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Extreme dietary switching: widespread consumption of meat by Rainbow Lorikeets at garden bird feeders in Australia

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Although wild bird feeding in Australia has a similar participation rate to that of North America and the United Kingdom, many of the species visiting feeding stations are carnivorous and are attracted by the provision of meat products. Whilst numerous species utilising feeders in Australia, including Rainbow Lorikeets *Trichoglossus haematodus*, consume seed mixes, a 2015 media report described this species also feeding on meat items. In order to determine whether this was more than localised, aberrant behaviour, a national online survey was conducted. A total of 140 respondents reported Rainbow Lorikeets consuming meat at feeding stations located throughout much of the species' distribution. Many of these reports were from the larger urban centres and a large proportion of respondents indicated that this behaviour had been occurring for more than five years. The phenomenon of meat-eating by Rainbow Lorikeets (and a range of other species) was found to be widespread and well-established. It is likely that this behaviour is an extension of the natural dietary switching of the species, it but could potentially be harmful if this type of food contributed significantly to the overall diet.

INTRODUCTION

The intentional provisioning of wild birds by people in their private gardens is one of the most widespread and popular forms of human-wildlife interaction in the Western world (Jones and Reynolds 2008). In North America, the United Kingdom, Germany, Australia, New Zealand and many other countries large proportions (35-75%) of households regularly feed wild birds, typically using commercial products, such as feeders and seed mixes (Jones 2011; Baicich *et al.* 2015; Galbraith *et al.* 2015). The scale of this pastime is extraordinary; it has been estimated that over 50 million people in the United States distribute around 500 000 tonnes of seed annually (Robb *et al*. 2008a). In the United Kingdom, enough birdseed is provided for Blue Tits *Cyanistes caeruleus* alone to support five times the actual national population of the species (Robb *et al*. 2008b). Notably, virtually all of these offerings consist of items completely absent from the natural diet of most species visiting the feeders (Robb *et al.* 2008a). Hence, wild bird feeding has been described as a supplementary feeding experiment on a global scale (Jones and Reynolds 2008).

In Australia, although participation rates are similar to those of the Northern Hemisphere (Jones and Reynolds 2008), the types of birds visiting feeders are strikingly different. Compared to tits and chickadees (10-14 g), Australian feeder species are typically much larger, with two of the most common species, the Australian Magpie *Cracticus tibicen* and the Rainbow Lorikeet *Trichoglossus haematodus*, weighing ~300 and ~150 g, respectively (Chapman 2015). Whilst most Australian feeder species are granivorous, the top ten feeder-using taxa include three (Australian Magpie, Laughing Kookaburra *Dacelo novaeguineae* and butcherbirds *Cracticus* spp.) which are insectivorous or carnivorous (Chapman 2015); indeed, the Australian Magpie is by far the most common and most popular wild species fed throughout the country (Rollinson *et al.* 2003; O'Leary and Jones 2006). Although various mixes of birdseed remain the commonest foods used, attracting non-seed-eating species has resulted in a proliferation of feeders offering various meat items, with mince meat being the most favoured (Ishigame and Baxter 2007; Chapman 2015). Given that between one third and one half of all Australian households regularly feed wild birds (Rollinson *et al.* 2003; Howard and Jones 2004), and that some of the most popular species are attracted by meat products, the amount of meat available to birds in typical Australian suburbs is substantial. The ready access to this food supply is regarded as one of the main reasons for the relatively high density of Australian Magpies in suburban environments in this country (Jones 2002).

Among the most frequent visitors to feeding stations in Australia is the Rainbow Lorikeet (Chapman 2015; Miller et al. 2015). Although naturally occurring throughout the *Eucalyptus* forests and woodlands of the continent, during the last few decades this species has moved into cities and towns, becoming the most abundant urban bird in many places (Fitzsimons *et al.* 2003; Higgins 1999). This spectacular population growth has been attributed largely to the popularity of nectar-rich trees and shrubs in private gardens, streets and public parks (Fitzsimons *et al*. 2003; Davis *et al*. 2012). Plants such as callistemons and grevilleas are especially attractive to lorikeets due to their large production of pollen and nectar, which are extracted by the bird's specialised brush-tongue (Higgins 1999). With many gardens also providing access to feeders, human supplementation may also be playing a role in the success of this species in urban areas.

