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CALLING BEHAVIOR OF SPOTTED OWLS IN NORTHERN ARIZONA[1]

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Abstract. I studied the calling behavior of radio-tagged Mexican Spotted Owls (*Strix occidentalis lucida*) in northern Arizona. Owls used a variety of calls, with three call types (Four-note Location Call, Contact Call, and Bark Series) accounting for 86% of calling bouts heard. These calls were used by both sexes, but in significantly different proportions. Males ($n = 4$) called twice as frequently as females ($n = 3$), and there also appeared to be intrasexual differences in calling rates. Calling activity increased from March through May, then declined from June through November. Calling activity was highest during the 2-hr period following sunset, with smaller peaks 4–8 hr after sunset and just before sunrise. Calling bouts averaged 9.9 min in duration, and were significantly longer when other owls were calling. Owls called more than expected during the last quarter and new moon phases of the lunar cycle, and called most frequently on calm, clear nights when no precipitation was falling. The timing and nature of Spotted Owl calls suggests that calling behavior may be as important in intrapair communication as in territory advertisement. Differences in calling rates among owls suggest that not all owls will be equally detectable using calling surveys.

Key words: *Arizona; calling behavior; call types; Mexican Spotted Owl*; Strix occidentalis lucida.

INTRODUCTION

The Spotted Owl (*Strix occidentalis*) has been the object of considerable research in recent years, due to its dependence on old-growth coniferous forests throughout much of its range (Dawson et al. 1987). Researchers usually locate Spotted Owls using nocturnal calling surveys (Forsman 1983), yet little is known regarding factors influencing calling behavior of Spotted Owls. Furthermore, although Forsman et al. (1984) described the repertoire of the Northern subspecies (*S. o. caurina*), the repertoire of the California (*S. o. occidentalis*) and Mexican (*S. o. lucida*) subspecies have not been fully described. Here I describe the vocal repertoire of the Mexican Spotted Owl, temporal patterns in its calling behavior, and the influence of some environmental factors on its calling behavior.

METHODS

I collected data on calling behavior of Spotted Owls in conjunction with a telemetry study in northern Arizona (Ganey and Balda 1989). Seven adult owls (four males and three females) were tracked for approximately 1,000 hr on 190 nights between June 1986 and August 1987, with tracking periods covering all nocturnal hours. I was normally able to remain within 400 m of the owls during tracking periods, and so was able to hear most of their calls.

I used calling bouts as the sampling unit, rather than individual calls. It was difficult to define bouts using intercall timing, as in Farabaugh (1982), because call sequencing was highly irregular. Owls were often silent for 1- to 3-min periods during otherwise continuous periods of calling. Therefore, I arbitrarily considered a bout to be over when an owl was silent for ≥ 5 min.

I recorded the following information for each calling bout by the focal owl: owl identity, date, time, call type, bout duration, cloud cover, wind speed, moon phase, and identity of other owls calling simultaneously. I used vocal pitch to identify individuals when both members of pairs were calling simultaneously. Female calls were higher in pitch than those of males (Forsman et al. 1984, Ganey 1988). Call types followed Forsman et al. (1984). I assigned bouts dominated by one call type or variations on one call type to that call type; variable bouts were classified as Mixed Calls. Bout duration was the time in minutes from the first call given to the last call given within a bout, and did not include the 5-min period used to determine the end of a bout. Cloud cover was classed as 0–25%, 26–50%, 51–75%, or >75%. Wind speed was classed as no wind,

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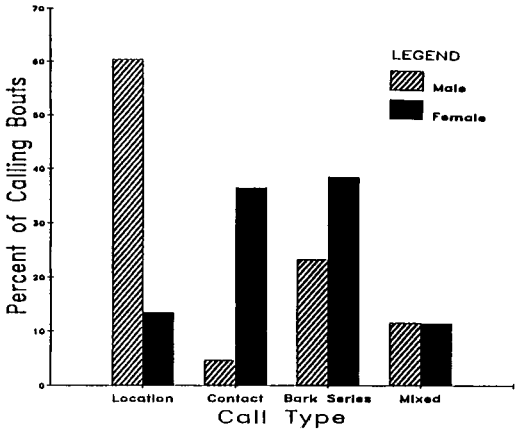

FIGURE 1. Proportions of major call types used by four male and three female Spotted Owls in northern Arizona.

