

Does Light Intensity Influence Song Output by Northern Mockingbirds?

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Introduction

The dawn chorus of bird song is widely recognized (at least among early-rising humans). Various mechanistic and functional hypotheses have been proposed to explain why individual birds might have a distinctive burst of song at particular times of day (Staicer et al. 1996). Nonetheless, the study of diel patterns in song has received much less attention than studies of song repertoire and song learning: we know much more about what birds sing than about how much birds sing or what time of day they sing. Quantitative documentation of patterns of song output remains unusual (Møller 1991; Amrhein et al. 2004), and only occasionally do studies link external cues or anatomical features with daily singing rhythms (Allard 1930; Leopold and Enyon 1961; Brown 1963; Thomas et al. 2002). Here we measure an index of song output from a single species and focus on light intensity as a possible mechanism influencing the quantity of song at three times of day.

During the breeding season, one can hear Northern Mockingbirds (*Mimus polyglottos*) sing, starting 0.5 to 1 hour before sunrise and continuing throughout the day. Merritt (1985) monitored the occurrence of song by marked individual Northern Mockingbirds in a Florida population between 6 May and 17 June. Song occurrences of unmated males peaked between 06:00 and 08:00, with song noted in 88% of the 2-minute intervals in that time window, and declined throughout the day, while mated males sang less frequently than unmated males but at a more steady rate (song noted in between 15% and 30% of 2-minute samples in each 2-hour block from 06:00–20:00) (Merritt 1985). Mockingbirds are well known for singing nocturnally, especially unmated males (Merritt 1985) and especially on nights near the full moon (Allard 1930; Derrickson and Breitwisch 1992). Derrickson and Breitwisch (1992) also suggested that nocturnal song is promoted by artificial light. Further support for a possible link between mockingbird song and light intensity comes from a recent study that found that mockingbirds singing at night orient towards light sources (Miskell and Justice 2001). In this study we measure light intensity and song output at dawn, dusk and in the middle of the day in a breeding population of Northern Mockingbirds.

Methods

We studied Northern Mockingbirds on a 110 ha. college campus in Conway, SC. All field observations were conducted between 7 and 20 April 2004. At the time of this study, approximately 15% of the mockingbirds on the site had been mist-netted and fitted with a unique combination of leg bands including an aluminum USFWS band and three colored plastic bands. Nine territories containing banded mockingbirds had recently been delineated by following banded birds and observing movements, interactions with neighbors, singing and agonistic behavior. Observations over the preceding four years have shown that mated pairs of mockingbirds at the site are usually nestbuilding, incubating or tending nestlings at their first nest of the year in mid-April (CEH, pers. obs.), and mockingbird song is frequent in the population at this time.

We were able to choose six sites that were separated from each other by enough distance that no singing bird could be heard from more than one site. Because of the relative constancy of the territory sizes measured, and because a previous study in similar habitat had also found relatively homogeneous territory sizes (Merritt 1985, p 27), we inferred that each of these sites was within earshot of two to four mockingbird territories. Thus our observations from all six sites sampled an unknown number of territories, but probably 12 to 24. We visited each site six times at dawn (defined for this study as the period from 0.5 hour before to 0.5 hour after sunrise), six times at midday (from 1.5 hours before to 1.5 hours after solar noon), and five times at dusk (0.5 hour before to 0.5 hour after sunset). To reduce bias from different observers' ability to detect song, and to prevent any effect of sampling one site first on each day, we set a schedule whereby three observers (KC, RG, JW) visited each site twice each per time period, and whereby the order in which the sites were visited was systematically rotated. During each site visit, we recorded the time of the observation, measured ambient light intensity as mW/cm^2 with a handheld light meter (Texas Instruments CBL system), and used a stopwatch to time the proportion of a 7–10 min. stay during which we could hear at least one mockingbird singing.

