Duelling and Nest Failures in Southern Boobooks
*Ninox novaeseelandiae*

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Summary

Male Southern Boobooks *Ninox novaeseelandiae* duelled with each other on territorial borders, often close to a neighbour’s nest that had been placed against the border. Nest failure increased with duelling during two periods: 1996–97 and 2004–05, the last increase linked to a new road cut through bushland of five Boobook territories. Three territories were abandoned, leaving two expanded territories over the same area. It is not clear why duelling males did not break off duels and forage for their incubating, food-begging mates. We suggest that males may compete for quality females by maintaining borders around important food sources, tree-roosts, and nest-hollows inside quality territories.

Introduction

Though the Southern Boobook *Ninox novaeseelandiae* is a common species, there is confusion in the literature about aspects of its biology (see Olsen & Trost 2003; Olsen & Debus 2006; Olsen et al. 2006): for example, which factors increase the frequency of territorial Boobook calling. Kavanagh & Peake (1993) found no seasonal differences but detected calling more often on nights with little or no wind, no visible moon, and clear skies. Nights when the moon was not visible, regardless of moon phase, appeared to stimulate calling. Debus (1997) noted that Boobooks in New South Wales called spontaneously (not responding to playback) throughout the night, with a peak in the first half of the night. Moon visibility and cloud cover did not affect calling rates, but rain and wind depressed calling, though there were individual exceptions. With a smaller sample of Boobooks, radio-tagged and identified individually, Olsen et al. (2002a) concluded that variations in territorial Boobook calling with temperature may be an artefact of statistical treatment; variations in frequency of calling disappeared when they controlled for season, and were independent of moon visibility, wind, or rain. In contrast, three variables—season, social context, and individual differences—seemed to explain much of the variation in the frequency of territorial Boobook calling, and they argued that territorial disputes over borders, especially when a pair placed its nest against a neighbour’s border, increased this frequency.

There is similar disagreement about duetting in Southern Boobooks, duetting being defined as a male and a female giving co-ordinated overlapping bouts of territorial calls that sound like one owl calling (Farabaugh 1982; Campbell & Lack 1985). Higgins (1999) concluded that male and female Boobooks duet in captivity and in the wild in Australia and in New Zealand. However, Olsen & Trost (1997) suggested that some behaviours interpreted as duetting between mated pairs actually were males duelling with each other over territorial boundaries. They defined duelling as an encounter between owls that started when a male called and was answered by another male. A quiet period followed, then the distant
male called again, from a tree closer than before. As the Duel progressed, both males gave Territorial Boobook or low, throaty Por calls while 50 m apart on their territorial border. Eventually the two males perched in the same tree, and continued to give Territorial Boobook or Por calls. Females were often present giving Bray calls, as if soliciting food from males (Olsen et al. 2002b), but usually did not engage in Duels. Stephenson (1998) described similar behaviour in Boobooks in New Zealand. Olsen et al. (2002b) looked for overlapping bouts of Territorial Boobook calling as evidence of Duetting, and found that most overlapping bouts were Duels between neighbouring males on borders. Bouts lasted up to one hour. At least 14 of 28 Duels (50%) had three birds present, usually two males Duelling, and a female sitting nearby quietly or giving Bray calls. Duels increased during border disputes.

Nest failures in raptors are commonly associated with poor food supply, inclement weather, predation, or sometimes pesticides and pollutants. However, interaction between pairs of raptors in dense populations can also cause nest failure, for example in close-nesting Black (Verreaux’s) Eagles Aquila verreauxii in Zimbabwe (Newton 1979). Pairs of these eagles usually avoided using adjacent nest-sites, and when these nests were used, breeding failures increased. In addition, the disturbance caused by a new pair establishing a territory reduced the breeding attempts and breeding success of neighbours. Nest failure has also been observed among close-nesting young Ferruginous Hawks Buteo regalis and Swainson’s Hawks B. swainsoni in Alberta, Canada. Nest failures in both these species increased with decreasing distance between neighbouring nests, and this was attributed to the observed increase in aggression between close-nesting pairs, which was often followed by nest desertion (Newton 1979). We know of no similar data for intraspecific interactions causing nest failure in Australian raptors.

In this study we calculated the frequency of nights on which we heard Territorial Boobook calls and Duelling per month and per year in adjacent territories of Southern Boobooks, and compared these with nest failures in each year.