0–8 km/hr, 8–16 km/hr, or >16 km/hr. Moon phase was split into four 7-day periods, centered around the calendar dates for new moon, first quarter, full moon, and last quarter (after Johnson et al. 1979). Categories for identity of other calling owls were: none, mate of the focal owl, or other owl besides the mate of the focal owl. In the latter case I recorded the species of the calling owl. All times were standardized to hours after sunset, and all calling rates were standardized to number of bouts per hour. I used nonparametric tests (Conover 1980) in all statistical analyses.

RESULTS

VOCAL REPERTOIRE

The vocal repertoire of the Mexican Spotted Owl consisted of a variety of hooting, barking, and whistling calls. Ten of the 14 call types described by Forsman et al. (1984) were heard in Arizona, including the Four-note Location Call, Agitated Location Call, Series Location Calls, Bark Series, Nest Call, Contact Call, Agitated Contact Call, Alarm Call, Cooing Calls, and the Juvenile Begging Call. The Wraak! Call, Chitter, and Male and Female Copulatory Calls were not heard, and only males were heard to give the Nest Call in Arizona.

Mexican Spotted Owls responded to tapes containing various Northern Spotted Owl calls, and a cursory examination of call structure (frequency and time characteristics) revealed a high degree of structural similarity between calls of these subspecies. Because calls heard in Arizona correspond closely to calls described and pictured in Forsman et al. (1984), these calls will not be further described here. The description by Forsman et al. (1984) of both the content and context of these calls is applicable to the Arizona population, except that females in Arizona appeared to use Contact Calls in long-range communication.

Three call types (Four-note Location Call, Bark Series, and Contact Call) accounted for 86% of the calling bouts in Arizona. These calls were used by both sexes, but in significantly different proportions (Fig. 1; $\chi^2 = 39.1$, df = 3, $P < 0.001$, $n = 142$).

CALLING RATES OF INDIVIDUALS

Differences between calling rates of four males ($\bar{x} = 0.23$ bouts/hr) and three females ($\bar{x} = 0.12$ bouts/hr) approached statistical significance (Mann-Whitney $U = 22.0$, $P = 0.052$). There also appeared to be individual differences in calling rates within sex (Fig. 2), but the low number of owls per sex did not justify statistical analysis.

TIMING OF CALLING BOUTS

Owls were heard calling in all months except December through February. Calling activity increased from March through May, then declined from June through November (Fig. 3). Males and females did not differ significantly in seasonal calling activity ($\chi^2 = 6.2$, df = 8, $P = 0.62$, $n = 142$), although nesting females were relatively silent during April and early May.

Owls were heard calling during all hours of the night, but were most vocal in the 2-hr period following sunset (Fig. 4). There were smaller peaks in calling activity from 4-8 hr postsunset and just before dawn. Nightly timing of calling activity was not significantly different between males and females ($\chi^2 = 3.6$, df = 5, $P = 0.46$, $n = 142$).

BOUT DURATION

Calling bouts averaged 9.9 min in duration (SE = 1.34, $n = 142$). Seventy-five percent of all bouts lasted <10 min; 89% lasted <20 min. Bout duration did not differ significantly between males and females (Kruskal-Wallis $\chi^2 = 1.82$, df = 1, $P = 0.18$), and was not significantly affected by month (Kruskal-Wallis $\chi^2 = 12.0$, df = 7, $P = 0.10$, $n = 133$; courtship vocalizations excluded from this analysis), time of night (Kruskal-Wallis $\chi^2 = 4.1$, df = 5, $P = 0.39$), or moon phase (Kruskal-Wallis $\chi^2 = 5.2$, df = 3, $P = 0.16$). Bout duration varied significantly with vocal activity of other owls (Kruskal-Wallis $\chi^2 = 12.87$, df =