In 2015, a media report (Watson 2015) describing a pair of wild Rainbow Lorikeets consuming beef mince ostensibly provided for Australian Magpies generated considerable popular interest (e.g., Lutz 2015). Although the informal comments that followed speculated that this observation was probably isolated and atypical (Lutz 2015), the incident highlighted the fact that many important aspects of wild bird feeding in Australia and elsewhere remained poorly understood, despite the scale and popularity of the practice (Jones 2011). In particular, recent studies have concluded that a range of potentially serious issues

relating directly to wild bird feeding need urgent attention, including the potential spread of disease, generation of nutritional imbalances and increases in the numbers of invasive species (Robb *et al.* 2008a; Galbraith *et al.* 2015).

Recently, the practice of providing large amounts of high-fat foods (suet) for wild birds, which is especially common in the northern hemisphere, has been investigated to assess the ecological implications associated with the widespread seasonal change to this food type (Plummer *et al*. 2013), a process known as dietary switching (Carnicer *et al.* 2008). Dietary switching is a natural behavioural process influenced by complex physiological 'drivers' that allow animals to optimise their nutritional requirements with respect to internal changes, such as those associated with breeding activity, or external changes, such as ambient temperature (Carnicer *et al.* 2008). In the case of suet, it is traditional practice to provide this high-fat food only during cold conditions (Plummer *et al.* 2013). Contemporary wild bird feeding, however, is increasingly a year-round phenomenon (Jones and Reynolds 2008). Moreover, the food types presented are usually unknown within the evolutionary history of the recipient species (Robb *et al*. 2008a), providing the opportunity for potentially sub-optimal or even detrimental dietary switching to occur.

The apparent discovery of meat consumption by a normally nectarivorous and granivorous species, the Rainbow Lorikeet, at feeders in Australia prompted us to examine this phenomenon in greater detail. Our aims were to describe the geographical scale and frequency of this activity, to determine its history and longevity, and to consider possible implications for the species and the practice of wild bird feeding generally.

METHODS

Information on meat-eating in Rainbow Lorikeets was obtained through responses to an online survey constructed specifically for this purpose. Potential respondents were recruited from a list of over 500 unsolicited emails sent to DNJ after media accounts which appeared in numerous platforms in March 2015 (Watson 2015; Lutz 2015). Several of the initial reports included invitations for readers of these websites to contact DNJ to share details of their experiences. After vetting to ensure that only Australian-based recipients who were reporting on wild birds (excluding those describing meat-eating in captive birds) were included, contacts were sent a personalised email inviting them to respond to an online questionnaire. The brief text explained that the purpose of the survey was to obtain general information on the phenomenon of meat-eating among wild Rainbow Lorikeets. The text also stated that the survey was entirely anonymous, that the researchers had no way of relating survey responses with email addresses and that the study had official approval.

The questionnaire (mounted by Survey Monkey, www.surveymonkey.com) contained ten items which canvassed basic information on general location of the respondent (postcode only), whether the respondent fed birds, the types of food provided and the bird species involved. Other items focussed on the lorikeets, requesting information on the number of birds observed, when the activity had first been noticed and whether other species also consumed meat at the feeders. Most items were answered via categorical, drop-down menus (e.g., Yes/No; designated food types), although respondents were required to list all species involved. The final item provided the option of an open-ended written response.

Table 1

Types of foods provided by respondents at feeding stations (n = 140), based on responses to the questionnaire.

Food type	Percentage
Meat	8.75
Seed Mix	65.3
Fruit/vegetables	44.4
Bread	36.1
Table leftovers	20.1
Honey/sugar & water	18.7
Cheese	11.1
Other	29.9

Given the exploratory nature of this study, only descriptive and summary statistical information are provided here. More detailed research into this topic is currently underway.

RESULTS

From 328 personal emails sent to contacts who had previously voluntarily responded to the media story (see Watson 2015), a total of 144 respondents completed the online survey (response rate 43.9%). Of these, 140 (97.2%) indicated that they provided food for wild birds, with 70% indicating that they did so daily; only 12.5% of respondents declared that they only fed birds 'occasionally'. Over half of the respondents indicated that they had been engaged in feeding wild birds for ten years or more, whilst only 3.5% had been involved for less than a year.

Respondents engaged in feeding wild birds reported using seven categories of foods (Table 1), with almost all providing more than one type of food. The two most common items provided were meat and seed mix, although bread and 'fruit/vegetables' were also popular (Table 1).

The list of species attracted to the meat supplied at feeding stations was dominated by Australian Magpies, Rainbow Lorikeets, butcherbirds (Grey Butcherbird *Cracticus torquatus* and Pied Butcherbird *C. nigrogularis* combined) and Laughing Kookaburras (Table 2). However, when asked to indicated which species had been observed consuming meat from their feeding station, respondents collectively mentioned ten species, but 53.8% stated that they were unable to identify the species observed consuming the meat (Table 2). As well as the three carnivorous species mentioned above, 'crows' (*Corvus* spp.) were reported by over one third of respondents. Most significantly, however, 87.9% of respondents reported observing Rainbow Lorikeets eating meat. A wide variety of other species was also mentioned as eating meat, most frequently rosellas (Eastern Rosella *Platycercus eximius* and Crimson Rosella *P. elegans* combined), Noisy Miners *Manorina melanocephala* and Crested Pigeons *Ochyphaps lophotes*, as well as numerous other species.