The proportion of time we could hear singing is thus an aggregate measure of song output: population song output rather than individual song output. By choosing this measure, we were able to monitor more individuals quickly, but we recognize that different individuals may be responding to different cues for different reasons, and we might not be able to tease out sources of variation that varied by individual (for example, different singing rates in mated and unmated males: Merritt 1985). Our measure of population song output also probably does not change linearly with total mockingbird song output. For example, one bird singing steadily would count by our measure the same as four birds singing equally steadily; four birds each singing 40% of the time could theoretically be counted as anything from 40% to 100% singing. We therefore refer to the proportion of time we heard singing as “song output index” or as “population song output” to emphasize

that the measure is a composite of the singing of several different birds at each site.

For statistical analyses we arcsine square root transformed the proportion of time with singing (Sokal and Rohlf 1995). We used analysis of variance to compare this song output index among dawn, midday and dusk periods, using the average song output at each site in each time period. We sought a relationship between light and song output index by conducting five sets of regressions, using all 102 observations with no averaging: song against light intensity for the entire data set, for each of the three sampling periods (dawn, midday, and dusk), and also for dawn and dusk combined, excluding midday. Because no previous study provided a basis for a clear prediction about the exact relationship of light level to song frequency, we conducted both linear and polynomial regressions to search for the best-fit model. For clarity, we show untransformed % time with singing in Figures 2 and 3.

Results

Light levels during the sampling periods varied over about two orders of magnitude, from 0.007 to 0.824 mW/cm² (Fig. 1). Light intensity during the midday observations varied only by about 12% (0.733–0.824 mW/cm²), but light intensity in dawn and dusk periods covered nearly the full range of brightness values we observed, from 0.007–0.669 mW/cm² (dawn) and 0.008–0.824 mW/cm² (dusk).

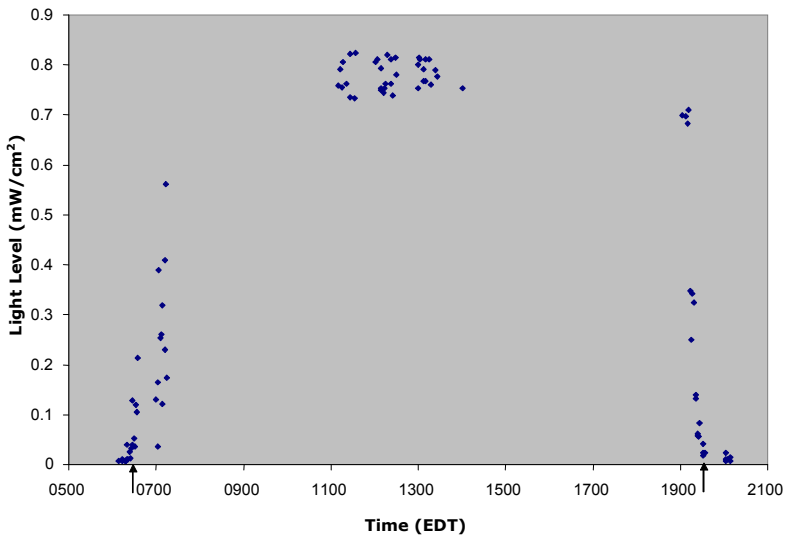


Figure 1. Changes in light level throughout the day. Times of sunrise and sunset on April 14 at Conway, SC are marked by arrows.

We observed a trend towards a decrease in song output index throughout the day (Fig. 2), but the trend was not statistically significant ($F_{(2,15)} = 1.1$, $P = 0.35$).

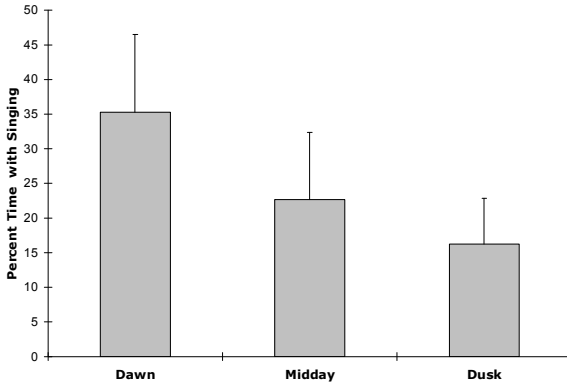


Figure 2. Song output by Northern Mockingbirds at three times of day (means and standard errors of percentage of time with singing).

