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INDIVIDUAL VARIATION IN THE ADVERTISING CALL OF MALE NORTHERN SAW-WHET OWLS

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Abstract.—Variation in a species' song could potentially be used in monitoring populations of secretive birds. I recorded advertising calls from five captive male Northern Saw-whet Owls (*Aegolius acadicus*) and used sonagraphic analysis to assess individuality in voice. All males were recorded several times on at least three different nights. The mean frequency of the sustained component of an individual's calls was highly distinctive; only two owls shared a similar mean call frequency. Internote interval and note length were not as individually distinctive; although these features varied significantly among males, there was as much or more variation among nights for the same male. I suggest that male Saw-whet Owls can be accurately identified using sonagraphic analysis of calls in combination with knowledge about the location of the singer.

VARIACIÓN INDIVIDUAL EN LAS LLAMADAS DE *AEGOLIUS ACADICUS*

Sinopsis.—La variación en la canción de una especie puede ser utilizada para monitorear poblaciones de aves de conducta secretiva. Grabé las llamadas de cinco individuos cautivos del búho *Aegolius acadicus* y utilicé un análisis sonográfico para detectar individualidad entre las voces. Todos los machos fueron grabados varias veces en al menos tres noches diferentes. La frecuencia promedio del componente sostenido de la llamada de individuos, resultó altamente distintiva; sólo dos individuos compartieron la frecuencia promedio de la llamada. El intérvalo internota y el largo de la nota no resultaron ser distintivos a nivel individual; aunque hubo variaron entre las aves estudiadas. Los machos de la especie estudiada pueden ser identificados utilizando una combinación de análisis sonográfico y conocimientos sobre el lugar de donde el individuo llama.

Surveys of vocalizing individuals may be useful for species that are hard to monitor visually, such as secretive or nocturnal species (McGregor and Byle 1992). This technique has proven successful in monitoring raptors, particularly owls, which tend to be widely dispersed and difficult to locate during daylight hours. During the spring, male owls can be enticed to vocalize in response to broadcast recordings of conspecifics (Lynch and Smith 1984, Mosher et al. 1990, Smith 1987), which increases their ease of detection for population surveys. For example, 13 of the 37 papers on field studies presented at the 1987 symposium on the Biology and Conservation of Northern Forest Owls (Nero et al. 1987) used vocal surveys to determine either location or breeding densities of owls. Thus vocal surveys have become a common means of detecting and monitoring owl populations.

Counts of owls heard singing in an area, especially on different nights, are subject to error. Due to relatively large home ranges found in most owl species and the potential for movement within and between nights by calling owls, it is difficult to assess whether calls heard separately from two nearby sites represent one or two males unless singing is simultaneous. In response to this dilemma, several authors have sonagraphically analyzed recorded vocalizations of males to search for distinctive features of calls that permit individual identification.

Individual variation in song has been noted in many passerine species (Falls 1982). Many non-passerines also exhibit sufficient distinctiveness in their vocalizations to allow individual classification (Cavanagh and Ritchison 1987, Dahlquist et al. 1990, Eakle et al. 1989, Gilbert et al. 1994, May 1994, McGregor and Byle 1992, Robisson et al. 1993). Galeotti and Pavan (1991) and Galeotti et al. (1993) have used sonagraphic analysis of vocalizations from different male Tawny (*Strix aluco*) and Pygmy (*Glaucidium passerinum*) Owls within their populations to identify individuals. Due to the owls' individually recognizable calls within and among nights, it was possible to monitor accurately both movements and breeding densities of owls without individual capture and radio tracking. As recording equipment and sound analysis software for personal computers are becoming readily accessible, individual identification by call may provide a valuable addition to auditory surveys and be used to supplement information gained from radio telemetry.

I recorded multiple bouts of calls over several consecutive nights from a captive population of Saw-whet Owls to determine whether there were distinctive characteristics within male calls that would permit individual identification.

METHODS

Study species.—Northern Saw-whet Owls are small, cavity-nesting, forest owls distributed widely over North America. Saw-whets tend to be secretive during the day, although when discovered on the roost site (usually in dense cover of cedars) they can be closely approached. Owls are most commonly detected through auditory surveys of calling males early in the breeding season (Cannings 1987, Cannings 1993, Swengel and Swengel 1986, Swengel and Swengel 1987), which ranges from February–May. For a detailed account on the breeding biology of the species see Cannings (1993).