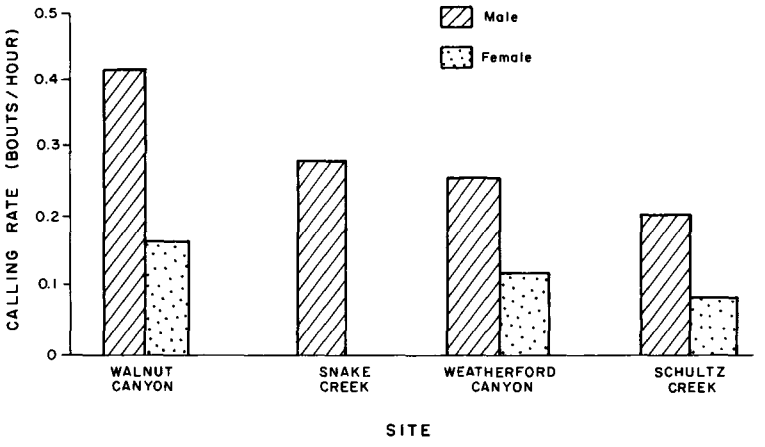

FIGURE 2. Calling rates of radio-tagged Spotted Owls at four sites in northern Arizona during the calling season (March–November). Only the male was radio-tagged at Snake Creek.

2, $P = 0.002$), averaging 4.3 min (SE = 0.65, range = 1–18 min, $n = 44$) when no other owls were calling, 11.7 min (SE = 2.26, range = 1–95 min, $n = 69$) when the focal owl's mate was also calling, and 14.1 min (SE = 3.32, range = 1–74 min, n = 29) when an owl which was not mated to the focal owl was calling. In most cases this other owl was a Spotted Owl from an adjacent territory or a Great Horned Owl (*Bubo virginianus*). Spotted Owls engaged in prolonged vocal exchanges with Great Horned Owls on several occasions.

LUNAR CYCLE

Frequency of calling activity was significantly related to moon phase ($\chi^2 = 47.3$, df = 3, $P < 0.001$, $n = 142$). Owls called more than expected during the last quarter and new moon phases, and less than expected during the first quarter and full moon phases (Fig. 5; expected values based on tracking periods during different moon phases). Calling by other owls may influence calling behavior of Spotted Owls, however (see above), and moon phase also influenced calling activity of other species of owls ($\chi^2 = 23.9$, df = 6, $P < 0.001$, $n = 29$). To control for this factor, I removed all observations involving calling activity of other owl species. The relationship between calling activity and moon phase was still significant ($\chi^2 = 46.0$, df = 3, $P < 0.001$, $n = 113$), and the pattern remained the same

INFLUENCE OF WEATHER CONDITIONS ON CALLING ACTIVITY

Spotted Owls called most frequently on calm, clear nights. Sixty-two percent of all calling bouts occurred when cloud cover was <25%, and 73% occurred when wind speed was <8 km/hr. Owls

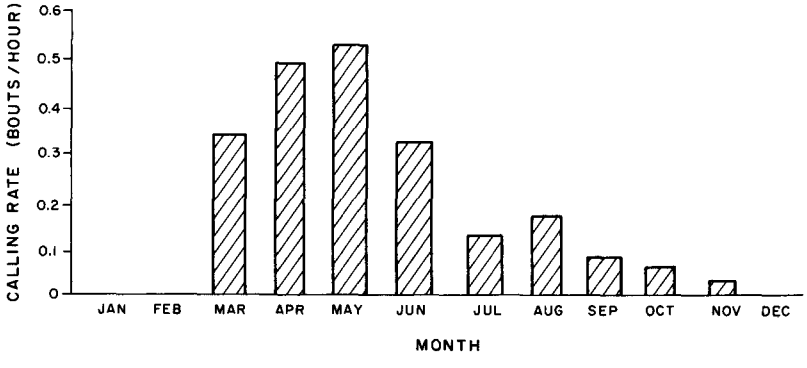

FIGURE 3. Monthly calling rates of radio-tagged Spotted Owls in northern Arizona.

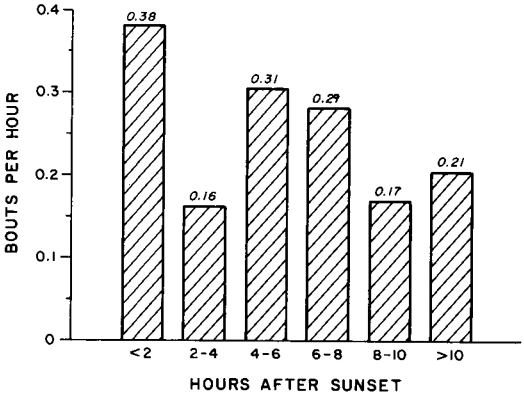

FIGURE 4. Calling rates of radio-tagged Spotted Owls in northern Arizona by 2-hr time periods. Only hours tracked during the calling season (March–November; n = 795 hr) were used to calculate calling rates.

