Behaviour and family association during the post-fledging period in Southern Boobooks *Ninox boobook*

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The post-fledging dependence period (PFDP), a crucial stage in developing survival skills, is a poorly studied ontogenetic phase in Australian owls. Post-fledging behaviour, development and dispersal were studied in 10 broods in six territories of the Southern Boobook *Ninox boobook* in Canberra, ACT during 1999–2008 using colour-bandng and radio-tracking. Owlets fledged in summer (usually December–January) at 33–41 days old (mean 37 days). Fledglings roosted with one or both parents in the early stages post-fledging (Weeks 1–4), progressing (Weeks 5–7) to roosting only with the mate after female desertion and then to only roosting together. They finally attained independence from parental feeding at 44–57 (mean 48) days and dispersed from the natal territory at 44–72 (mean 56) days post-fledging in late summer/early autumn. The findings refine the ages at which young Boobooks have been claimed to fledge and disperse, and give us a better understanding of the species’ ecological requirements in the face of increasing human pressures on their environment.

INTRODUCTION

The Southern Boobook of mainland Australia is classified as *Ninox boobook*, separate from the Tasmanian Boobook *N. leucopsis* and the Tasman Morepork *N. novaeseelandiae* of New Zealand and Norfolk Island (BirdLife Australia 2019). Knowledge of the Boobook’s post-fledging period and family relationships summarised by Higgins (1999) partly incorporated information on the Tasman Morepork. Subsequent studies of the Southern Boobook were partly summarised by Olsen (2011), and included coverage of some aspects of the post-fledging period, with clarification of the terms ‘branching’ (clambering out of the nest-hollow) and ‘fledging’ (first true flight from the nest tree) (Olsen and Trost 2009; Olsen et al. 2008, 2013). Juvenile Southern Boobooks are said to fledge at 5–6 weeks old and become independent at 6–7 weeks post-fledging (Olsen 2011). There is some uncertainty about how long juveniles remain in the natal territory after independence (Higgins 1999).

The post-fledging dependence period (PFDP) is a poorly studied developmental phase in Australian owls. Before becoming independent, most fledged nidicolous birds, including owls, have a substantial period of dependence on their parents (Newton 1979). This post-fledging dependence period begins with a juvenile’s first departure from the nest and finishes with its dispersal from the breeding territory and/or the cessation of parental care. It is a crucial stage for most raptors if they are to survive and reach adulthood because juveniles develop the skills essential to their continuing survival then. During the PFDP, juveniles mature physically and behaviourally and develop the hunting, predator-avoidance and other survival skills required in independence. Immediately after fledging, members of most raptor species exhibit clumsy movement and lack appropriate responses to potential predators or foraging opportunities (Marcetti and Price 1989). If juveniles fail to acquire hunting skills during the PFDP they may starve, even if prey is abundant. They need to attain these skills before seasonal food shortage increases the chance of mortality (Olsen 2014). The PFDP of most raptors is focused around the nest site or a safe location nearby; adults return to the nest or its vicinity with food, deliver it, either feeding the young directly or simply depositing the food, then linger or depart. Fledgling raptors learn that prey will be delivered to this site, so they stay close to it (Olsen 2014) and may even fly to intercept food-bearing parents. However, some *Ninox* owls differ from other diurnal and nocturnal raptors in that during the PFDP the adults and fledglings move together away from the nest site at night to forage and then roost away from the nest during daytime (Olsen 2011). This behaviour may be partly related to defence of territorial borders by male vocal ‘duelling’, sometimes accompanied by their dependent juveniles (e.g. Olsen 2011), and to accessing localised concentrations of invertebrate prey.

