# Within Season Movements of Yellow-breasted Chats (*Icteria virens*)

Final Report

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**Summary.**

The Illinois Wildlife Preservation Fund provided the resources to help Mark Alessi address questions associated with the movement of chats as part of his MS at the University of Illinois, Urbana Champaign. The bulk of this final report is from Mark's thesis which provided new insights into the behavior of yellow-breasted chats.

Chats are a Neotropical migratory bird species that breed in shrubland habitat in Illinois. Chats exhibit an unusual behavior for a diurnally active bird, namely- they sing at night. While most diurnally active birds are assumed to be active only during the day, this nocturnal behavior of chats suggests they also may be active at night. We investigated whether chats engage in extra-territorial movements at night, and if so, why they were engaging in this behavior. We used an automated radio telemetry system to quantify the nocturnal movements of male and female chats. Both males and females moved at night significantly more when they (or in the case of males, their females) were receptive (i.e. fertile). Both males and females moved most often on "dark" nights when the moon was least illuminated, and there was no indication that birds engaged in more movements at a certain time of night or during a specific stage of the breeding season. These data, in association with other studies of extra-pair copulations and extra-territorial movements of chats, suggest that birds engage in these movements to assess potential mates and/or copulate with an extra-pair mate. Foraying nocturnally on dark nights by females may allow them to stay undetected by their mates.

The movement of female and male chats at night suggests that nocturnal behaviors may be an important part of the life history of chats. While these movements and male song may be primarily associated with mate attraction and assessment, these behaviors may also be associated with habitat selection. Like most other passerines chats migrate at night and therefore must

select breeding or stopover habitat either at night or shortly after sunrise. I attempted to attract migrating females using male chat song at night to predetermine, site that lacked appropriate habitat for chats. If nocturnal song was used by chats when selecting breeding or stopover sites then I would expect to capture chats on nights when I played chat songs at night. Significantly more individuals (eight males, seven females) were captured on mornings following treatments (playbacks conducted) relative to control nights when no songs were broadcast (2.5 vs. 0.0 birds/morning, respectively).

This research has documented that nocturnal behaviors are common in chats and that these behavior may be important in the selection of mates and habitats. Little attention has been paid to what diurnal active birds do at night, however this study highlights this species exhibits behaviors at night at may explain patterns of extra-pair paternity and site occupancy. It is likely that many other species also exhibit nocturnal behaviors and more research is warranted not only on chats but on many other species.

In summary this research confirms that chats are likely constantly moving to assess habitat conditions within an area (even at night). Therefore managers interested in shrubland habitats can expect high colonization rates and even though sites may not directly connected to other shrublands they may be used by chats. Given the movement of chats it suggests that they are attempting to locate high-quality habitats. Poor nesting success coupled with the reduction of shrubland in Illinois is probably the cause for their (and other shrubland birds) long-term population decline. Further research is needed to determine what constitutes a high quality habitat and the best course of action to manage shrubland habitats.

CHAPTER 1

NOCTURNAL MOVEMENTS OF YELLOW-BREASTED CHATS (*Icteria virens*) DURING

THE BREEDING SEASON

ABSTRACT

At night, most diurnally active birds are assumed to be inactive and presumably sleeping; however, some diurnally active species engage in nocturnal behaviors, including singing and foraging. One behavior that has been largely investigated during the day, but not at night, is movement outside of one's territory (extra-territorial forays). Traditionally, birds with radio transmitters are frequently tracked by hand only during the day. Many of these studies have found that females and males engage in extra-territorial forays and often females engage in extra-pair copulations while foraying. I used an automated radio telemetry system to quantify the nocturnal movements of male and female Yellow-breasted Chats (*Icteria virens*). Both males and females moved significantly more at night when the female was receptive (i.e. fertile). Individuals moved most often on dark nights when the moon was least illuminated. There was no indication that birds engage in more movements at a certain time of night or during a specific part of the breeding season. These data suggest that birds engage in one or two extra-territorial forays per night, and these movements are on average 170 m. This behavior is consistent with females engaging in extra-territorial forays for extra-pair copulations. Engaging in extra-territorial forays on dark nights may reduce the chances of their social mate harassing or even being aware of the female's behavior. Male chats may be foraying themselves or moving between song posts attempting to attract foraying females on dark nights.

