UTILITY OF ACOUSTIC LOCATION TECHNOLOGY FOR STUDYING AVIAN DAWN CHORUSES: SOCIAL DYNAMICS OF MALE BLACK-CAPPED CHICKADEES

Jennifer Foote[1], Daniel Mennill[2], and Laurene Ratcliffe[1]
[1]Dept. of Biology, Queen's University, Ontario, Canada, K7L 3N6 footej@biology.queensu.ca; ratcliff@biology.queensu.ca
[2]Dept. of Biological Sciences, University of Windsor, Ontario, Canada, N9B 3P4 dmennill@uwindsor.ca

1. INTRODUCTION

Beginning before sunrise, males of many songbird species participate in a distinct chorus characterized by high song rates and simultaneous singing by all males. Despite widespread occurrence, the function of chorusing is not well understood. Adjustment of social relationships among territorial neighbours by interactive communication has been proposed to be the most likely function of chorusing (Staicer et al. 1996). The social dynamics hypothesis predicts that social relationships among males will be reflected in their dawn chorusing interactions.

Recently developed acoustic location systems (ALS or microphone arrays) can be used to locate singers in space and time and monitor the content of vocal interactions of multiple individuals (McGregor et al. 1996). Prior to ALSs, it was difficult to record multiple individuals in the field and as a result, the social dynamics hypothesis has remained largely untested. We used a 16 microphone ALS to simultaneously record dawn choruses in four areas up to 160,000m^2. Because a considerable amount of song and background noise occurs during the dawn chorus, we tested whether black-capped chickadee (*Poecile atricapillus*) choruses could be reconstructed from multi-channel ALS recordings. If choruses are successfully reconstructed then acoustic location can be used to examine content and function of male dawn choruses.

2. METHOD

2.1 Field Methods

We monitored an individually colour-marked population of black-capped chickadees at Queen's University Biology Station near Chaffey's Locks, Ontario (44°34'N, 76°19'W) from January – June 2005. We tabulated pairwise dominance interactions at feeding stations in order to determine each bird's position in its winter flock hierarchy as described by Otter et al. (1993).

Once birds began defending individual territories in early spring we monitored territory boundaries and nesting stages of pairs. From 3-8 May we recorded the dawn chorus in four different regions of continuous chickadee habitat using a 16 microphone ALS. Microphones were placed ≥ 50 m apart throughout male territories where topography and vegetation were suitable and were connected to a central computer using 2200m of cable. A multi-channel data acquisition card was used to digitize microphone input. While recording, three observers walked through the recorded area describing male positions and identifications. GPS coordinates of microphones and nests were taken using a Trimble GPS system.

2.2 Recording Analysis and Localization

We used Syrinx PC (John Burt, Seattle, Washington) to browse the 16 channel recordings. Using the time and frequency cursors we selected all songs of all males recorded during the chorus. We then used MATLAB (Mathworks Inc, Natick, MA) to localize every 20th song of each male. When a song was overlapped by song of another chickadee or species, the previous/next closest non-overlapped song was located instead. As black-capped chickadees do not move often at dawn (Otter and Ratcliffe 1993) this sampling effort is sufficient to determine all male positions during the chorus. When males made large movements, additional locations were estimated to determine the path of movement. For a detailed description of the MATLAB cross-correlation and location estimate components of the localization process, as well as accuracy of this system, see Mennill et al. (2006). The end of each dawn chorus was defined as the point when the second last male stopped singing and only one male remained.

3. RESULTS

The four arrays recorded complete dawn choruses for 26 males (Table 1). One male was on the edge of two arrays and was recorded twice.

Table 1. Duration and content of 4 chickadee dawn choruses recorded in array configurations 1-4 in 2005

Array	1	2	3	4
Date	3 May	4 May	7 May	8 May
Duration (min)	41	51	54	50
# of males	6	5	10	6
# of songs	2723	2893	4859	2821
# of localizations	177	189	324	223

All songs could be assigned to a territorial male based on location; locations matched those described while recording. Therefore, the time and location of each song in the dawn chorus of these males was successfully extracted from the multi-channel recordings. Chorus end time varied from 41-54 minutes after the first song of the morning. Fig. 1 shows the dawn chorus positions of 2 neighbouring males during the first 30 minutest after the chorus began.

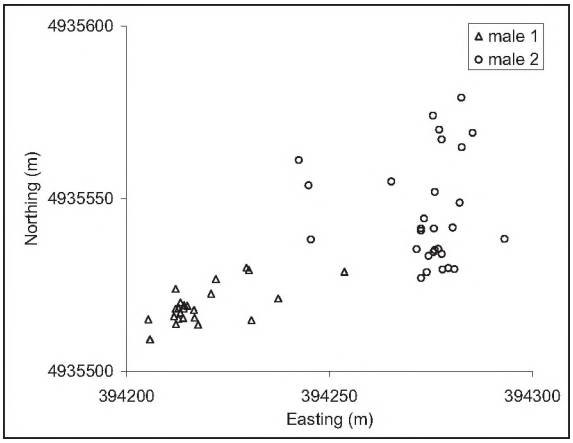

Fig. 1. Positions of 2 males in a 100m X 100m area during the first 30 minutes of the dawn chorus. Male locations are represented by symbols.

4. DISCUSSION

We used acoustic location to simultaneously record 5-10 male chickadees during each dawn chorus. Despite the quantity of sound recorded during dawn choruses, songs of males could be successfully localized to known male singing areas. This technology will be particularly useful for determining if male songbirds are: 1) involved in intra-sexual countersinging interactions at dawn as predicted by the social dynamics hypothesis; or 2) singing individually, for example, for mate advertisement purposes (Staicer et al. 1996), as inferred from close proximity to female nests (Otter et al. 1993). Acoustic location systems are unique because they allow analysis of real-time dawn chorusing interactions, which were previously difficult to study. Using ALS, Burt and Vehrencamp (2005) found that in a tropical species (*Thryothorus pleurostictus*), males song-type match at dawn. We predict that temperate passerines interact in similar ways during the dawn chorus.

Black-capped chickadees present an ideal species with which to investigate the social dynamics hypothesis as they have been well-studied with respect to winter flock and dominance behaviours. Both daytime singing interactions and individual dawn choruses have also been characterized. Once breeding territories are established, pairs are frequently involved in boundary disputes (Smith 1991). Thus status-related signalling differences are probably detectable in naturally occurring vocal-interactions of territory holders.

Black-capped chickadees can vary the frequency at which they sing their single song type continuously within an 860 Hz range (Horn et al. 1992). Frequency matching is used in daytime interaction (Mennill and Ratcliffe 2004) and would, therefore, be a good interaction measure to look for during the dawn chorus. From our ALS recordings we will determine if males interact at dawn using frequency matching and whether interactions reflect male social dynamics. Now that chorus songs have been localized and males have been identified, the frequency of all songs recorded can be measured using SYRINX. Because the ALS records time of each song, songs of neighbouring male can be compared to determine if they frequency match and how frequently matching occurs. We hope that this analysis will contribute to a greater understanding of the function of avian dawn choruses.

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