Linear regressions showed no relationship between song output index and light for the entire dataset (Fig. 3; $r = -0.05$, d.f. = 100, $P = 0.59$). When we examined each time period individually and dawn and dusk together, we also found no linear relationship between light intensity and song output: dawn ($r = 0.11$, d.f. = 34, $P = 0.53$), midday ($r = -0.11$, d.f. = 34, $P = 0.53$), dusk ($r = -0.02$, d.f. = 28, $P = 0.94$), dawn and dusk together: ($r = 0.01$, d.f. = 64, $P = 0.91$).

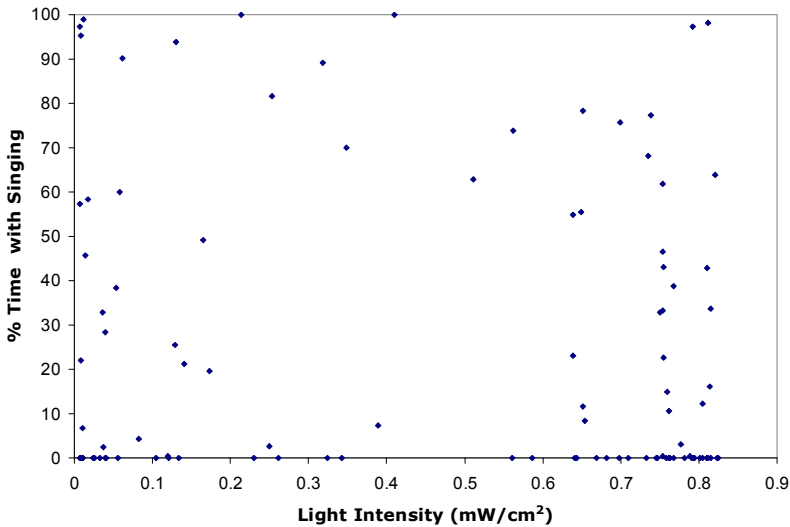


Figure 3. Ambient light did not affect song output by Northern Mockingbirds.

Curved lines fit by polynomial regression were slightly better fits than straight lines for each data set; but polynomial regression on the entire data set ($r = 0.15$, d.f. = 100, $P = 0.13$), for dawn data only ($r = 0.18$, d.f. = 34, $P =$

= 0.28), for midday ($r = 0.21$, d.f. = 34, $P = 0.22$), for dusk ($r = 0.02$, d.f. = 28, $P = 0.92$), or for dawn and dusk together ($r = 0.17$, d.f. = 64, $P = 0.18$) still never explained more than 5% of the variance in the song output index.

Discussion

Although we tracked singing from 0.5 hour before dawn until broad daylight, and again in the evening until 0.5 hour after sunset, we found little evidence for a relationship between light intensity and song output index for Northern Mockingbirds. No model based on light intensity explained more than 5% of the variance in population song output, and no correlation between song and light intensity was statistically significant.

Although the exact number of birds we monitored is unknown, our design should have assured that we sampled a composite of a dozen to two dozen mockingbirds. We will discuss several possible explanations for the lack of obvious relationship between light and song output index in this study: (1) Light levels are an important cue for singing, but only at the dimmest light levels (i.e., > 0.5 hour before sunrise and after sunset, or on moonlit nights). (2) Light levels are important cues for song to many birds, but not for mimids in general and Northern Mockingbirds in specific. (3) Light levels may influence the onset of morning song, but are unimportant once singing commences. (4) Light levels affect singing, but the specific measure we used was insensitive to that change.

