VOCA LISATIONS USED BY SOUTHERN BOOBOOKS (NINOX NOVAE-SEELANDIAE) IN THE AUSTRALIAN CAPITAL TERRITORY

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Three adjacent nesting territories of Southern Boobooks Ninox novaeseelandiae were studied from October 1996 to October 1999; six adults were colour-marked, four of them radio-tagged. Observations were made several nights per week from just before the birds left their day roost each evening until one hour after. During 529 observation nights, we attempted to identify ten vocalisations for adults: (1) boobook call, (2) single hoot, (3) por (croak), (4) squeal, (5) bray, (6) trill, (7) yelp, (8) growl, (9) scream, and (10) squeak, and seven vocalisations recorded on a commercial audio tape. Where possible, we determined the sex of the calling owls and counted the frequency per month of boobook, single hoot, por, squeal, and bray calls. Both sexes used most calls, though there were individual differences, and different authors may label the same calls differently. We classified the boobook calls as contact or territorial, and suggest that por calls may be two types of call, that the single hoot call in some descriptions was more likely the por call, and that males did not give the bray call, though both sexes gave a quieter ‘purr’ call. We investigated the relationship between the frequency of some of these calls and (1) moon phase, (2) moon visibility, (3) temperature, (4) cloud cover, (5) wind speed, (6) wind direction, (7) rain, and (8) season, and found that most of the variation in frequency of calling in different months was related to (1) season, (2) social context, and (3) individual differences. These findings differed from those of earlier studies.

INTRODUCTION

Much of what is known about the behaviour and status of Ninox species in Australia is inferred from their vocalisations and not based on observation of the owls. However, no detailed studies
have been done on vocalisations even in common species, such as the Southern Boobook *Ninox novaeseelandiae* (Higgins 1999). This paper is part of a long-term study of the behaviour and vocalisations of *N. novaeseelandiae*.

The Southern Boobook is the smallest of the nine owl species, five *Tyto* and four *Ninox*, that breed on mainland Australia (Schodde & Mason 1980; Hollands 1991; Higgins 1999). Fleay (1968), Schodde & Mason (1980), Hollands (1991), and Debus (1996, 1997) described vocalisations of this species in Australia, but none were from studies of colour-marked or radio-tagged owls. Imboden (1975) was the first to report on vocalisations from radio-tagged Southern Boobooks, in New Zealand. The significance of using marked birds is that the sex is known with certainty.

Here we report on 529 observation nights from 3 October 1996 to 22 October 1999 on three adjacent nesting territories of Southern Boobooks. We noted all vocalisations heard, categorised the vocalisations according to Higgins (1999), and attempted to identify the callers. Our aims were to: (1) document the frequency per month that males and females used the ten main vocalisations listed by Higgins (1999), and the seven call segments recorded by Buckingham & Jackson (1990); and (2) investigate the relationship between the frequency of Territorial and Contact Boobook calls (see below), Por calls, Bray calls, and ‘duelling’ (Olsen & Trost 1997), and seven weather and temporal variables in four seasons.

PREVIOUS STUDIES

Previous audio recordings of vocalisations of Southern Boobooks reveal a number of calls given by both sexes. For example, Buckingham & Jackson (1990) have seven audio-tape segments and list the calls, in order, as Duet, Higher-pitched call, Aggressive calling by two males, Call when disturbed, Churring calls and mating squeal, Falsetto call, and Food begging call from juvenile. These differ from descriptions of vocalisations in the literature, which often differ from one another. For example, Olsen & Trost (1997) described five vocalisations, Boobook, Croak, Bray, Single Hoot, and Trill, commonly heard during a study of colour-marked Southern Boobooks observed mainly during the nestling and post-fledging periods. Debus (1996, 1997), reported similar calls but heard females give Boobook and Croak calls, and males give Bray calls, while Olsen & Trost did not. Olsen & Trost also described ‘duelling’: neighbours calling with bouts of Boobook (and Por) calls overlapping. However, in contrast to Debus (1996, 1997), they heard no duetting. Higgins (1999) described the Single Hoot as a series of deep guttural calls used as a prelude to Boobook Calls, and as a response to the Boobook calls of rivals. In contrast, Olsen & Trost (1997) described the Single Hoot as predominantly an alarm call, given by males and females, especially in defence of fledged young. Fleay (1968), Debus (1996), and Olsen (1997) reported that females had deeper voices than males, but Stephenson (1998), in New Zealand, could not sex radio-tagged Southern Boobooks by call.