The duration of the PFDP depends on several factors (Bustamante and Hiraldo 1990; Ferrer 1992) and departure from natal areas can be influenced by progressively decreasing parental investment (Balbontín and Ferrer 2005), weather and/or innate factors. Evidence for involvement of the latter comes from ‘hack’ (see Definitions below). Another interesting feature of the PFDP is the habitual desertion of the fledglings by female Southern Boobooks, i.e. female parents cease to feed fledglings, leaving them in the care of the male parent (Olsen and Trost 1997; Olsen 2011). Female desertion raises the issue of female parental investment, where there is thought to be a conflict between male and female parents over how much care to provide for their offspring (Trivers 1972, 1974; Sunde 2008).
In species with biparental care, each parent benefits from the effort invested by its partner and avoids some of the associated costs (Eldegard and Sonerud 2009), so one sex behaves in a way that shifts a proportion of parental care onto the other sex (Korpimäki and Hakkarainen 2012).

Studying radio-tracked juveniles during the post-fledging period as they acquire skills necessary in independence can help to elucidate some of the issues raised above. Using field observations of vocalising, foraging, different modes of flight and other behaviours, we aimed to elucidate the behavioural development of fledged owlets. We studied 25 just-fledged Southern Boobooks from 10 broods over six breeding seasons from the night they fledged to the night they dispersed.

**STUDY AREA AND METHODS**

The study was conducted inside the Canberra city limits. The tracked owls fledged from nests in Aranda Bushland and Black Mountain Nature Reserves in Canberra, Australia (149°5'E, 35°17'S) at elevations from 600 to 800 m. Owls were observed within the 80-ha Aranda Bushland, the north-western corner of the 600-ha Black Mountain Reserve, the suburbs of Cook and Aranda, open grazing land to the south of Aranda Bushland and Cook, and occasionally the wooded northern flank of Mount Painter (Figure 1). Except for Mount Painter and the grazing land, the area is primarily open eucalypt forest and tall woodland, with dominant tree species being Scribbly Gum Eucalyptus rossii, Brittle Gum E. mannifera, Red Stringybark E. macrorhyncha and Blakely’s Red Gum E. blakelyi, and Red Box E. polyanthemos and Yellow Box E. melliodora in more open areas (NCDC 1988). The understorey has abundant tussock grasses (Poa spp.), with the shrub Cassinia longifolia dominating areas that are more open. Wildfire has largely been absent from the area and a regime of prescription fires has created a mosaic effect on the understorey. The suburbs of Cook and Aranda have retained a significant element of eucalypt overstorey of large Brittle Gums and Yellow Box, with a mix of native and non-native understorey elements occurring along roadsides, and in bushland corridors and backyards. A common tree in all areas is the Native Cherry Exocarpos cupressiformis, which is characterised by dense foliage that is favoured by the owls for daytime roosts (see Olsen et al. 2002; Olsen and Trost 2007 and Olsen et al. 2013 for details). We used a clinometer to measure the height of 12 Boobook nest-hollows and nest trees, and a tape measure to measure the diameter at breast height (DBH) of these trees. Nest metrics are reported as the mean ± standard deviation.

Adults and fledged young were trapped by means of bal-cha-tri traps baited with a House Mouse Mus musculus, a noose mounted on the end of a surf-casting rod, and fishing nets on...
extended poles. Sirtrack™ single-stage transmitters, on a backpack string harness with a weak link designed to break if the bird became entangled, weighed 5.4 g and harnesses 1.0 g, together equating to 2.4% of body weight of a 270-g male or 1.9% of a 340-g female. Batteries lasted 10–12 months, and owls were tracked with a Yagi hand-held antenna.

Adult Boobooks were sexed by size and the presence of a brood-patch (confined to females); adults and juveniles were banded (and adults colour-banded), fitted with radio-transmitters and tracked as described in previous papers (Olsen & Trout 1997; Olsen et al. 2008, 2010, 2011). Age of juveniles at fledging was determined by wing length (see Olsen et al. 2015):

\[ A = (W + 0.91)/0.50 \quad (r^2 = 0.985; P < 0.0001) \]

where \( A = \) age (days) and \( W = \) wing-length (cm)