Table 2

Percentage of respondents reporting various bird species eating meat at feeding stations (n = 140), based on responses to the questionnaire.

Species	Percentage
Australian Magpie *Cracticus tibicen*	90.1
Rainbow Lorikeet *Trichoglossus haematodus*	85.4
Butcherbirds (Pied *Cracticus nigrogularis,* Grey *C. torquatus*)	76.4
Laughing Kookaburra *Dacelo novaeguineae*	68.1
Noisy Miner *Manorina melanocephala*	46.5
'Crows' *Corvus* spp.	34.0
Rosellas (Eastern *Playcercus eximius,* Crimson *P. elegans*)	15.3
Crested Pigeon *Ocyphaps lophotes*	10.4
Other species	42.4

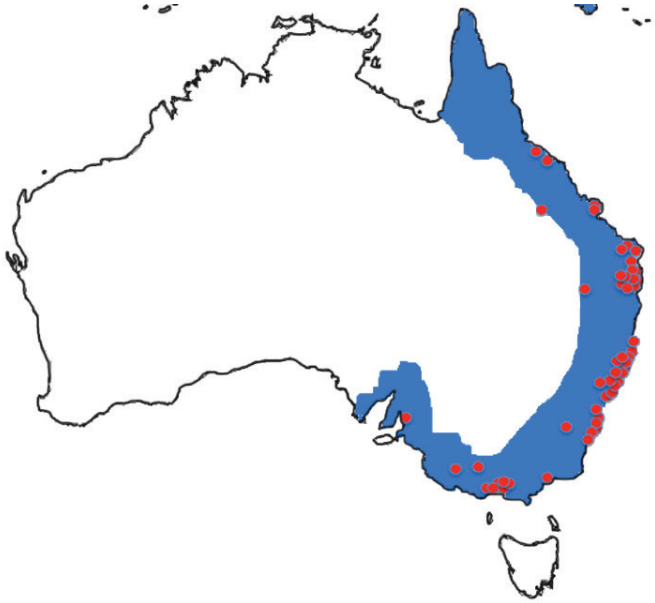

Figure 1. *Distribution of the Rainbow Lorikeet in Australia (blue), with locations of meat eating (red points) reported by 140 respondents. Note: map does not include introduced populations in western Australia.*

The locations of the 140 reports of meat-eating lorikeets spanned a substantial proportion of the species' distribution (Fig. 1) (excluding the sparsely populated tropics) from Cape Otway, Victoria (38.84° S) to Townsville, northern Queensland (19.25° S) and Quorn, central South Australia (138.03° E). Unsurprisingly, however, the majority of reports were clustered around the more heavily populated coastal areas of Victoria, New South Wales and southern Queensland.

Respondents reported first noticing meat consumption by lorikeets at their feeding stations both recently (23.5% within the previous year) and over a prolonged period (19.4% for more than five years). Over two thirds of respondents included comments in the optional, open-ended item of the survey indicating that the lorikeets arrived "suddenly" at the meat-laden feeder and subsequently became regular visitors. Many respondents also mentioned that lorikeets routinely excluded all other species from the feeding station while feeding, including the larger Australia Magpie.

DISCUSSION

We readily acknowledge that the way these data were obtained seriously limits the extent to which the findings can be generalised, especially given the high proportion of respondents who were unable to reliably identify the species that they observed. Nonetheless, the data do provide the first evidence that meat consumption by Rainbow Lorikeets visiting feeding stations is common, widespread and has been occurring for a prolonged period. It also suggests that a variety of other species, all abundant in urban environments (Rollinson *et al.* 2003), also utilise this widely available, anthropogenic, foraging resource, and some of them do not normally have high-protein diets (Miller *et al.* 2015).