In the latest review, Higgins (1999) described ten main vocalisations given by adults of this species: (1) Boobook, (2) Single hoot, (3) Por call (Croak), (4) Squeal, (5) Bray, (6) Trill, (7) Yelp, (8) Growl, (9) Scream, and (10) Squeak.

Some observers have attempted to relate the frequency of certain calls to time of year, time of night, or weather conditions. Kavanagh & Peake (1993) used two survey techniques, a one-hour census followed by a 15 minute tape playback and spotlighting, to determine the distribution and detectability of seven nocturnal bird species. With Southern Boobooks, they found no seasonal
differences in detectability, but heard them 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 Southern 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. Calls given were usually the disyllabic hoot, sometimes preceded by low croaks. The Bray and Yelp calls were occasionally heard in autumn and winter. Calling declined from February through autumn to a low in winter then rose in late winter or spring. Southern Boobooks responded to playback throughout the winter, but activity was still lowest then, even when playback was used. Certain owls tended to call even during rain and moderate wind during the days or weeks pre-laying.

STUDY AREA

The owls we studied near Canberra ranged over all of the 80 ha Aranda Bushland, and the northwestern 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 (see map, Figure 1). Except for Mount Painter and the grazing land, the area is primarily open forest and tall woodland, with dominants of Scribbly Gum *Eucalyptus rossii*, Brittle Gum *E. mannifera*, Red Stringybark *E. macrorhyncha*, Blakely’s Red Gum *E. blakelyi*.

Fig. 1. Location of three Southern Boobook nests in Black Mountain Reserve and Aranda Bushland, Canberra, ACT in 1996 at the beginning of this study. Heavy line denotes territory borders between nests. Distance between Nest 1 and Nest 2 = 1080m; between Nest 2 and Nest 3 = 1140m; between Nest 1 and Nest 3 = 460m.
woodland with 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.

Aranda Bushland is bordered on the north by the suburb of Aranda, on the west by Bindubi Street, on the south by grazing land, and on the east by Caswell Drive, with woodland similar to Black Mountain Reserve. Wildfire has been largely absent and a regime of prescription burning 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 plants along roadsides, bushland corridors, and backyards. A common tree in all areas is the Native Cherry *Exocarpus cupressiformis*, which contains dense foliage that was favoured as daytime roosts by the owls.

**METHODS**

*Trapping, banding, and radio-telemetry*

We used wire bal-chatri traps (Olsen & Woollard 1975) baited with a House Mouse *Mus musculus*, a noose mounted on the end of a surf-casting rod, and fishing nets on extended poles, to trap adults and fledged young. All adults were sexed (Olsen & Trost 1997), fitted with a stainless steel, numbered Australian Bird and Bat Banding Scheme band, and a plastic colour-band sealed with super-glue (*n* = 6 adults). Some individuals removed the plastic colour-bands, so we banded them again with coloured aluminium bands attached with two rivets. Four of the adults had back-pack style Sirtrack single-stage 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 wt.) and on a 340 g female (1.9% of body wt.). Batteries lasted 10–12 months.

*Survey methods*

We located the nests (see Figure 1) in three adjacent nesting territories straddling Aranda Bushland and Black Mountain Reserve; the larger of the pair, by weight, that had a brood patch, was determined to be the female (Olsen & Trost 1997).