We followed the 25 fledged owls (\( n = 12 \) radio-tracked) from the date they fledged to the date they dispersed i.e. when we could no longer find them at any known roost. We visited the area on 3–4 nights per week at sundown and stood 10–30 m from a nest or roost until the owls first flew; the first half of the night, from dusk, is the period of peak activity for Southern Boobooks (Debus 1997). Then, we observed the owls continuously for 1.2 h each night, qualitatively and quantitatively recording roosting and calling behaviour, family group structure, parental care, dates of life milestones (cessation of food-begging, independence), movements and dispersal. We watched owls for a total of 279 nights over 10 nest-years (eight pairs and offspring studied for either one or two summers each) from 1999–2008. Our sampling effort was similar for every week (1 to 6) in the post-fledging period, as indicated by the low standard deviation (±3.01 nights/week), with an average of 31.4 observation nights per PFDP week (range 28–35). However, sampling effort decreased towards Week 7 (\( n = 18 \) nights per week) as the post-fledging family association ended and the young dispersed.

Study birds

Between 1999 and 2008 we studied 10 broods in six territories: five territories were in Canberra Nature Parks in the ACT and one nest/territory was in the suburb of Cook, located in a small open area next to a bike path, bordered on both sides by houses. We noted brood sizes and behaviours before and after fledging (as above) (see Appendix 1 for territory codes, usually the male parent’s band colour).

Where only one juvenile in a brood was radio-tagged, it was still possible to closely observe the behaviour of siblings in that brood, as brood-members tended to stay together before dispersal. They called to one another and were easily located and observed. The Quarry female was radio-tagged, so we could locate her juveniles during the period she roosted with them. They continued to roost in the same trees after the female deserted them (see Female desertion, below). The Wybalena juveniles stayed in an area close to their nest site, usually roosting in the same trees, and their constant calling enabled us to find them each night of the study.

In each adult pair, at least one bird had been colour-banded; therefore, it was possible to distinguish the parents’ sex. None of the radio-tagged juveniles died before dispersal. Vocalisations of adults and fledglings are described by Olsen et al. (2002).

In summer 2002–03 the fledged White and Orange brood-members merged into one large brood of six fledglings cared for solely by the Orange adults (see Olsen et al. 2008 and Olsen 2011 for details).

Definitions

Fledging: a technique used to give orphaned or captive-bred owls hunting experience when there are no wild parents to feed them. A wooden ‘hack box’ with the front covered with vertical bars is placed high in a tree, and nestlings are placed in the box about two weeks before fledging. Nestlings are fed every day on a ledge at the barred entrance. Close to fledging, the bars are lifted and the fledglings begin to explore the local habitat and return to the ledge for food until they disperse some weeks later, even when food is provided continuously (Olsen 2011).

Independence: the point at which parents stop feeding young, often marked by cessation of food-begging in juveniles, although they may continue calling to one another.

Natal dispersal date: the first day a juvenile was not detected on its natal territory.

Female desertion: the date when adult females started to ignore juvenile food-begging and no longer fed their young. Sometimes females remained on the natal territory, but sometimes they moved to a separate non-breeding territory (e.g. see Olsen 2011).

RESULTS

Nest-tree metrics

Nest-hollow entrances were 9.15 ± 3.09 m above the ground (range 4.70–12.30 m), nest trees were 17.92 ± 4.33 m high (range 9.96–23.40 m) and nest tree DBH was 0.66 ± 0.14 m (range 0.50–0.87 m).

Pre-fledging behaviour

Before fledging, owlets crowded in the nest entrance and peered out (Figure 2a). Some perched just outside on the edge of the nest-hollow, facing in with their tails pointing out, or facing out, and exercised their wings (Figure 2b). Occasionally they lost their grip and fell to the ground. Usually they could clamber back up the nest tree or an adjoining tree, using their feet and flapping their wings, and re-enter the nest-hollow.

No juveniles in this study moved to a ledge or roost near the nest and then returned to the nest-hollow. On fledging, the juveniles made a short flight to a nearby tree, often 5 m away (Figure 3). There they perched and begged for food and the parents usually fed them. We saw no evidence to suggest that adults enticed young to fledge by calling, withholding food or removing cached food from the nest.