Study location and recording.—I recorded five male owls over four nights from 3–7 Apr. 1992 at The Owl Foundation, St. Catharines, Ontario, Canada (McKeever 1987). Males typically sing a repeated tonal note (Bent 1938) termed the advertising call (Cannings 1993). Recordings of spontaneous advertising calls were made using a Sennheiser MKH816 shotgun microphone and a Sony Professional Walkman WMD6C tape recorder. Calls sometimes begin with a short series of notes lower in frequency and amplitude, and usually at an accelerated rate (introductory component), followed by louder notes with a greater internote spacing that can be sustained for several minutes (sustained component) (K. McKeever pers. comm., pers. obs.). For measurement purposes, I defined a bout of the advertising call as a series of notes that continued at regularly spaced intervals without a break in the pattern. Each new call bout usually began with an introductory component or was separated from the previous bout by at least 2–3 s (approximately 4 times the average internote interval).

I sampled multiple bouts for each individual over at least three of the four nights of recording (minimum of 7 and maximum of 48 bouts). I recorded males from 1400–0600 h with the majority of recordings (approx 70%) from 2000–0200 h. I attempted to obtain recordings from all males scattered throughout these time periods during each night to account for possible variation associated with time of night. Features of song that are individually maintained throughout the night increase the usefulness of this technique for individual identification, because time of recording would not need to be controlled for.

All males were housed in separate enclosures (19–55 m^2, McKeever 1987) with a minimum of approximately 3 m and maximum of 30 m between male enclosures. Because no enclosure housed more than a single male, individual identification was unequivocal. During most recordings, several owls were singing simultaneously. Thus, features of song I found to be individually specific are likely to be maintained even in response to interactions with other owls or broadcast song. The owls could be closely approached at night and all recordings were made within 1 to 5 m of the owl.

For analysis, I focused solely on the sustained component of the advertising call following the introductory component. I chose this component because (1) the introductory component does not always precede a calling bout, (2) the introductory component is variable within males (pers. obs.), and (3) the sustained component is most commonly used for surveying this species (Cannings 1987, Swengel and Swengel 1987). Within each calling bout, I randomly chose a single note and measured the length of the note and internote spacing to the nearest millisecond (Kay Elemetrics Sonagram 5500, 300Hz band pass) as well as the frequency of the note in Hz (59 Hz band pass). Internote interval was defined as the time from the start of the note to the start of the next note.

Statistical analysis.—In order to assess the overall variation among individuals, I subjected the three measures of call to single-factor ANOVAs. Because I had different numbers of bouts from each of the five owls, I randomly chose ten calls from each owl, three calls each from two of the nights and four from the remaining night, for analysis. One owl (D) was an exception, with only seven calls in total among the three nights.

For the four owls with at least five bouts of calling on three separate nights, I quantified the variation among and within individuals between nights with a Nested ANOVA. For owls that I had recorded more than five calling bouts on a given night, I used measurements from the first five recordings of the evening. I tested each variable (frequency, note length, and internote interval) separately, with day nested within individual as the classifying variables. All statistical analysis was performed on JMP for Macintosh (SAS Institute Inc.) and P values were sequentially Bonferoni corrected (Rice 1989).

RESULTS

Single-factor ANOVA.—There were significant differences among males in the mean frequency of calls ($F_{4,42} = 141.8$, $P < 0.001$), the internote interval ($F_{4,41}$ = 8.04, P = 0.002), and the note length ($F_{4,42}$ = 3.763, P = 0.011) (Table 1). Frequency of calls (R^2 = 0.93) explained more of the variance among males than either internote interval (R^2 = 0.44) or note length (R^2 = 0.26).

Post-hoc multiway comparisons revealed a high degree of individuality in mean frequency of calls. Birds A, C, and E were significantly different in the mean frequency of their calls from each other and from birds B and D (Tukey-Kramer HSD) (Table 1). Birds B and D, however, did not differ significantly from each other. Such distinctions were not as clear in multiway comparisons of the birds for internote interval or note length.

Nested ANOVA.—The high degree of individuality in frequency of the call is maintained between nights by individual owls. Among the four owls with multiple calling bouts from three nights, 86.4% of the total variation in frequency was attributed to between individuals, while only 2.8% was attributable to between nights within individual (Nested ANOVA: $F_{individual}$ = 53.4, F_{day} = 2.3, $P_{individual} < 0.001$, P_{day} = 0.11). However, there was significant variation between nights within owls for both note length (28% of total variance) and internote interval (49%), accounting for as much or more of the variation as between individuals (note length—32%, internote interval—1%), leaving these variables of the call less reliable for individual classification (internote interval, $F_{individual}$ = 1.05, F_{day} = 5.89, $P_{individual}$ = 0.42, P_{day} = 0.0015; note length, $F_{individual}$ = 3.67, F_{day} = 4.46, $P_{individual}$ = 0.12, P_{day} = 0.0017).