INTRODUCTION

Several bird species that appear to be active diurnally also engage in nocturnal behaviors such as singing (Barclay 1985, Amrhein et al. 2002, 2004, Canterbury 2007).  It is often assumed that these diurnally active birds do not move at night.  Many studies have investigated the movements of territorial birds into conspecific territories (i.e., extra-territorial forays), and many of these studies have found that both males and females enter other territories to potentially assess mates and engage in extra-pair copulations (Double and Cockburn 1999, Mays and Ritchison 2004, Stutchbury et al. 2005, Pedersen et al. 2006, Chiver et al. 2008, Evans et al. 2008).  Extra-pair fertilizations are common in many socially monogamous species and many studies have illustrated the sex-specific costs and benefits of engaging in extra-pair copulations.  Additionally, researchers have documented that in many species females control paternity (Neudorf et al. 1997, Double and Cockburn 1999, Roth et al. 2009).  Often, females engage in extra-territorial forays during their fertile period in order to copulate with males that are not their social mate.  Females are often secretive when engaging in extra-territorial forays (Johnsen et al. 1998, Mays and Ritchison 2004), and males often engage in mate guarding and harassment (Edinger 1988, Mays and Ritchison 2004) to dissuade them from leaving their territory.

The secretive behavior of females engaging in extra-territorial forays is most likely the result of the costs experienced by females if cuckoldry is detected by their social mate (Birkhead and Møller 1992).  There are several potential costs; one of the most likely costs is harassment from their social mate (Edinger 1988, Mays and Ritchsion 2004).  Also, if a male detects a female engaging in extra-territorial forays he may provide less parental care to the female's offspring (Birkhead and Møller 1992, Dixon et al. 2002).  Because of the potential costs, if

females can secretly engage in extra-territorial forays then the female can receive the benefits associated with extra-pair fertilizations without the potential costs. Although extra-territorial forays can result in copulations, some forays are probably to simply gather information on the quality of potential mates (Neudorf et al. 1997).

One obvious difficulty in investigating extra-territorial forays is the time and resources associated with tracking the movements of individuals. Due to these difficulties, many studies are constrained to tracking birds during daylight hours or soon before sunrise. I used an Automated Radio Telemetry System (ARTS) to gather data on whether male and female Yellow-breasted Chats (*Icteria virens*) moved and engaged in extra-territorial forays nocturnally. The chat is an ideal species to investigate extra-territorial forays for several reasons. This shrubland species sings at night (Canterbury 2007), so females may potentially move at night to other territories to assess males. Extra-pair paternity has been documented in the species, and both males and females engage in extra-territorial forays (Mays and Ritchison 2004). Mays and Hopper (2004), using conspecific models of chats, demonstrated that females are likely the sex that controls extra-pair copulations. Finally, Mays and Ritchison (2004) documented that males engage in mate guarding, harass females that attempt to leave their territory, and females in dense habitats were less likely to be guarded by males suggesting the denser the habitat the less likely females would be detected during their extra-territorial forays. I documented whether male and female chats move at night, when they move at night, and potential factors associated with their nocturnal movements. Specifically, I predicted that male and female chats engage in more nocturnal movements when females are receptive (i.e., fertile, without a nest with eggs or nestlings). I also predicted that birds would move more with increased moon illumination, which would provide increased visibility and possibly reduce the chances of colliding with vegetation.

METHODS

*Study species and site*. Yellow-breasted chats are a Neotropical migrant that breed in shrubland habitat, primarily in eastern North America.  Female chats build the nest and incubate alone, while both males and female care for nestlings (Schadd & Ritchison 1998).  Females may renest after nest failure; however, only small percentages (8%) are double brooded (Thompson and Nolan 1973).  I conducted this research at Kennekuk Cove County Park in Vermilion County, Illinois from May-July of the 2008 breeding season.  Kennekuk is approximately 1200 ha with scattered patches of shrubland habitat ranging from 4-24 ha dominated by Autumn Olive (*Elaeagnus umbellate,*) Bush Honeysuckle (*Lonicera maackii)*, and Multiflora Rose (*Rosa multiflora*).  I captured male and female chats using targeted mist netting with song playbacks or by flushing females from their nest into a mist net.  Upon capture, birds were aged and sexed and fitted with a USGS numbered leg band and a unique combination of three color bands.  Birds were also fitted with a 0.8 g radio transmitter, which is approximately 3% of the adult's body weight.  Transmitters were attached at the base of the central rectrices using heat-shrink tubing (Alessi et al. 2009).