Over 529 nights, we noted all vocalisations heard in three territories and, where possible, identified the callers by triangulating the location of radio-tagged birds with a hand-held Sirtrack yagi-antenna and Telonics TR–4 receiver, and sighted colour-bands with a torch and binoculars. We concentrated our observations during the following time frames: **Territory 1** (colour-banded, not radio-tagged), 103 nights between 3 October 1996 and 24 September 1997; **Territory 2** (colour-banded, radio-tagged), 110 nights between 1 January 1999 and 22 October 1999; **Territory 3** (colour-banded, radio-tagged), 316 nights between 1 October 1997 and 31 December 1998. Because of common borders, we had observations and counted Territorial Boobook calls from all three pairs during each time frame, until the male disappeared from Territory 1. We also had observations of a fourth colour-banded male (in **Territory 4**, banded in 1993), when he and his fledglings moved close to the nest of Pair 2 in January 1999, and during his interactions with the female in Territory 2 from August to October 1999.

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 three pairs, then followed individuals after they left
the roost or nest as closely as possible without disturbing them. Olsen and Trost observed most intensively between August and February, the pre-breeding to post-fledging phases of breeding, while Hayes observed the pair in Territory 2 about once per week from 17 January 1999 to 17 July 1999.

**Dependent variables**

We divided Boobook calls into Territorial (louder, usually given from a high perch across the territory and often in long bouts up to one hour) or Contact (usually given facing and close to a mate or young, most often in short bouts of one to three calls). We also observed and counted 'duels', defined by Olsen et al. (2002) as two unmated owls from different territories, facing each other, up to 50 m apart and calling with Boobook or Por calls during overlapping bouts, but not in a co-ordinated or synchronised fashion. We scored each vocalisation as heard or not heard each night.

**Independent variables**

For each observation night, we obtained moon phase and moon visibility from the Australian Surveying & Land Information Group, Department of Industry Science Resources, Bruce, ACT, and weather data from the Canberra Meteorological Office (Station 70014, Canberra Airport). We used the weather data for that day measured as close as possible to one hour after sundown, when we did our observations, and checked these data for accuracy against weather we noted in the field each night. Weather data and seasons were categorised as follows, partly after Kavanagh & Peake (1993):

- **moon visibility**: one of two categories (visible; not visible).
- **moon phase**: one of four categories (1/4, 2/4, 3/4, 4/4), whichever was closest to the night of observation.
- **cloud cover**: corresponding to eighths of the sky covered, but for analysis reduced to three categories (clear 0–1; partly clouded 2–5; overcast 6–8).
- **rain**: recorded in mm, but classed in two categories (dry 0; wet >0).
- **wind speed**: in km/hr reduced to three categories modified from the Beaufort Scale adapted for use on land (equivalent Beaufort Scale in brackets): gentle 0 to 10 (0–3); moderate 11 to 21 (4–5); strong >21 (6+).
- **wind direction**: reduced to four categories: (W; N; E; S).
- **temperature**: in degrees Celsius: one of four categories (cold <9; mild 9–14; warm 15–21; hot >21).
- **season**: we divided the year into four categories based on the annual cycle of the owls: **non-breeding** – from when parents stop feeding young to pre-breeding (1 March – 14 August); **pre-breeding** – from when pairs begin roosting together near potential nests and copulating to egg-laying (15 August – 30 September); **breeding** – from egg-laying to fledging (1 October – 1 January); **post-fledging** – from fledging to when parents stop feeding young (1 January – 28 February).

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Table 1. Total number of observation nights by month, 3 October 1996 to 22 October 1999.
Data analysis

We calculated nightly frequency per month of Territorial Boobook, Contact Boobook, Single Hoot, Por (Croak), Mating Squeal and Bray calls (Figs. 2 & 3). Using a separate analysis for duels, and the most common vocalisations observed (Territorial Boobook, Contact Boobook, Por (Croak) and Bray), we employed chi-square analyses (Zar 1984) to test if weather and temporal conditions or season had an effect on the calling of owls. Where there was one degree of freedom, a Fisher’s Exact Test was used. In view of the large number of statistical tests involved, we used the Dunn-Sidak method (Sokal & Rohlf 1995) to correct for compounding Type I errors. Tests were carried out on data for the full year (Table 2) and, in order to eliminate seasonal effects, for the period in which calling was most common (September-December) (Table 4).

