), and rates did not vary diurnally (D1 60, D2 and D3 each 55 pecks per min.; $F_{(2)} = 2.401$, $P > 0.05$). The mean feeding rate overall was 57 pecks per minute continuous feeding ($n = 56$).

Discussion

Spotted Doves spent a mean of only 17% of observation time foraging, and the allocation would have been even smaller as a proportion of daylight hours given that some individuals were probably incubating eggs or brooding nestlings. This is a very small PFT when compared with most mean values for ten other Australasian land birds of varying ecology measured during the breeding and non-breeding periods and in various seasons (Table 1). The observed greater PFT earlier and later in the day in Spotted Doves was predictable for birds that must fast overnight.

Three factors possibly facilitating Spotted Doves' ability to meet their daily food intake requirement on this small PFT can be tentatively identified:

(1) They did not have to travel far between feeding sites during a ground-foraging bout. Only about a quarter of a bout was spent walking between feeding sites, and the distances travelled were typically only a few metres.

(2) At feeding sites, doves obtained food items at a very rapid mean rate (nearly one item per sec. of feeding).

(3) Inter- and intraspecific competition for food appears to be limited in this species in Melbourne. Urban birds often occur at higher population densities than those of exurban conspecifics (Schochat *et al*. 2006; Anderies *et al*. 2007; Møller 2009), which might be expected to heighten intraspecific competition. Urban Spotted Doves occurred at similar densities to many co-habiting bird species (White *et al*. 2005; Mulhall & Lill 2011), but relevant, comparative data are too few to know whether these densities are generally higher than those of exurban conspecifics. Nonetheless, interference competition for food is apparently rare among Melbourne's Spotted Doves. Mulhall & Lill (2011) showed that ground-foraging Spotted Doves in the city were within 5 m of conspecifics 84% of the time, but intraspecific agonistic interaction was extremely uncommon. Far less time was spent foraging close to other dove species and interspecific agonistic interaction was also rare.

Another possible factor contributing to the small PFT of urban Spotted Doves is that they accumulate food rapidly and store it in the crop. Birds that do this often have to

Table 1. Mean percentage foraging time allocation in 10 species of exotic and native Australasian diurnal land-birds. A = adult, I = immature; F = female, M = male; a = autumn, w = winter, sp = spring, su = summer; and b = breeding, nb = non-breeding season. *Some values incorporating breeding-season data may overestimate the proportion of daytime spent foraging because, probably like the present Spotted Dove estimate, they refer only to 'off-nest' time. On the other hand, adults rearing nestlings presumably need to spend proportionally more time off the nest foraging in order to harvest sufficient food for their young and themselves.

Species	*Age*	*Sex*	*Time of year*	*Habitat*	*Mean time foraging (%)*	*Source*
Kaka *Nestor meridionalis*	A		w, sp	Forest	43–73*	Berry (1998)
Crimson Rosella *Platycercus elegans*	A I		a (nb)	Forest	45 66	Magrath & Lill (1983, 1985)
Rifleman *Acanthisitta chloris*	A		a, w (nb)	Forest	83	Lill (1991)
Superb Lyrebird *Menura novaehollandiae*	A		All year	Forest	53–58*	Lill (1996)
Bellbird *Anthornis melanura*	A		w, sp, su	Forest	25–60*	Murphy & Kelly (2001)
Grey Warbler *Gerygone igata*	A	F M	b	Forest	~79* ~41*	Cameron (1990)
Brown Thornbill *Acanthiza pusilla*	A		a, w (nb)	Forest	88	Haylock & Lill (1988)
Magpie-lark *Grallina cyanoleuca*	A		a, w (nb)	Urban parks & streets	68	Kitchen *et al.* (2010)
South Island Robin *Petroica australis australis*	A	M	a, w (nb)	Forest	72–87	Powlesland (1981)
Common Myna *Acridotheris tristis*	A		sp, su	Urban–rural gradient	75*	McGiffin *et al.* (2013)

wait until the crop is at least half empty and there is more storage space available before they can recommence foraging (Diamond *et al*. 1986). Consequently, they forage in frequent, short bouts, interspersed with long periods of energetically inexpensive resting, and therefore have a small daily PFT. This seems likely to apply to Spotted Doves in the breeding season, except for *c*. 10 days when both the male and the female feed crop milk to the young, a process incompatible with seed storage in the crop. The urban food supply for this species must be sufficiently abundant to permit this kind of foraging strategy. The observed time structure of foraging behaviour is consistent with exploitation of a food resource distributed in fairly closely spaced patches with a high internal food-item density that would make them uneconomical to defend; this would enable a dove to fill its crop quite rapidly. However, this proposed food dispersion needs to be empirically demonstrated.

Much of the urban Spotted Dove's non-foraging time away from the nest was spent resting alert, which is more energetically costly than just resting (Magrath & Lill 1983). However, this pronounced alertness is consistent with Melbourne's Spotted Doves being less bold than co-habiting Crested Pigeons *Ochyphaps lophotes*, which are much more recent colonisers of the city. Gendall *et al*. (2015) showed that the former were more likely than the latter to escape from approaching humans (perceived as predators) by rapid flight rather than on foot, and to flee further. Urban Spotted Doves also had a significantly greater proportional vigilance time allocation while foraging than tamer, cohabiting Rock Doves *Columba livia*, and hence probably a superior ability to detect approaching (actual and perceived) predators; they retreated from an approaching human significantly earlier than did Rock Doves (Gendall *et al*. 2015).

Conclusions

Spotted Doves in Melbourne in the breeding season (spring and summer) had a small PFT, probably facilitated by a high abundance of patchily dispersed human food waste and exotic plant seeds and a low level of food competition, and possibly partly dictated by their digestive physiology. Although the field observations were conducted 11 years ago, these proposed basic, facilitatory and determining factors of a small PFT in Spotted Doves are unlikely to have changed in urban Melbourne since then.

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Received 25 May 2015, accepted 27 July 2015, published online 25 August 2016