I located chat nests from 1 May to 31 July, 2008 by incidentally flushing females or by observing parental behavior.  I recorded nest locations, and checked nests every two to three days until nestlings fledged or the nest failed.  I separated moon phase into four categories: 1) 0-25% illumination, 2) 26-50%, 3) 51-75%, and 4) 76-100%.  I considered females to be receptive if they did not have a nest with eggs or nestlings.  A male was considered receptive if his mate was receptive, and all radio tracking was completed by 10 July.

*Automated Radio Telemetry System* (ARTS). The ARTS uses six directional yagi antennas to continuously record the location and activity of radio-tagged animals (Crofoot et al 2008, Rattenborg et al. 2008). Antennas were mounted on a 14.3 m tower and were connected to an Automated Receiving Unit (ARU; Cochran 1980). The ARU was programmed to search for all radio-tag frequencies every three minutes. The output from the ARU is the signal strength (dBm) from each antenna during each search. Individual movement can be estimated from radio signals since any change in the position of a transmitter will result in a change in received signal strength (Cochran and Lord 1963, Cochran 1980). Relative strengths were entered into an algorithm in order to estimate a bearing ($0^{o}$ to $360^{o}$) and distance from the tower. I then determined movements by calculating the differences in bearings from the tower and the change in signal strength (distance from the tower). While estimating bearings from the tower has been done previously with these systems (Crofoot et al. 2008), using signal strength to estimate distance from a tower is more challenging. Changes in signal strength can occur on three planes: signal strength will decrease as a transmitter moves away from the receiver, signal strength will decrease as a bird moves lower due to greater attenuation from vegetation, and the direction in which a transmitter's antenna is facing will affect the signal strength. A movement was recorded if both the signal strength and bearing changed simultaneously. Because a movement may occur over the course of several minutes, I defined a movement to be from the initial change in bearing and signal strength until the bearing and signal strength stopped changing for at least six minutes. I considered a movement to be nocturnal if it occurred an hour after sunset through an hour before sunrise.

*Estimating female distance from the tower.* Estimating distance from the tower using signal

strength is less precise than estimating bearing. In order to use signal strength to estimate

distance, I used radio-tagged females that were incubating their nests in known locations as test

transmitters. I used 200 samples from nine incubation or brooding events for each of the eight

nests and averaged the two strongest antennas per sample to establish average signal strength (S)

for each female. I then assessed the relationship between signal strength and distance (d) as a

quadratic relationship using linear regression (Fig. 1). I developed an equation that explained

99% of the variation between signal strength and distance from the tower, and used this equation

to estimate the distance females were from the tower ($d=0.2792(S)^2 + 43.509(S) + 1693.5$). I did

not estimate the distance the males were from the tower because males often perch in the highest

vegetation to sing, and the variation in heights resulted in an average of 16 dB difference during

tests I conducted (Fig. 2). These tests involved placing a transmitter at varying heights and

distances from the tower. This 16 dB difference would result in error estimates too large to draw

any inferences; however, to illustrate male core use area, I used male diurnal points to estimate

their 60% core area using Kernel density estimators in ArcView 3.3 (Fig. 3). Mays and

Ritchison (2004) found that females spend 96% of the time close to the ground, within 2 m.

Therefore, I assume that variation in signal strength due to changes in the height from the ground

would not result in a significant bias for females.


*Estimating bearing and bearing error.* I determined bearings using the difference in signal

strengths between the two strongest antennas (Crofoot et al. 2008). If a signal is directly

between two antennas, then each antenna will receive the same amount of energy from the

transmitter. To determine bearing error, I used 200 samples from known nest locations (*n*=8) for

incubating radio-tagged females.  Using ARCGIS, I measured the difference between actual and

calculated bearings as well as the difference in actual and calculated distances; I averaged the

values for the eight locations to determine an average bearing error and average distance error

associated with the bearing.  The average bearing error was $\pm 2.0°$ ($\pm 0.4°$ [SE]), and this bearing

error can be converted to an average distance error of $\pm 12.0$ m ($\pm 3.6$ m [SE]).