Fledging dates and fledging age

Fledging dates for individual juveniles ranged from 10 December to 10 February (\( n = 14 \); Appendix 1). Most broods fledged in December or early January. One brood (Wybalena 2007–08) fledged later after two clutches in the nest had failed (egg predation by Common Brushtail Possum Trichosurus
vulpecula: Olsen and Trost 2009), the young from a third clutch fledging on 10 February. Siblings from the same nest did not always fledge on the same night (i.e. fledging was asynchronous), usually fledging over two or three consecutive nights. Mean age at fledging (determined by wing length of trapped individuals) was 37.2 ± 2.2 days (range 32.8–40.8; \( n = 13 \) individuals).

**Family group structure at day-roosts**

Fledged broods were observed roosting with both adults, the female only, the male only, or with no adults (Figures 4 and 5). This pattern varied among broods, but also changed between the early (Weeks 1–4) and later (Weeks 5–8) fledgling period. Family group structure at roosts and various behaviours changed through four broad stages of the PFDP: (a) fledgling dependence, (b) female desertion, (c) fledgling independence, and (d) fledgling dispersal (see Figure 4).

**Stage 1 – fledgling dependence**

In the first four weeks after fledging, juveniles roosted with their siblings and at least one adult (Figure 4). The female roosted with the brood more frequently than did the male (\( n = 8 \) ‘normal’ broods, excluding the combined brood described by Olsen et al. 2008 and Olsen 2011). Over all weeks (1–7) of the PFDP, the female was present on 57.2% of evenings, the male on 31.2%, and no adults on 28% (\( n = 8 \) broods). In Weeks 1–4, only the female roosted with the juveniles on 57.5% of evenings, and only the male roosted with them on 12.5%. In Weeks 5–7, only the female roosted with the juveniles on 17.8% of evenings, and only the male on 17.8%. The juveniles roosted alone, without either adult, on 57.5% of evenings. In one brood (White 2000–01) the male was never observed roosting with the juveniles. These findings suggest a temporal pattern of decreasing roost association by the juveniles with the parent(s), although the sample size of broods is small.

During this stage, the parents sometimes brought food to just-fledged young, although they more often continued feeding those still in the nest-hollow. Once fledged, owlets rarely returned to the nest-hollow. Newly-fledged young sometimes landed at the base of a small tree or on a low branch, and the adults located and perched near these young. Fledglings did not tear up delivered vertebrate prey. Sometimes we saw the adults bring in vertebrate prey and watched the fledglings’ reaction; they were fed pieces of prey bill-to-bill by the adults, even if the fledglings attempted to seize the whole prey item.

On nights shortly after fledging, broods usually did not move far (e.g. ~10 m from the nest tree). When the female left the day-roost giving ‘Purr calls’ (Olsen et al. 2002), the juveniles followed. Juveniles gave food-begging/contact ‘Trill calls’ (Olsen et al. 2002) and made short flights, or perched on an exposed limb where the adults could land beside them to deliver food. Often one or both adults hawked insects close to where the juveniles perched. Food deliveries quantified at seven of these territories averaged 11 deliveries/hr during the first 14 days of the PFDP (Olsen et al. 2013).

There was some evidence that, if necessary, newly-fledged young could move far from the nest area. In 2006, the sole nestling was evicted from its nest-hollow by a Brushtail Possum (Olsen and Trost 2009); this juvenile and its parents were eventually located where they day-roosted and foraged 500 m from the nest site.
Boobooks need to settle in a roost tree before diurnal birds become active and mob or attack them. One observation indicated how adults may choose day-roosts and juveniles follow them to the roost. At 0550 h the female parent began calling to the juveniles, which were still distant from their previous day-roost, a bushy Native Cherry. She Purr-called repeatedly, and moved toward the roost. By 0611 h the two juveniles had followed her, trilling, and were ~50 m from the roost tree. At 0625 h, the juveniles had stopped following; the female’s calls became louder and more frequent, until the fledglings responded and again followed. She led them into the roost tree at 0631 h, where the three owls perched together and trilling stopped.