The frequent provisioning of meat products at feeding stations recorded in Australia appears to be a rare practice among countries in which wild bird feeding is popular (Jones 2011), although the feeding of Red Kites *Milvus milvus* in some English towns is another example (Orros and Fellows 2014). Nonetheless, it is important to appreciate that almost every item offered by feeders anywhere in the world would not have been part of the traditional diet of most species utilising bird feeders (Baicich *et al*. 2015). From this perspective, all feeder visitors have engaged, at least initially, in some level of dietary switching, a behavioural ability driven by nutritional requirements and closely related to their success in colonising urban environments (Chace and Walsh 2006). Nonetheless, most feeder-visiting species around the world are granivorous and are attracted to a reliable and predicable supply of seeds, albeit of types unknown to their ancestors. The consumption of meat by an apparent nectar and pollen specialist, however, would appear to be an exceptional example of dietary switching. This raises two central questions: 1) is meat-eating known among wild lorikeets? and 2), what might be driving this clearly widespread phenomenon.

The possession of a specialised, brush-tipped tongue by all lorikeet species (subfamily Loriinae) enables them to extract both pollen and nectar from a large variety of plants. Whilst pollen alone does not supply sufficient protein (Pryor 2003), when combined with the amino acids found in nectar, the mixture provides most of the high-energy diet required by these fast-flying birds (Frankel and Nyram 2001). This particular dietary preference has profoundly influenced the highly mobile and nomadic movements of these species as they follow the flowering cycles of a wide range of trees and shrubs over large expanses of Australia (Smith and Lill 2008). Pollen and nectar supplies are, however, often unpredictable, necessitating an ability to seek alternative sources of protein when the plant-borne supplies are low. In large part, this appears to be provided by the opportunistic consumption of insects, although there are also numerous accounts of large flocks of lorikeets feasting on major infestations of moth and beetle larvae, and taking other insects, including psyllids and gall insects (Higgins 1999). Many Australian birds that consume nectar also feed on psyllid larvae and their sweet exudates; this is a special feature of Australia's bird fauna (Low 2014).

An additional source of protein, only rarely mentioned in the literature (Higgins 1999), emerged from the communications received after the initial media report (Watson 2015) but not included in the data presented here. Among the more than 500 unsolicited emails received were two categories of anecdotes of relevance (D. N. Jones, unpublished data). In the first, 34 owners of captive Rainbow Lorikeets described their birds as being "obsessed" or "becoming excited" when cooked meat was being eaten in the household, with free-flying birds often taking items directly from plates. The second group consisted of 22 emails providing accounts of wild parrots, including lorikeets, of over 20 species (from South America and Papua New Guinea, as well as Australia) which had been observed consuming the flesh of dead animals, such as kangaroos, sheep and cattle.

These observations and anecdotes strongly suggest that, contrary to perceptions of lorikeets as strictly consumers of nectar and pollen (Cayley 1961), these species frequently seek high protein items, including meat in a variety of forms. It is also important to emphasise that the natural diet of lorikeets contains a very broad range of food types, including many seeds, grains, fruits and plant parts, indicative of a highly malleable and opportunistic approach to foraging (Bell 1966; Higgins 1999). This is relevant in terms of both the nutritional requirements of captive birds (a grain-only diet is likely to be inadequate) and the often-repeated assertion that lorikeets should not be fed seeds, as this damages their brush-tongues (Adams 2011).

These findings indicate that rather than being the aberrant behaviour of a few individuals, the consumption of meat at feeding stations may actually be an extension of Rainbow Lorikeets' and other species' natural inclination to seek high-protein food sources. Under natural conditions, however, such sources are typically unpredictable, spatially isolated and short-lived, as exemplified by examples such as caterpillar outbreaks or the occurrence of dead animal carcasses. In significant contrast, however, the meat available at suburban feedings stations offers a reliable supply of a super-abundant, high-protein resource in extremely predictable locations. This situation resembles the situation of contemporary humans who retain a powerful desire for sugar, salt and fat initially evolved in an evolutionary landscape where such dietary components were rare, yet critical for survival (Jew *et al.* 2009). Modern lorikeets probably retain the evolutionary nutritional drive for protein, but are now able to satisfy this requirement daily rather than occasionally.

If correct, this scenario also suggests a potential for harm if meat comprised a major and regular part of an individual bird's diet. As the commonest type of meat provided at feeding stations is uncooked beef mince, there is the possibility of serious physiological effects if this food source dominated the diet. A condition well-known among zoo veterinarians working with meat-eating mammals is nutritional secondary hyperparathyroidism (Robbins 1983). If captive animals consume only raw meat (without bones, skin and fur), the imbalance in calcium and phosphorus can lead to the thinning of bones and a range of related problems, including rickets. This appears to be unlikely among wild Rainbow Lorikeets, however, as numerous studies from around the world indicate that wild birds rarely rely on feeders for most of their diet (Jones and Reynolds 2008). Nonetheless, we cannot be entirely certain that this is not a problem for wild birds without more detailed research (Cleary *et al*. 2016).

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