Methods

Trapping, banding, and radio-telemetry

We used wire bal-chatri traps (Olsen & Woollard 1975) baited with a House Mouse Mus domesticus, a noose mounted on the end of a surf-casting rod, and fishing nets on extended poles, to trap adults and fledged young. Where possible we trapped breeding adults, sexed them (Olsen & Trost 1997), fitted them with a stainless-steel Australian Bird and Bat Banding Scheme band, and a plastic colour-band sealed with super-glue (seven males, nine females). If an adult was not marked, we sexed it during observations, by the female’s prominent brood-patch (Olsen & Trost 1997). Some individuals removed the plastic colour-bands, so we banded them again with numbered aluminium colour-bands attached with two rivets. Five breeding males and four breeding females had backpack-style Sirtrack single-stage radio-transmitters, fitted with a string harness and weak link designed to break if the bird became entangled by its transmitter and harness (Karl & Clout 1987). Radios weighed 5.4 g and harnesses 1.0 g, making 6.4 g on a 270-g male (2.4% of body weight) or 340-g female (1.9% of body weight). Batteries lasted 10–12 months.

Survey methods

In 1993 we located three nests (see Figure 1) in three adjacent nesting territories straddling Aranda Bushland and Black Mountain Reserve, Canberra (35°15’S, 149°05’E), Australian Capital Territory. In subsequent years we observed three to 11 breeding attempts
Figures 1 a–b. Adjacent nests of Southern Boobooks studied in Aranda Bushland and Black Mountain Reserve, Canberra, ACT, in: (a) 1993 (above) and (b) 1998 (below); see Figure 1c (2004) over page. The letters CIT, G, HS, O, R and W refer to breeding events of marked males as discussed in the text.
in adjacent territories each year; from 2003 we searched two new areas in Black Mountain Reserve, which added additional nests to the study. See Olsen et al. (2002a) for a description of the study area; the habitat was grassy or shrubby dry open forest or tall woodland dominated by eucalypts.

Observations were made throughout the year (Table 1) from just before the birds left their day-roost or nest, to one hour after. We visited the area several nights per week at sundown and stood 10–30 m from the nest or roost of one of the pairs, then after Boobooks left the roost or nest we followed individuals as closely as possible without disturbing them.

Over 1463 observation nights from January 1993 to December 2005 we scored all Territorial Boobook calling and Duelling heard. Where possible we identified the callers by triangulating the location of radio-tagged birds with a hand-held Sirtrack yagi antenna and Telonics TR-4 receiver, and by sighting colour-bands with a torch and binoculars. We defined nests as often Duelled when we observed Duelling on >10% of observation nights during breeding, in August to December, and scored nests as seldom Duelled when we observed Duelling on <10% of nights in August to December.

Each year we counted nest failures and fledged young. Nest failure was defined as a mated pair copulating near or in a nest-hollow, or laying eggs in that breeding year, then abandoning the breeding attempt. Pairs sometimes laid a second or third time in different hollows in the same territory, and each of these was counted as a separate breeding attempt. In some years we found fewer pairs at nest-hollows than in other years, so percentage of nest failures in a year may not reflect the number of Boobooks present in the study area from year to year (Table 2).

**Results**

Territorial Boobook calling and Duelling were seasonal, increasing in the pre-breeding stage and peaking around the time of incubation and hatching.
The frequency of Duelling per observation night changed over the 13 years of the study (Figure 3), with two peaks: around 1996–97, and again around 2004–05, which corresponded with an increase in the percentage of nests that failed (Figure 3). The first peak related to a pair that, from 1993 to 1997, placed its nest against the border of two other pairs and pushed farther east each year until one of the original pairs disappeared (see Olsen et al. 2002a). Between 1998 and 2003 the percentage of nights on which we observed Duelling, and the percentage of nest failures in each year, remained fairly constant at low levels for six breeding seasons (Figure 3). The second peak in Duelling and nest failure in 2004–05 coincided with the building of a major new road, which cut through the bushland territories of five pairs of Boobooks and destroyed 8000 trees. Only two of the five pairs along the course of the roadway remained after 2004. During this time, a male previously without a mate or breeding territory, which had not attempted breeding in 2003, attracted a female and attempted breeding in 2004 and 2005.

Changes in territorial borders of breeding males often occurred near the sites of Duels, as shown by the changes in nest-site locations from 1993 to 1998 to 2004 in the same area (Figure 1). In each year, nests where males often Duelled were less successful than nests where males seldom Duelled ($\chi^2 = 15.8$, df = 1, P < 0.001: Table 3). Nests where males often Duelled had a failure rate of 50% either because the nests of both Duelling males failed, or because one succeeded and one failed. Duelling and nest failures of Duelling males followed a similar pattern, as illustrated in the following case studies involving marked males:

(1) White (W) and Red (R) vs Green (G)

From 1993 to 1997 males R and G Duelled close to G’s nest as G nested farther east each year, pushing into the centre of R’s territory, and into a corner of the territory held by W (Figures 1a,b). W shared a border with G and with R and engaged in Duels with G but never with R. R successfully fledged young from 1992 to 1996, then failed in 1997, and disappeared around 1 January 1998.