RESULTS

Territorial Boobook Calls. The two-note Territorial Boobook call has been likened to the call of the Common Cuckoo *Cuculus canorus* of Europe (Hollands 1991), which it superficially resembles. In this study Territorial Boobook calls were seasonal (Figs. 2a, b, c, d). Combining male, female and unidentified callers, we heard calling on 149 of 529 nights (28.2%). We saw females giving this call mainly when alone near the nest, and before egg-laying, and after nesting failure when females moved to a new nest location. They rarely called with males, but males commonly called on their own or in duels with other males (see Olsen *et al.* 2001). Around 3 July 1999, Female 2 left her breeding territory for a winter home range in a suburban street near Parliament House (7 km southeast of her nest). We did not hear her calling on this winter range, but she did commence calling on 25 August after she returned to her breeding territory.

We attempted, in three single blind trials of thirty minutes each, to sex individuals by ear in
Fig. 3. (a) Percent of observation nights per month that we heard Contact Boobook calls during 1996–99. Total nights heard = 124/529 observation nights (23.4%); all male, except both male and female on two nights, and female alone on one night. (b) Percent of observation nights per month that we heard Single Hoot calls during 1996–1999. Total nights heard = 18 of 529 observation nights (3.4%); male 6 nights, female 12 nights. (c) Percent of observation nights per month that we heard Croaking Boobook and Por calls during 1996–1999. Total nights heard = 39 of 529 observation nights (7.4%); males alone 32 nights, females alone six nights, unknown one night. (d) Percent of observation nights per month that we heard Mating Squeals during 1996–1999. Total nights heard = 12 of 529 observation nights (2.3%); all, we believed, given by females. (e) Percent of observation nights per month that we heard Bray calls during 1996–1999. Total nights heard = 119 of 529 observation nights (22.5%); all, we believed, given by females.
Table 2. Calling behaviour of Southern Boobooks in relation to weather and season across 529 observation nights. Levels of significance of variation in calling behaviour are indicated by: ** $P < 0.001$. Data for each call type represents the number of nights in which owls were heard. $n$ represents the total number of nights in which owls were surveyed. Contingency chi-square analyses and Fisher’s Exact Tests used where appropriate. Dunn-Sidak method used to correct for compounding Type I errors.

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all three territories, and then confirmed the sex of the caller with radio-telemetry and colour-band. We could not reliably separate males from females, except in Territory 2 where the male had a particularly deep and loud voice compared with the female and with the males in Territories 3 and 4. However, the same male in Territory 2 occasionally gave a higher pitched series of Boobook calls that we could not distinguish from those of his mate, or from the males’ calls in Territories 3 and 4.

**Contact Boobook Calls.** Contact Boobook calls followed a similar seasonal pattern to Territorial Boobook calls, but finished and started earlier in the year (Fig. 3a).

**Single Hoot.** This call sounded something like the first note, accentuated, of a Boobook call. Owls used the Single Hoot call most commonly after young fledged, so it was heard more often in December and January (Fig. 3b). Females used it when young first fledged, then males used it after parenting responsibilities transferred to them (Olsen & Trost 1997). In contrast, one female in late January 2000 (not included in Fig. 3b) after the male took over parenting, did not defend or feed the fledgling, as normal, though the fledgling sought her out each morning and roosted with her for the day. This female gave a series of Single Hoot calls if we approached her at her roost, or followed her after she left her roost, but ignored us if we approached her fledgling after it left the roost.