*Signal strength estimation and error*. To calibrate the system, I used the same eight nest

locations that had a radio-tagged female on the nest.  This approach was taken instead of using

humans on a test walk so I could assess the natural variation that occurs when a bird is

stationary.  I collected 200 samples when a female was stationary on her nest from nine different

brooding or incubation events per female.  Therefore, I collected a total of 200 samples from

eight nests, which totaled 1,600 samples.  Females often rotate their eggs or change positions on

the nest, so fluctuations can occur while a female is located at a single position; therefore, using

the bird as the mechanism to ground truth when a movement actually occurred was the best

approach.  The average signal strength standard deviation for the eight nest locations was 3.2

dBm $\pm 0.5$ [SE].  Because signal strength can vary depending on the plane of the movement, and

in order to be conservative I used twice the signal strnegth (6.4 dBm) as the threshold for a

movement.  I then used the distance function (see Fig. 1) to generate distances for each of the

200 samples per location.  Because the location of the transmitter was known (i.e., at a nest), I

subtracted the actual distance from the tower from the estimated distance (i.e., from the

function).  I then averaged the distance error for the eight nest locations (51.3 m $\pm 5.7$ [SE]).

I chose a conservative measure of when a bird moved to exclude erroneous readings.

This conservative cut-off likely removed many small movements (i.e. < 10 m).  Because I was

interested in documenting extra-territorial forays, I defined a movement as an occasion when the

bearing exceeded the average bearing standard deviation (5.2°) and the signal strength was twice

the average signal strength deviation (6.4 dB), and these changes both at the same time.

Consequently, birds likely moved considerably more than I report, but again, I was interested in

movements that would result in them leaving their core-use area (Fig. 4).

*Statistical analyses*. I used Generalized Linear Mixed Models (SAS PROC GLIMIX; Littell et al.

2006) to examine the effects of receptive vs. non-receptive stage, sex, moon phase, and day of

year, and their interactions on nocturnal movements.  I subsequently removed non-significant

effects in the model and report only the significant models.  Because the number of nocturnal

movements per night represents count data, I modeled these relationships using the Poisson

distribution with a log link function, and, to account for repeated measurements of movements

for individuals, I treated an individual as a random effect.  I conducted a linear regression on the

average number of movements per night with the time these movements occurred.  I recognized

statistical significance when $P<0.05$, and followed significant main effects and interactions with

pairwise contrasts to explore differences (Littell et al. 2006).

## RESULTS

I tracked six females and six males during the 2008 breeding season.  Eight of the 12

birds were paired when they were tracked.  Two females renested after their nests failed for a

total of eight nests, these nests were used to calibrate the ARTS data.  The ARTS recorded data

for 276 bird/nights, and one or more birds were active on 142 of these (51.4%).  The effect of

day of year*sex and day of year*receptive were not significant and were removed from the

model. After removing the two, day of year interactions, the day of year model itself was nonsignificant and was removed. Males ($n=6$; 1.43 ± 0.66 movements/night) and females ($n=6$; 1.10± 0.41 movements/night) did not differ in the average number of movements per night (Table 1; $F_{1,7}=0.19$, $P=0.67$). However, the sex by receptive interaction was significant with both females ($t_{240}=$ -6.96, $P=<0.01$) and males ($t_{240}=$ -2.61, $P=0.01$) moving more during the receptive phase than the non-receptive phase (Fig. 5). Additionally, males (1.13 ± 0.53 movements/night) moved nearly twice as much during the non-receptive stage than females (0.65 ± 0.25 movements/night). There was a difference in the number of nocturnal movements among moon phases (Table 2; Fig. 6). Birds moved significantly more on nights with 0-25% moon illumination than on nights with greater illumination ($t_{240}>$ 2.53, $P < 0.01$). There was no difference in the number of movements between 26-50% nights and 51-75% nights ($t_{240}=1.09$, $P=0.28$), but birds moved significantly more on 26-50% nights than on 76-100% nights ($t_{240}=3.52$, $P <0.01$), and on 51-75% nights than 76-100% nights ($t_{240}=2.33$, $P=0.02$). The interaction of sex and moon phase was not significant. There was no tendency for birds to move during certain times of night (Fig. 7; $n=12$, $P=0.66$, $R^2<0.01$). Three of the 12 birds with a transmitter left the area during the study; however, before leaving these birds were not more likely to move than the birds that did not migrate. Also, there was no effect of day of year. The average distance of a nocturnal movement for females was 170.x m ±11.7 m [SE] and the longest nocturnal movement recorded was estimated at 493.x m (Fig. 8). This average is likely skewed by my conservative estimate of what constitutes a movement. Although both the male and female of a pair were more likely to move when the female was receptive, the male and female never moved at the same time at night.