DISCUSSION

The sustained component of the advertising calls of five male Saw-whet Owls were individually distinctive. Mean frequency of the call represents the greatest amount of the total variation among individuals of the three measured variables. Internote interval and note length of the call were more variable between nights for the same individual than between individuals and, thus, are less helpful in discriminating among males. This variability in note length and internote interval is probably not an artifact of recording distance, since all birds were recorded at less than 5 m. The variability in two of the three call measurements between nights for the same individual does suggest that future studies looking for distinctive features of calls should concentrate on collecting recordings from the same bird over a number of occasions. While variability in internote and note length may have some as yet unknown importance for other aspects of communication, for example interactive signalling (McGregor et al. 1992), only those features of the advertisement call that are invariant will be useful in surveying individuals.

Frequency of calls did not appear to be influenced by simultaneous singing of other males. Throughout the period that I recorded the owls, at least two and up to four owls could be heard singing from nearby enclosures. The low variance in frequency of the call that I found suggests that males do not adjust frequency to match calls of other males, as found in some passerines (Morton and Young 1986, Otter et al. 1994). Because

TABLE 1. Among-individual differences in the frequency, internote interval, and note length of Advertising Calls in five captive male Saw-whet Owls. Initial comparisons are single-factor ANOVA with post-hoc pairwise comparisons using Tukey-Kramer HSD tests. In Tukey-Kramer comparisons, brackets group those owls (represented by letters A–E) that are significantly distinct from other owls for the variable measured. Means ± SE are presented. *P*-values are Sequentially Bonferoni corrected (Rice 1989).

	Owl							
Variable	A	B	C	D	E	*F*	*P*	Tukey-Kramer
Frequency (Hz)	1210 ± 7	1020 ± 7	1089 ± 7	1007 ± 8	1155 ± 7	141.8	0.00003	(A) (E) (C) (BD)
Internote interval (s)	0.50 ± 0.01	0.51 ± 0.01	0.44 ± 0.01	0.55 ± 0.02	0.46 ± 0.01	8.04	0.0002	(DBA) (BAE) (EC)
Note length (s)	0.11 ± 0.005	0.12 ± 0.005	0.10 ± 0.005	0.13 ± 0.006	0.12 ± 0.005	3.76	0.01	(DEB) (EBAC)

frequency did vary during periods when males could have been engaged in vocal interactions, use of this measure to distinguish owls should be robust even when calls are initiated with playbacks.

By tape recording males during auditory surveys and later analysing frequency with computer software, such as Canary (Cornell Laboratory of Ornithology), researchers can use a combination of location of the singer and frequency of the call to identify individuals. If only frequency measurements are required, the time taken to analyze calls is short. Comparing frequency of calls over several surveys will give researchers greater confidence of tracking individual males. There are, however, limitations to this technique. When densities of owls increase in local areas (Swengel and Swengel 1987), the chance that two neighboring owls will overlap in the mean frequency of the call will also increase. The five males recorded in this study sang over a total range of 200 Hz. Although each male's calls varied on average by only 20 Hz among nights, the ability to use a single measure to distinguish individuals will diminish as the number of individuals monitored increases (May 1994).

Even if overlap among a few individuals in neighboring areas does occur, the high stereotypy of the mean frequency of the calls that I measured among the five owls would permit fairly accurate monitoring of a majority of the owls in an area. This technique will give greater confidence of owl densities than surveys which merely count singing males. The ability to track specific males may yield some insight into territory use, and even the breeding biology of this species. For example, as calling diminishes with pairing and completion of clutches (Cannings 1993), it would be possible to measure among males the time required to attract mates, potentially giving an indication of female availability.

Currently, radio telemetry remains the best method for assessing the territorial and breeding behavior of owl species. Monitoring individuals by calls is limited to periods when males are vocal, and is also limited to monitoring the behavior of males only. While auditory monitoring may not be as effective as radio telemetry, it does have some advantages that make it a valuable addition to research techniques on difficult to observe species. This technique is not costly (simple recording equipment is sufficient to obtain recordings of frequency features) and does not require capture and handling of the individuals, which may not always be possible or desirable on large numbers of owls. By recording calls produced over several nights in neighboring areas and comparing the mean frequency with calls recorded previously it may be possible to assign calls to individual males, particularly with males that call at very distinctive frequencies. In this regard, information on territory size and use can be gathered on additional individuals, potentially supplementing data collected from capture and radio tracking (Galeotti et al. 1993).

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