**Por (Croak).** Following previous authors, we have combined these two lower pitched calls (Fig. 3c), even though they are distinguishable. Por calls are single notes repeated; they are not uttered in two-note (disyllabic) segments. They contrast with low pitched ‘Croaking Boobook calls’ that, like other Boobook calls, are uttered in two-note segments. As with Boobook calls, Por (Croak) calls were seasonal.

**Mating Squeal.** Mating squeals (Fig. 3d) sounded like the squeal given by a European Rabbit *Oryctolagus cuniculus*, and lasted 2–3 seconds, as on the Buckingham & Jackson (1990) tape. They were given as copulation finished, probably by females, but we could not confirm this. Figure 3d may not represent normal frequencies for the species near Canberra, because Pair 3 failed twice in 1997 and copulated before each re-laying into December. Also, we began intensive observations of Pair 2 in 1999 and this female fledged young later each year, 1993–99, than the other females we observed.

**Bray.** Females gave a food-begging Bray call (Fig. 3e) that was like a deeper version of the Trill call given by nestlings, but both sexes also gave a softer Purr call (see Trill and Growl below).

**Trill and Growl.** On ten occasions in December – January, we heard calls given by adults of both sexes that we termed Purr. These were contact calls given mainly to their young, like quieter, subdued Bray calls, and could be confused with the Bray, Trill, or Growl calls described by Higgins (1999). Bray calls, given by females, were more ‘whiney’, as if given with an open beak, while Purr calls, given by both sexes, were even and more subdued, as if given with a closed beak.

Nestlings and fledglings used the cricket-like Trill call (food begging). Fledglings often called in this way for the entire one hour observation, and often while flying from perch to perch. On three occasions we saw neighbouring fledglings cross territorial borders, and territory owners did not drive them off or feed them, even though the fledglings begged for food. Adults seemed to recognise their own fledged young.

**Yelp (yeo).** Although we heard this call in an earlier study on these territories (Olsen & Trost 1997), the female that gave this call disappeared and we have not heard it subsequently.

**Scream.** Not heard.

**Squeak.** This was heard only once. The function was not clear.
Chitter. We heard on three occasions a ‘chitter’ call (Olsen & Trost 1997) that occurred just before mating squeals, or when an owl fought with, or was displaced from a perch by, a fledgling or adult.

Weather and temporal variables

Although we found significant effects of temperature on Territorial Boobook calls and of season on all calling categories (Table 2), the effects of temperature disappeared when we limited the analysis to the four months, September – December, when Territorial Boobook calling was most common (Figure 2a; Table 4). This differed from the findings of Kavanagh & Peake (1993) and Debus (1997) (Table 3).

Social context and individual differences

Social context and individual differences appeared to account for some of the variation in Territorial Boobook calling. Although we had to stand within 30 m of the owls to hear most types of vocalisations, we could hear Territorial Boobook calls up to one km away; one of us could walk to and identify the caller with a torch, so we scored these calls from all territories during each of the study’s three time frames (Table 5, Figs. 2b, 2c, 2d). The decrease in Territorial Boobook calling by males after 1 January 1998 reflected the end of a border dispute. From 1993, Pair 3 had nested further east each year, and ranged into Territory 2, and especially into Territory 1. The conflict continued until Male 1 disappeared around 1 January 1998 (Fig. 2c), though Female 1 remained.

In 1998 Male 3 moved into the nest tree vacated by Male 1, and reduced his Territorial Boobook calling. We observed him copulating with Female 1 at this tree, before Female 3 moved over the hill into this area. On 30 August and 1 September 1998, Females 1 and 3 called from high perches in the manner of singing males, and the two females duelled. On 1 September 1998, Female 3 apparently killed Female 1 and decapitated her; she carried the carcass from tree to tree for the 2.5 hours that we watched (Fig. 2c). From then, Pair 3 occupied the expanded territory and we saw no other adults there. From this new site, Female 3 continued to call during September-October 1998, as she had in October-December 1997 after each breeding failure and move to a new nest.
Table 4. Calling behaviour of Southern Boobooks in relation to weather and season in the four months when calling was heard close to 50% of nights – September to December. Data for each call type represents the number of nights in which owls were heard. n counts represents the total number of nights in which owls were surveyed. Contingency chi-square analyses and Fisher’s Exact Tests used where appropriate, Dunn-Sidak method used to correct for compounding Type I errors. None reached levels of significance of $P < 0.001$.