When potential ground predators, such as humans or House Cats Felis catus, approached the nest or fledglings, adult females sometimes gave ‘Single Hoot’ calls (see Olsen et al. 2002) and sometimes swooped at the intruder. In contrast, they flew, bill-clacking (snapping their bill), at Common Brushtail Possums in the owls’ nest tree. On some occasions, they struck the possum as it moved down the tree trunk, dislodging it (see Olsen and Trost 2009). Adult Boobooks bill-clacked and swooped at other arboreal mammals, such as Common Ringtail Possums Pseudocheirus peregrinus and small gliders Petaurus sp., near the nest and/or fledglings. (We note the recent split into the inland Krefft’s Glider P. notatus and coastal Sugar Glider P. breviceps by Cremona et al. 2020, and assume that the ACT gliders are the former). The adults did not use the ‘Single Hoot’ call to arboreal predators. Boobooks in one territory at dusk occasionally swooped or chased Little Eagles Hieraetus morphnoides nesting nearby and once a raven Corvus sp. Although Krefft’s Gliders weigh only about 120 g, Boobooks seldom captured them, but treated them as potential nest predators or competitors rather than prey (Olsen 2011) and attempted to drive them off.

Stage 2 – female desertion

In the second stage of the post-fledging period, adult females stopped feeding and defending the young. Initially the female continued to roost with the juveniles, but in the evening at roost departure time she ignored the trilling and food-begging of the juveniles. Sometimes the juveniles followed the female after she left the day-roost, but she ignored them when they perched beside her food-begging. She sometimes left her perch and moved to another part of the territory, away from the family. Adult females (n = 9) deserted juveniles at a mean post-fledging age of 32.9 days (range 20–40 days). All females dispersed (moved away from the brood) and in some cases left the breeding territory.

Males defended their fledglings and provided some food until the young became independent. There was much variation in this male attendance behaviour. The Green male (1999–2000) roosted with the young each night in Weeks 4–6 post-fledging after the female had stopped roosting with the family. In contrast, the White male rarely roosted with the young (only five nights in 2003–04 and none in 1999–2000 and 2000–01).

The ratio of male: female ‘Single Hoot’ calls directed at ground predators often changed during the breeding season as caring responsibilities shifted from females to males (Olsen et al. 2002).

Stage 3 – fledgling independence

In the third post-fledging phase, no adults were seen feeding the fledglings and they were rarely seen roosting with them. Fledglings of a brood continued roosting together until they dispersed from the natal area. There was no clear pattern of movement away from the nest site as the juveniles became more independent. Initially, the young moved around the natal territory following the parents while being fed (see above), and then moved around the territory as they foraged for themselves. The juveniles became independent of adult care (feeding, defence, roosting) at 42–57 days after fledging (mean 47.9 days; n = 11 including the Orange brood, but not the three White young in the combined brood; Figure 4).

A Wybalena fledgling banded on 14 February 2008 was hit by a car on 6 March 2008, breaking its wing. Although the wing was strapped and successfully treated by a veterinarian, healing and subsequent release were completed outside the PFDP i.e. the period when the parents were feeding the other young had
finished, even though the parents were still present. The juvenile flew well, but it did not know how to hunt and by that stage in autumn few (easily caught) insects were available. It was found dead on 14 May 2008 100 m north of the release site.

Stage 4 – juvenile dispersal

Excluding the brood-switching White young (see Olsen et al. 2008 and Olsen 2011), juveniles dispersed at a mean of 56.1 days post-fledging (range 44–72 days; \( n = 11 \)); inclusion of the White brood decreased this interval to 52.7 days (range 33–72 days; \( n = 14 \)). The enlarged brood dispersed at 33 and 41 days (White origin juveniles) and 61 and 62 days (Orange origin birds). The Orange parents seemed able to identify their own young and did not feed the White fledglings at first, but they eventually did feed them. However, the White fledglings may have dispersed earlier because of this lower feeding rate from the foster parents (see Olsen et al. 2008 and Olsen 2011). We never found the third White brood (radio-tagged) fledgling during dispersal; apparently, she had travelled beyond the range of our receiver.