Although we found no response by mockingbirds to changing light levels, we cannot rule out an effect of light at very low light levels. The lowest light levels we sampled, at 0.5 hour before sunrise and after sunset, were approximately 0.007 mW/cm^2 . These light levels approximate civil twilight, when the sun is 6 degrees below the horizon. Northern Mockingbirds occasionally sing more than an hour before sunrise (Merritt 1985) and are noted for singing on moonlit nights (Allard 1930). In both of those situations, perhaps only 1/20 as much light is available as at civil twilight (Allard 1930; Leopold and Enyon 1961). It is possible that at night or in early twilight, light has a stronger effect on song output.

Although when a bird starts singing is not the same as how much it sings, the two may covary. Merritt (1985), for example, found that unmated mockingbird males both sang at a high rate during the day and also sang earlier, being the only males heard singing between midnight and 04:00. If the relationship between song onset and song output is general, studies of the dawn onset of singing by North American birds might shed light on the results of this study. Of 20 species whose morning onset of song was monitored in Wisconsin, the species most closely related to the Northern Mockingbird is the Gray Catbird (*Dumetella carolinensis*). Catbirds were singled out by the authors as showing the "maximum amount of irregularity" in the timing of their first song of the day (Leopold and Enyon 1961), as onset of catbird song only bore a vague connection to dawn or civil twilight. Allard (1930), in a similar study, graphed the timing of first songs of the day for 11 species, but did not comment on which birds started on a more regular

or erratic schedule. We conducted an informal reanalysis of that question. We presented five observers, all trained scientists unaware of the details of the current study, with Allard's (1930) graphs and asked them to rank the 11 species by amount of vertical scatter (corresponding to erratic timing of first songs) during April and May. In this analysis as well, Gray Catbirds were the most erratic of all 11 species. Brown Thrashers (*Toxostoma rufum*), another mimid, were also below the median in this measure, seventh most regular of the 11 species included. Thus, the result we found (little connection evident between light level and mockingbird song output) could be explained by a looser than normal connection between light level and song in mimids in general, apparent in the previously published studies of song onset, but also applicable to song output once song commences. This is a possibility that would need further testing by close observation of (1) the timing of song onset in more mimids, including Northern Mockingbirds, and (2) the correlation of light levels and song output in more species in the period after song onset.

While light levels are important for determining the onset of song (Allard 1930; Leopold and Enyon 1961; Thomas et al. 2002), it may be that light level plays no role beyond stimulating song onset. Anecdotal evidence of nocturnal singing on moonlit nights and of birds ceasing song when a dark cloud passes but resuming when sunlight returns seems to favor a role of light beyond merely initiating the first song bout of the day, but these patterns need to be quantified further.

Finally, it is possible that we missed a real effect of light on song output because of the population-composite nature of our sample, particularly if light levels affect the singing of different mockingbirds in different ways. An example that illustrates this possibility comes from a study of Nightingales (*Luscinia megarhynchos*), which vary their song output due to social factors (mating status, fertility of mate), time of year, and time of day. These factors are complexly interrelated so that the effect on an individual Nightingale's song output, if his mate was laying, might depend on the time of day when the song output was measured (Amrhein et al. 2004). Merritt (1985) found that occurrence of song in Northern Mockingbirds was affected by mating status, phase of breeding cycle for mated males, and by time of day, especially for unmated males. We did not know the mating status of males or breeding phase of mockingbirds we observed in this study. It is possible that males at different stages of breeding (e.g., unmated, nestbuilding, incubating, feeding young) might have been affected differently by light levels, and individual changes in opposite directions might have been masked by the composite nature of our sample.

We found no significant difference in singing rate throughout the day (Fig. 2). However, our analysis of this data was conservative, essentially collapsing the 102 measurements of song output to five or six composite measurements in each of the three time periods, with a predictable loss of statistical power. We suspect that the trend of song output being highest in

morning, lower at noon and lowest in the evening reflects an underlying reality, as previously noted (Merritt 1985; Derrickson and Breitwisch 1992).

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