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<tr>
<td>Por (Croak)</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Bray</td>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td>Contact</td>
<td>37</td>
<td>6</td>
</tr>
</tbody>
</table>
The increase in female calling during August-October 1999 (Figure 2d, Table 5) was mainly from Female 2, after a pair not included in this study (Pair 4) nested closer (500 m) to Pair 2’s northern border. Since 1993, pair 4 had nested 850 m northwest of Pair 2. In 1998 we observed Male 4 with fledged young roosting 30 m from the Territory 2 nest; the previous Pair 4 nest was occupied by an unbanded pair. During August–October 1999, Female 2 called frequently from a high perch, facing Pair 4 on the border; Male 2 called little. Female 2 duelled twice with Male 4, on 25 August and 17 October. This was before Female 2, but after Female 4, had laid eggs.

DISCUSSION

Vocalisations heard

Territorial and Contact Boobook calls peaked during pre-breeding and breeding; the distribution of Contact Boobook calls was similar to Territorial Boobook calls though some earlier Contact Boobook calls, in July, we interpreted as pre-breeding behaviour. Like Stephenson (1998), we could not discriminate between male and female calls, although we would expect the males’ calls to be generally lower in pitch, as with most other owls (Marks et al. 1999), but with considerable individual variation.

This study observed one of the same females that Olsen & Trost (1997) watched (2), but with a different mate (moved from Male 3 to Male 2), on a different territory, in a different year, and from an earlier stage (before egg-laying) in the breeding cycle. She was not heard giving Boobook calls in the earlier study, but did give Boobook calls in the later one, before egg-laying. Season, more than individual differences, could explain why Olsen & Trost (1997) did not hear females give Boobook calls. Much of the variation in Territorial Boobook calls from year to year in these three territories could be explained by (i) season, (ii) individual differences, and (iii) social context (owls called more during border conflicts, and duelled with some neighbours but not others). That females engaged in territorial disputes, perched alone on exposed branches, and engaged in territorial singing with Boobook and Por calls, was surprising, particularly as this happened before egg-laying when we expected males to guard females.

We heard Single Hoots used mainly in defence of young, but never as a prelude to a series of Boobook calls, or as a response to Boobook calls of a rival, as suggested by Higgins (1999). The calls referred to by Higgins were more likely Por or Croaking Boobook calls, a softer, lower pitched call than the Single Hoot, uttered by males or females in a different context – to their mates, or when alone, often when starting a series of Territorial Boobook calls. The three calls

<table>
<thead>
<tr>
<th>Year of study</th>
<th>Sex and territory of identified calling owls</th>
<th>Total males</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>Total females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996–1997</td>
<td>10</td>
<td>8</td>
<td>29</td>
<td>47</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1997–1998</td>
<td>14</td>
<td>4</td>
<td>34</td>
<td>52</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1998–1999</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td>28</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Totals</td>
<td>24</td>
<td>19</td>
<td>84</td>
<td>127</td>
<td>2</td>
<td>18</td>
</tr>
</tbody>
</table>
probably require separate classifications (see below). Similarly, two calls, the Por (Croak) call and the Croaking Boobook call, were combined here. Further study of the structure and context of the Por and Croaking Boobook calls is necessary to determine whether they are different calls or variations of the same call.

We did not observe males giving the Bray call, as reported by Higgins (1999). We wonder how commonly males use this call, and if observers confuse the Bray call with the Purr call which we saw both adults use, or the Trill or Growl Calls. The Purr call was used in a different context (often to young) from the Bray call (often the adult female to the adult male). This may be individual variation, and analysis of recorded calls from identified males and females should help determine if Purr and Bray are one call or two.