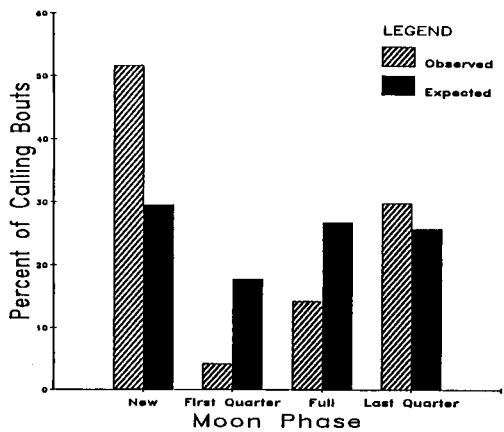

FIGURE 5. Calling activity of radio-tagged Spotted Owls in northern Arizona during different moon phases. Expected values based on proportion of tracking hours in different moon phases during the calling season (March–November).

seldom called during periods of precipitation. I did not keep complete data on changes in weather conditions, and was therefore unable to calculate relative availability of different weather conditions.

DISCUSSION

The similarity between calls used by Mexican and Northern Spotted Owls suggests that Spotted Owls use similar calls throughout their range. Although Mexican Spotted Owls used a variety of calls, three calls dominated their calling activity (Fig. 1). These calls were apparently also common in the repertoire of Northern Spotted Owls (Forsman et al. 1984).

Some owls appeared to be more vocal than others (Fig. 2). Laymon (1988) reported similar trends in California Spotted Owls, with males significantly more responsive than females, and some intrasexual differences as well. Whether such differences are due to individual variation or some quality of the site itself is unknown. Pair or breeding status can influence calling rates (Martin 1974, Forsman 1983, Bondrup-Nielsen 1984, Reynolds and Linkhart 1987, Laymon 1988), as can prey abundance (Lundberg 1980, Palmer 1987). Pair status did not explain the differences seen here, as all seven owls were mated. I cannot rule out the possibility that breeding status or prey abundance influenced relative calling rates. Regardless of the underlying reasons, the observed differences in calling rates suggest that nocturnal calling surveys may not be equally effective in locating all owls, and that females will generally be harder to locate than males.

Calling activity was highest during the nesting season (March–June; Fig. 3), and peaked during the nestling period (May). Lundberg (1980) suggested that a similar pattern in Ural Owls (*S. uralensis*) was partially due to calls accompanying frequent prey deliveries at this time. This did not explain the pattern observed here, because only one of the four pairs monitored bred successfully during the study.

Calling activity of Eastern Screech-Owls (*Otus asio*; Smith et al. 1987, Ritchison et al. 1988) and the Collared Scops-Owl (*O. bakkomoena*; Higuchi and Momore 1980) peaked in late summer and autumn. Lundberg (1980) suggested that increased calling activity in late summer and autumn might discourage dispersing young from attempting to settle in an occupied territory. Spotted Owl young did not disperse until September or later (Forsman et al. 1984), and adults also began to wander at that time in Arizona (Ganey and Balda 1989). Thus, calling activity was declining during the period of greatest movement within the population, suggesting that advertisement of territory occupancy was not the sole function of calling activity in Spotted Owls. This is also suggested by the fact that Forsman et al. (1984) noted only 17 territorial interactions between Spotted Owls in Oregon in 353 nights of observation. The significant effect of other owl activity on bout duration suggests that territory

advertisement is important, however. The prolonged vocal interchanges between Spotted and Great Horned owls may indicate some degree of interspecific territoriality between these species, although Great Horned Owls were heard calling within the home ranges of all radio-tagged Spotted Owls (Ganey 1988).