In the 1997 breeding season G’s original mate had switched territories and nested with W. Also in 1997, during the first peak in Duelling (Figure 3), R persistently called within 30 m of G’s nest, where G and his new mate failed to fledge young three times that year: once at the nestling stage, and twice at the egg stage. In 1998 G and his new mate absorbed R’s abandoned territory, though R’s mate remained near their original nest and was apparently killed by G’s mate (see

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Olsen et al. (2002a). G remained with this second mate on the expanded territory, and fledged young each year until 2004. They disappeared during the second peak in Duelling in 2004–05 after road construction expanding Caswell Drive cut through important foraging trees (see below) in their territory (Figures 1b,c).

W fledged young in 12 out of 13 years from 1993 to 2005; he failed in 1996.
During the first peak in Dueling, but fledged young during the second peak. By 1998 (Figure 1b) W and Orange (O) were nesting closer than two pairs had nested at any time during the study, and from 2001 to 2003 they nested even closer, about 200 m apart, but never Duelled and had no nest failures.

(2) Frith (Fr) vs Power Station (PS)

In 2003, in the new area that we began to study on the eastern flank of Black Mountain (east of Figure 1), Fr was not observed Dueling, and he fledged three young. Quarry (Q), the male in an adjacent territory, was not seen Dueling and also fledged three young. In 2004, in adjacent territories, males PS and Fr Duelled on 50% of observation nights, and both nesting attempts failed. In an adjoining territory, Q gave Territorial Boobook calls on some nights but did not engage in Duels with Fr or PS, and Q fledged four young. In 2005 Fr disappeared, Q had four young, and PS moved to nest within 150 m of Q but this nest failed. Some of this disruption of breeding in 2004–05 may have been linked to displaced owls and habitat destruction on the western side of Black Mountain, after road construction expanding Caswell Drive cut through important foraging trees in the territories. However, we were unable to identify individual Boobooks or verify this.

(3) White (W) vs ‘Floater’ (F)

In 2001 a new male F with no mate or breeding territory appeared on the border between males G and W. He lived and called occasionally from a gully that G originally took from W during the 1993–97 dispute (Figures 1a,b). In 2002 and 2003 F gave Territorial Boobook calls on some nights but was not engaged in Duels with either G or W. In 2004 (Figure 1c) G and O disappeared after the new road cut through important foraging trees in the territories of G, W and O (see Olsen et al. 2006 for description of Boobooks foraging in trees). These three males had shared territorial borders from at least 1992 to 2003. W lost considerable foraging area from the new road and absorbed the now-empty territories of O and G (Figures 1a–c).

In 2004 W with a third female (from 2001 to 2005; his second mate was killed by a cat on her winter home-range in May 2001: see Olsen & Taylor 2001) bred in this new-expanded territory, and F attracted a female for the first time; both pairs laid eggs, in nests about 200 m apart. W initiated Duels with F close to F's nest (F1), on most observation nights. In November F and his mate abandoned their breeding attempt, and tried again 300 m farther west (F2) (Figure 1c). Dueling then stopped. W fledged three young in December 2004, the normal fledging time, and foraged with these over his previous territory, and over the now-abandoned territories of O and G. F fledged two young in the second breeding attempt, during February 2005 (2 months later than normal), and stayed out of

Table 3

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<th>Duelling</th>
<th>Successful</th>
<th>Unsuccessful</th>
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<td>&gt; 10% nights</td>
<td>12</td>
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<td>&lt; 10% nights</td>
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Number of successful versus unsuccessful Southern Boobook nests, Canberra, ACT, 1993–2005; (n = 59 breeding attempts) where owls often Duelled (Dueling observed on > 10% of nights) or seldom Duelled (Dueling observed on < 10% of nights) with neighbouring males in a breeding attempt. Success was significantly higher at nests where males seldom Duelled compared with nests where males often Duelled ($\chi^2 = 15.8$, df = 1, $P < 0.001$).
W’s expanded territory. In 2005 W still held an expanded territory and was not seen duelling. W and his mate fledged two young in December that year, but W was found dead on 13 February 2006, 13 years 1 month after he was banded as a breeding adult in the same territory.