In the 2020 autumn, ST watched a juvenile return to its natal territory after it had dispersed and food-beg to its still-resident female parent, but she drove it from the tree limb where it had perched next to her.

Harassment of parents

Hungry juveniles became aggressive while attempting to obtain food from, and actually taking it from, an adult, and this may have been a challenging time for the smaller adult male feeding larger female offspring. We observed juveniles chasing and displacing adult males from perches, aggressively seizing food and mantling over it (defending it with drooped wings), and adult males shying away or ‘chittering’ in apparent distress during such encounters. This may have contributed to adults roosting apart from their offspring late in the post-fledging period.

Calling behaviour and cessation of food-begging

When the owlets fledged, they emitted the cricket-like ‘Trill call’ while stretching and preening before leaving the day-roost at dusk, and continued calling as they moved around the natal territory. We did not hear any of the young give the two-note ‘boobook’ call. The trilling call appeared to have two functions, namely in food-begging and maintaining contact with siblings and parents. Siblings appeared to use the call to communicate with one another when parents were absent. Nestlings and fledged young responded to the presence of adults delivering food with excited louder, rapid trilling. The amount of calling declined as the juveniles became more independent and food deliveries by the adults became less frequent.

Mortality during the fledgling period

In the 1999–2000 season, two fledglings disappeared early on from the White brood and only the one radio-tagged juvenile survived to independence. Initially the adult female and three juveniles roosted in a eucalypt and the male roosted ~30 m away in a Native Cherry. Eight days after fledging, two juveniles were observed roosting with the female, but there was no sign of a third juvenile. Sixteen days after fledging a second juvenile had disappeared. In the 10 broods studied, these were the only juvenile mortalities observed in the PFDP i.e. two out of 25 juveniles or 8.0% mortality. In 2008, one injured, rehabilitated juvenile was released back into the natal area outside the PFDP but died (see above).

DISCUSSION

The juvenile Southern Boobooks in this study fledged at a mean of 37.2 days post-hatching (\( n = 13 \)). Our findings confirm that juvenile Boobooks become independent at about 6–7 weeks post-fledging, and normally disperse from the natal territory at about eight weeks post-fledging (range 6–10 weeks). One exceptional case of brood-switching reduced this interval to 5–6 weeks in the foster young, possibly encouraged by low feeding rates by the foster parents. Our findings largely corroborate the information summarised by Higgins (1999) on the post-fledging phase of the Southern Boobook in Australia, which relied partly on early findings from the study by Olsen and Trost (1997). Our study of marked and tracked juveniles has refined knowledge of the age at which young Boobooks disperse from the natal territory i.e. at ~2 months post-fledging in late summer/early autumn, substantially less than the 3–4 months or ‘first winter’ as sometimes claimed (see Higgins 1999).

Our observations suggest that crowding in the nest-hollow may contribute to the young fledging, although chronological age (physiological maturity) may be the main factor. In the weeks immediately after fledging, juveniles roosted with their siblings and with at least one parent. Sometimes both parents roosted with their offspring, but the most common pattern was one parent and all the juveniles roosting together. There were few exceptions to the identified strong patterns of post-fledging behaviour. Thus, in only six out of 207 observation evenings did members of a family roost separately: examples were a juvenile roosting with a ‘floater’ (non-parent, non-sibling Boobook) in White territory, and three days on which fledged juveniles roosted with the female parent while one juvenile remained

Figure 5. Two Boobook fledglings roosting with the Quarry female parent (centre), 5 January 2005.

Photo: Jerry Olsen and Susan Trost.
On two days, the Quarry male and female roosted separately, each with some of the young; on the first day two juveniles roosted with the male and two with the female, and on the second day three juveniles roosted with the male and one with the female (Figure 5).