In this study we did not hear adults give Scream, Yelp (yeo), Trill or Growl calls. We heard Squeak calls rarely, and these seemed to be situation specific. We heard a call we termed 'Chitter' that may be the Scream call identified by Higgins (1999).

The seven recordings by Buckingham & Jackson (1990) could serve as an auditory guide to most of the calls we heard, but we would reclassify them as follows (Buckingham & Jackson description in quotes, followed by our classification in italics): (i) 'Duet' – more likely a duel between adults giving Boobook calls, sexes unknown; (ii) ‘Higher-pitched call’ – an adult of unknown sex giving Boobook calls; (iii) ‘Aggressive calling by two males’ – Croaking (Por) calls (not Croaking Boobook), sexes unknown; (iv) 'Call when disturbed' – adult giving Bray calls (food-begging), probably a female; (v) 'Churring' calls and 'mating squeal' – one adult giving Boobook calls, one giving Croaking (Por) calls (not Croaking Boobook), then Mating Squeal (vi) ‘Falsetto call’ – adult giving Yeo calls, sex unknown; and (vii) 'Food begging trill from juvenile’ – Juvenile giving Trilling calls.

Weather and temporal variables

Although Territorial Boobook calling in this study varied with temperature, these variations disappeared when we controlled for season. We did not find variations in calling frequency with moon visibility or wind, as did Kavanagh & Peake (1993), or with rain or wind, as did Debus (1997).

In our study, because of the large number of statistical tests involved, we used the Dunn-Sidak method (Sokal and Rohlf 1995) to correct for compounding Type I errors. Also, we determined 'season' by dividing the year into four categories based on the annual breeding cycle of the owls in three territories, while Kavanagh & Peake (1993) observed seven species, including Southern Boobooks, and selected two periods in the year to census these species – winter/early spring, and late spring/summer. Finally, we observed the owls at close range, but Kavanagh & Peake (1993) and Debus (1997) mostly listened for the owls, sometimes at a distance. Although Debus (1997) found that rain and wind significantly depressed calling, certain owls in his study did call during rain and moderate wind in the pre-laying days or weeks. Owls in our study did not call significantly less often on rainy or windy nights, but moderate rain and wind might depress the detectability of calls to human listeners at a distance as much as depress the calling frequency itself. We would expect calling to stop during heavy rain or strong wind.

Evidence that the lunar cycle affects the calling behaviour of owls is inconsistent. For example, Ganey (1990) found that Spotted Owls Strix occidentalis called more than expected during the last quarter and new moon phases of the lunar cycle, but he summarised other studies that
claimed that Tawny Owls *Strix aluco* reduced their calling in moonlight, that Western Screech Owls *Otus kennicotti* were most responsive under a bright waxing moon, that Boreal Owls *Aegolius funereus* and Northern Saw-whet Owls *Aegolius acadicus* were most responsive to playback when the moon was full, and that moon phase had no effect on the response rates of Eastern Screech Owls *Otus asio*, or on the calling behaviour of Spotted Owls in some other studies. Populations may differ, but we also wonder about differences in experimental conditions, and the likelihood of statistical artefacts and confounding variables in such studies. Recent reviews, such as that by Gutiérrez *et al.* (1995), have dropped the claim that Spotted Owl calling is affected by lunar conditions, and a number of researchers to whom we have spoken question the validity of such claims.

**Conclusions**

Three variables seemed to explain much of the variation in the frequency of calling we observed, namely, season, social context and individual differences. We limited our observations to the period just before the owls left their roost or nest to one hour after. We make no claim that the same patterns would hold later in the night.

There is much yet to understand about the delimitation and purpose of these calls. Given the current state of knowledge, we do not believe that observers can reliably sex Southern Boobooks by territorial calling alone. Care must be taken if behaviour, territory size, and status of these owls are inferred solely from surveys of vocalisations.

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