After trees were felled for the road in 2004, another breeding male, Hospital (HS), disappeared (Figures 1b,c). His neighbour, Canberra Institute of Technology (CIT), filled the vacuum by doubling the size of his territory. CIT fledged three young in December 2004 and four young in 2005. We spent too little time in this area to determine if there was an increase in duelling before the two territories, of CIT and HS, were absorbed into one, but on the eight nights of observation in 2004 we heard none. HS may have left because of the disturbance caused by road construction, or he may have left because of earlier duelling that had changed territory borders.

(4) F vs Bike Path (BP)
In 2005 F and his mate occupied the hollow used in their second 2004 breeding attempt (F2, Figure 1c) after W had forced them west from their first attempt (F1); F courted his mate and copulated inside and outside this second hollow. A new unmated male (BP) from the suburb of Cook, to the west, engaged F in duels on most nights on F’s western border, until F’s mate left him to pair with BP and breed in a small park in Cook. F continued to engage BP in duels, but remained unmated during 2005.

BP’s nest was the only suburban nest that we found during 13 years of study. Many resident Common Brushtail Possums Trichosurus vulpecula foraged nearby, apparently because humans fed them. A female possum with a dependent young roosted and fed in the tree where BP nested, and tried each night to climb past the Boobooks’ nest-hollow to gain access to eucalypt flowers in the crown. Each
night the incubating mate of BP attacked them, making contact, and driving them away from the nest-hollow, and sometimes BP also attacked them (Plate 6). In the first hour after dusk, BP fed the female with vertebrate and invertebrate prey; however, when F engaged BP in Duels, ~200 m east of the nest, the female had to
hunt and defend the nest on her own. On some occasions she followed BP away from the nest to collect food from him, or she hunted out of sight of the nest. Twice we saw the juvenile possum dart into the Boobooks’ nest-hollow when chased by the female Boobook, and suspected that this happened at other times when we were not present. Eventually the nest failed, either because of rain, the high frequency of Duelling, the female not getting enough food, and/or possums entering the nest and crushing or eating the eggs.

In all Duels, one of the males had a recognisably higher-pitched call than the other. For example, the two males that prevailed over F in Duels (W and BP) had, to our ears, deeper calls than F did. It is important to note that the proximity of nests did not necessarily lower nesting success. W and O nested within 200 m between 2001 and 2003, and fledged three young each year. However, there was no Duelling along this border, even though males were commonly in view of each other. That is, it appeared to be Duelling, not proximity of nests, that caused nest failure.

Discussion

Duelling could have been confused with the Duetting reported by earlier writers because both involved two owls calling with overlapping bouts, close to a nest, sometimes with both owls in a single tree, one with a higher-pitched call (Olsen & Trost 1997; Olsen et al. 2002b). However, we found no evidence in this study to confirm Duetting.

Nest failures in this study resembled those observed in diurnal raptors, where pair density, close nesting, and the disturbance caused by a new pair establishing a territory reduced breeding success, and were attributed to the observed increase in aggression between close-nesting pairs (Newton 1979). However, in this study W nested closer to R than to G in 1993 (Figure 1a), and W and R did not Duel. By 1998 (Figure 1b) W and O were nesting closer than pairs had nested at any time during the study, and from 2001 to 2003 they nested ~200 m apart, but never Duelled, and never had nest failures. In addition, after eggs were laid, we saw no females involved in these disputes, and assume that the disputes between breeding pairs described by Newton involved both sexes. Finally, we recorded an increase in Duelling and nest failure in 2004 and 2005 (Figure 3), when pair densities were at their lowest, that could have been linked to food shortage caused by the destruction of trees in all five Boobook territories.

Males

Some pairs may have been stressed by bouts of Duelling, but the exact mechanism of clutch- or brood-destruction or desertion was not clear. We never saw neighbouring males break off and leave in the middle of a Duel. Sometimes a male stopped calling and sat facing the challenging male, as if watching and listening, but he did not leave and forage even when his mate was food-begging. Males could have broken off and foraged outside our 1-hour observation periods, but apparently were reluctant to do so. We could see no potential harm to the breeding attempts if males had broken off and left: an incubating or brooding female could kill a neighbouring male trying to enter the nest-hollow in her mate’s absence; but if her mate could return with food this would increase the likelihood that she remained at the nest to incubate and brood. Duelling appeared to be a ritual with clear rules, one of which was a cost to males if they disengaged, especially if a female was looking on. At least two females switched to neighbouring males.
after bouts of Duelling. At the main points of Duelling, along Caswell Drive and Frith Road (east of Figure 1), nesting attempts of three of the four participating males failed. In comparison, two adjacent males that did not participate in Duelling both fledged young.