Allowing for differences in body size and hence maturation rates, the post-fledging period of the Southern Boobook and the associated parental behaviour resemble those of some congeners. The mortality rate for juvenile Boobooks in this study seemed low. The slightly smaller Tasman Morepork shows similar post-fledging behaviour, but possibly a longer juvenile dependence period (~2 months) and higher post-fledging mortality, although secondary poisoning may have contributed to the latter (cf. Higgins 1999; Stephenson and Minot 2006). In the larger Barking Owl *N. connivens* and the much larger Powerful Owl *N. strenua*, post-fledging behaviour and development resemble those of the Southern Boobook, but the dependence periods are correspondingly longer (Barking Owl partly dependent at ~5 months, Barnes et al. 2005; Powerful Owl dependent for ~5–6 months, McNabb and McNabb 2011; Bilney 2013; Mo and Waterhouse 2015). These differences may be related to the development of skills for catching difficult prey e.g. large arboreal mammals by the Powerful Owl, whereas young Boobooks can subsist wholly on insects (this study; Olsen and Trost unpubl. data).

Species of similar body size in strigid genera overseas are also similar in some respects in their post-fledging biology to the Southern Boobook. Examples of comparable post-fledging developmental stages for the slightly smaller Little Owl *Athene noctua* and Boreal Owl *Aegolius funereus*, and larger Tawny Owl, Spotted Owl *Strix occidentalis* and Long-eared Owl *Asio otus* are given in Table 2.
In our study juvenile ‘trilling’ stopped at a mean of 45 days (range 42–57 d) post-fledging. After they became independent, juveniles roosted in the natal territory for about nine days, on average, before dispersing (Table 1). In a study of 72 radio-tracked fledgling Tawny Owls Strix aluco, Sunde (2008) found that juveniles stopped food-begging at a mean of 71 days post-fledging. Whilst juveniles remained on their natal territory, parental control of food determined the duration of juvenile food-begging. After they became independent, young roosted in their parents’ territory for 18 days on average before dispersal. Sunde (2008) concluded that young Tawny Owls ‘maximise’ the parental care period rather than disperse while parents still offer food. This may have been the case for Boobooks in our study too. However, as with fledging, chronological age (physiological maturity) must be the main factor determining dispersal age because juvenile owls at ‘hack’ disperse even when supplied daily with food (Olsen 2011).

Female desertion in owls, and raptors in general, deserves further study. Olsen and Trost (2007) suggested that, in the early stages of breeding, male Boobooks appeared to compete for females (especially large ones) by holding a high-quality territory with a good food supply, nest site and roost trees. We saw no evidence during the PFDP that females deserted territories because of food shortage; they may even have deserted when food was abundant. There is evidence for other species (e.g. Tengmalm’s or Boreal Owl, Barn Owl Tyto alba) that females desert fledglings if food is abundant enough for males to finish the breeding cycle alone (Zarybnická 2009; Béziers and Roulin 2016). Olsen and Trost (1997) suggested a link between female desertion and parental investment (Trivers 1972). That is, females seemed to ‘switch off’ parental behaviour, but males took longer to ‘switch off’ than females did and so were left with parental responsibilities for a longer period. Korpimäki and Hakkarainen (2012) characterised the breeding system of Boreal Owls as a ‘tug-of-war’ over biparental care, where both sexes ‘attempt’ to shift a majority of parental care duties to their mate. They pointed out that female birds of prey desert their offspring more often than do males. For example, 70% of female Boreal Owls deserted their first brood and left males to care for the offspring alone (Eldegard and Sonerud 2009). However, in contrast to Boobooks, many of these Boreal Owl females remated in the same breeding season and fledged a second brood. Korpimäki and Hakkarainen (2012) suggested that the costs of searching for mates may constrain female mate choice in Boreal Owls, and females mate with one of the first males they find. The Southern Boobook is thought to be declining over much of southern Australia, and this decline may be at least partly related to secondary poisoning from anticoagulant rodenticides (Debus 2009; Olsen 2011; BirdLife 2015; Lohr 2018). Other factors involved could be declines in woodland bird prey (Olsen 2016) and invertebrate prey (see Debus et al. in press) and the loss of nest-hollows, including high-quality hollows of sufficient size, to increasing populations of species such as the Sulphur-crested Cockatoo Cacatua galerita, possums and other competitors, as well as habitat clearing and perhaps increased wildfire (Olsen and Trost 2009, 2015; authors’ pers. obs.). Local declines in Boobook populations are also associated with habitat loss to urbanisation, including in our study area in Canberra (Olsen and Trost 2007, 2015). Even less is known about the Tasmanian Boobook, which is at risk and declining (Mooney 2017), and experiences the above pressures plus ‘fierce’ competition for hollows from the introduced Laughing Kookaburra Dacelo novaeguineae (N. Mooney pers. comm.). The Tasmanian Boobook is genetically closest to the Tasman Morepork (Gwee et al. 2017), which has already lost two subspecies on islands in Australian territory (Norfolk and Lord Howe), and seems more strictly forest-dependent than the widespread Southern Boobook (Bell et al. 1997; Todd et al. 2018). There is a clear need for further study of the post-fledging phase of Australian Ninox and Tyto owls, to achieve a better understanding of their needs in the face of increasing human pressures on their environment, including climate change.