Calling may also be important as a means of intrapair communication in Spotted Owls. Spotted Owls were largely solitary from November through January (Forsman et al. 1984, Ganey 1988), and little calling activity occurred in Arizona during this period (Fig. 3). Both pair members called during 49% of the observed calling bouts in Arizona, even though pair members often foraged in different parts of the home range (pers. observ.). Mated owls often called to each other as they converged on day roosts from distant foraging areas, and sometimes called softly to each other within the roost. The primary calls used by Spotted Owls are audible at long distances (Forsman et al. 1984, pers. observ.), and could provide an effective means of communication across the large home ranges occupied by Spotted Owls (Forsman et al. 1984, Ganey and Balda 1989). This assumes that Spotted Owls are able to recognize individuals by their calls. However, this has not yet been tested.

Spotted Owls exhibited a definite cycle in calling activity throughout the night, with peak activity occurring just after sunset (Fig. 4). Calling activity was bimodal in the Ural Owl, with a peak shortly after sunset and one just before sunrise (Lundberg 1980). Bull et al. (1989) reported that Long-eared Owls (*Asio otus*) called most frequently within 2 hr of sunset. Palmer (1987) reported that Boreal (*Aegolius funereus*) and Northern Saw-whet (*A. acadicus*) owls began calling within 1 hr after sunset, and Tawny Owls (*S. aluco*) are also relatively vocal at dusk (Southern 1970). I frequently heard Flammulated Owls (*O. flammeolus*) and Northern Pygmy-Owls (*Glaucidium gnoma*) calling at dusk, suggesting that many species of owls are vocal at that time.

The effect of the lunar cycle on owl calling activity appears to vary among species. Hansen (1952) reported that moonlight reduced calling activity of Tawny Owls. In contrast, Western Screech-Owls (*O. kennicottii*) were most responsive on nights with a bright, waxing moon (Johnson et al. 1979), Boreal and Northern Saw-whet owls were most responsive when the moon was full (Palmer 1987), and moon phase had no effect on response rates of Eastern Screech-Owls (Carpenter 1987, Smith et al. 1987).

Spotted Owls in this study were most vocal during the last quarter and new moon phases (Fig. 5), while Franklin et al. (1986) and Laymon (1988) found no significant relationship between moon phase and Spotted Owl response to playback in California. Laymon compared the week surrounding the full moon to the rest of the month, however, while Franklin et al. (1986) apparently analyzed moon phase according to moon size or brightness rather than stage in the lunar cycle. Spotted Owls in this study appeared to respond more to stage of the lunar cycle than to moon size or brightness, and use of the above analyses would likely mask this pattern. In addition, results from Franklin et al. (1986) and Laymon (1988) were based on response to playback rather than spontaneous vocalization patterns. Thus, the apparent difference in response to moon phase observed here could be due to either differences in methodology or to actual differences in calling patterns among Spotted Owls in different areas.

Spotted Owls in Arizona called most frequently on calm, clear nights. This pattern was also observed in Spotted Owls in Oregon (Forsman 1983) and in Tawny Owls (Hansen 1952). Cloud cover did not significantly influence response rates of Boreal and Northern Saw-whet owls in Colorado or Eastern Screech-Owls in Connecticut, however (Palmer 1987, Smith et al. 1987), and neither cloud cover nor winds <25 km/hr influenced response rates of Eastern Screech-Owls in Wisconsin (Carpenter 1987).

Most studies of owl vocalizations have relied on responses to playback (Johnson et al. 1979, Franklin et al. 1986, Carpenter 1987, Palmer 1987, Smith et al. 1987, Laymon 1988, Ritchison et al. 1988). These studies may not identify natural rhythms in owl calling activity (but see Ritchison et al. 1988), but have the advantages that variation in environmental conditions can be partially controlled for, and that results are directly applicable to population surveys conducted using playback techniques. The significance of the patterns discussed here to population surveys of Spotted Owls is not entirely clear. My observations suggest that nocturnal calling surveys might be most effective during certain lunar phases and periods of the night, and may not be equally effective at locating all owls. Spotted Owl response to playback may differ from

natural calling patterns, however. Also, because sampling was opportunistic rather than systematic, there may be interactions among environmental factors that I was unable to account for. In light of the importance of calling surveys to Spotted Owl research and management, it would be desirable to further examine the patterns observed here through the use of controlled playback experiments. Such experiments might result in improvements in survey techniques, and could also be valuable in clarifying the function of various calls and the behavioral context in which they are used.

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