It was never clear why certain males Duelled with one neighbour but not another; this may be related to kinship, the length of time that males had shared a common border, or other factors. W Duelled with G and F, but never with neighbours O or R; G never Duelled with F, even though F seemed to live on part of G’s territory. However, after F attracted a female, W engaged in Duels with him each observation night and this apparently prevented the fledging of young from F’s first (F1) breeding attempt.

These pairs did not appear to suffer food shortage early in the breeding season: all had enough food to initiate breeding and lay eggs, and G had enough food to make three breeding attempts in 1997. The time and energy used in Duelling appeared to relate to failure or disadvantage later in the breeding attempt. Females could leave, or territorial borders could change at important food sources used later in the nestling or post-fledging stages. That is, each male tried to maintain a territory border that enhanced the remainder of the breeding attempt. The male described by Olsen & Trost (1997) (W) appeared to lead his fledglings to feeding areas and day-roosts close to the nest of G (an intruding male with a newly hatched nestling), the site of considerable Duelling early in the season. At the time we interpreted this as defence of a food source; however, our impression since then was that Duelling of males W and R against G related to G’s placement of a nest against their common border. That is, W kept his fledglings with him during this dispute, close to G’s nest but away from his own nest, because W’s mate had deserted, as females commonly do in the fledgling period (see Olsen & Trost 1997, 2003), and he balanced costs of caring for his fledglings versus maintaining this border. In subsequent years, after the dispute finished, he did not lead his fledglings to this place.

Females

Females usually took no part in Duels, either because they were incubating or brooding, or because they were not present. However, they witnessed or heard most Duels, so the intensity and purpose of the ritual could be related to females. Perhaps males did not break off Duels because this would represent a ‘back-down’ to females looking on, or listening from inside hollows, and might increase the chance of a female leaving. Female raptors move territories more often than males do (Newton 1979), and Boobooks are no exception (Olsen & Trost unpubl. data). When a pair placed its nest against a neighbour’s border, Duelling increased; that is, there was more Duelling after the nest was occupied, and there was no Duelling against F from G or W when F occupied a small territory in 2002–03 without a female.

The increase in Duelling in 2004 was linked to a road, which cut through the territories of five pairs of Boobooks and had involved the felling of many trees used for foraging. Three pairs disappeared; two remained and bred, but spread their foraging over the new expanded territories. Only one nest-tree of 11 used by the five pairs disappeared; that is, the loss of three pairs appeared to relate to the loss of trees used for foraging (see Olsen et al. 2006), not to lost nest-trees. Duelling at Caswell Drive and Frith Road seemed to occur after the abandonment of certain territories; that is, the proximate cause of Duelling seemed to be related to changes
in borders, not shortage of food. However, shortage of food probably resulted from destruction of trees, and this may have changed borders in the first place.

Conclusion

Future research could explore the possibility that Duelling has two related functions: (1) to guard and maintain territory borders and food supply over the long term, and (2) to attract quality females. Males appeared to compete for females (Olsen 1994) by holding a quality territory with a good food supply, nest, and roost-trees, the opposite of what has been previously suggested by Olsen & Olsen (1987). Olsen & Cockburn (1991) linked female–female competition for high-quality males with female-biased sex ratios among nestlings. However, Krackow (1993) argued that the \( \chi^2 \) values given by Olsen & Cockburn (1991) were incorrect, and that broods of raptors do not necessarily show female sex-bias. Furthermore, Kruger (2005) investigated correlates of reversed sexual dimorphism in raptors, and, referring to Olsen & Olsen (1987) and Olsen & Cockburn (1991), found no evidence for female–female competition for males in raptors. He suggested that raptors show female choice and male–male competition for access to females. We suggest here that male Southern Boobooks may successfully Duel with neighbouring males in the presence of females, and this outcome increases the likelihood of quality females remaining for that breeding attempt, and for breeding attempts in subsequent years. Female raptors with reversed sexual dimorphism tend to hunt close to the nest where they can also defend young, whereas males hunt farther from the nest and defend territory borders (see Olsen 1994; Olsen & Tucker 2003).

The Duelling that was characteristic of Southern Boobooks in this study has not been described for other species. This behaviour may separate Ninox from other genera, or separate the Southern Boobook from other Australian Ninox species, or Duelling may occur in other owl species but has yet to be described. Vocal behaviour described for the Christmas Island Hawk-Owl \( N. natalis \), a boobook-type owl, suggests Duelling (cf. Hill & Lill 1998; Higgins 1999), though it was not defined as such.

It has yet to be determined if a relationship between Duelling and nest failure holds with a larger sample of owls. Investigation of Duelling (or alleged Duetting) requires individually marked birds, to distinguish mates, rivals, and sex-roles of participating birds.

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