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REFERENCES


APPENDIX 1

Development of post-fledging behaviours for 14 juvenile Southern Boobooks from 10 broods, Canberra, ACT. Six territories (White, Green, Orange, V5, Quarry, Wybalena) studied during 1999–2008. Broods and territories were (colour = band of male parent; Quarry, V5 and Wybalena = additional nest locations):

Summer 1999–2000: White brood of three fledged; all banded and one juvenile radio-tagged. Two juveniles disappeared early in the post-fledging period. Orange brood of one fledged; banded and radio-tagged. Green brood of two fledged; both banded and one radio-tagged.

2000–2001: White brood of two fledged; both banded and one radio-tagged. V5 brood of three; one banded and radio-tagged.

2002–2003: White brood of three fledged; all banded and radio-tagged. Orange brood of three fledged; one banded and radio-tagged. Fleaed White brood left White territory for Orange territory and the two broods merged into one large brood of six fledglings cared for solely by the Orange adults; see Olsen et al. (2008) and Olsen (2011) for details.

2003–2004: White brood of two fledged; both banded and radio-tagged.

2004–2005: Quarry brood of four fledged; adult female but no juveniles radio-tagged.

2007–2008: Wybalena brood of two fledged; one banded but no radio-tagged.

Wybalena and Quarry juveniles were not radio-tagged (Quarry female parent tagged). Days (age post-fledge)/dates of first foraging and female desertion refer to first sibling to fledge; other juvenile ages/dates (last calling, independence of parental feeding, dispersal) also refer to days post-fledge. For the Wybalena brood (two juveniles) and the Quarry brood (four juveniles), dates for observed behaviours are the first record for the brood. Fledging date refers to first sibling to fledge; other juvenile ages/dates (last calling, independence of parental feeding, dispersal) also refer to days post-fledge. For the Quarry brood (two juveniles) and the Wybalena brood (four juveniles), dates for observed behaviours are the first record for the brood. Fledging date refers to first sibling to fledge; other juvenile ages/dates (last calling, independence of parental feeding, dispersal) also refer to days post-fledge. For the Wybalena brood (two juveniles) and the Quarry brood (four juveniles), dates for observed behaviours are the first record for the brood. Fledging date refers to first sibling to fledge; other juvenile ages/dates (last calling, independence of parental feeding, dispersal) also refer to days post-fledge.

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<th>Territory</th>
<th>Year</th>
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<th>Date banded/tagged</th>
<th>N obs.</th>
<th>First forage (d)</th>
<th>Female desert (d)</th>
<th>Last calling (d)</th>
<th>Independent (d)</th>
<th>Dispersal (d)</th>
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<td>20/1/2001</td>
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