DISCUSSION

The territory size for a Yellow-breasted Chat has been estimated at 1.2 ha $\pm$ 0.51 [SD] (Thompson and Nolan 1973).  Therefore, many of these nocturnal movements would have resulted in the bird leaving its territory and are consistent with extra-territorial forays.  Yellow-breasted Chats moved often during the night, and female chats moved large distances.  Both male and female yellow-breasted chats engaged in nocturnal movements throughout the breeding season, but were more likely to move when the female of a pair was receptive.  An increase in extra-territorial forays during the receptive period in birds has been documented in females of several species (Neudorf et al. 1997, Double and Cockburn 2000, Pedersen et al. 2006, Evans et al. 2008) during daylight hours.  Although both individuals of a pair engaged in movements when the female was receptive, I found no evidence that males and females moved together, as even if they moved at the same night it was not at the same time or place.  Additionally, the number of movements per night was greater for males than for their non-receptive females (1.13 vs. 0.65 movements per night, respectively).  I suggest that females engage in nocturnal extra-territorial forays for either male assessment and/or extra-pair copulations.  Yellow-breasted Chats are in the minority of passerines in that they do frequently sing at night (Canterbury 2007).  Since males are singing, it provides an ideal situation for females to assess future mates acoustically.  Two species that exhibit similar nocturnal behaviors are the Nightingale (*Luscinia megarhynchos*; Roth et al. 2009) and Reed Warblers (*Acrocephalus scirpaceus*; Bulyuk et al. 2000, Mukhin et al. 2005).  Female nightingales appear to use nocturnal song as an indicator of male pairing status and possibly to evaluate male quality (Roth et al. 2009).  Additionally, female nightingales traveled an average of 1.12 km nocturnally when unpaired males were singing, and five of ten (50%) females settled in the territory of a male that was singing at night (Roth et al.

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2009). Mukhin et al. (2009) radio-tagged twelve breeding pairs of Reed Warblers and simulated nest predation on the females while translocating their males away from their territories. They found that the majority of adult reed warblers nocturnally emigrated after their nest was depredated, and the translocated males attempted to relocate their territories nocturnally, suggesting that some species are active at night when necessary. Male reed warblers moved between 1.7 and 20.6 km nocturnally when attempting to locate their territories after being translocated (Mukhin et al. 2009). Although these Reed Warbler movements are not related to assessment of mates, it suggests that some birds that are active diurnally also engage in nocturnal activity when they are required to do so.

On average, female chats moved 171.x m in this study; possibly permitting females to leave their males' territory and enter an adjacent males' territory, and 35% of these females' movements were between 200-400 m. One of the unexpected results of this study is that chats (both males and females) were more likely to move at night when the moon was less illuminated. Double and Cockburn (2000) report that female Superb Fairy-Wrens (*Malurus* cyaneus) initiated forays 20.5 min before sunrise and returned before sunrise. The authors suggest that these females may be able to avoid being guarded by their mate if they move in low light. Dark nights, for chats, may provide more cover for females to engage in extra-territorial forays; however, it is not clear why males would also move more on these nights. The average number of movements per night was nearly the same between males and females on "dark" nights, but on nights with greatest illumination, males were nearly twice as likely to engage in nocturnal movements. Males may have been moving around on dark nights searching for females entering their territory or were singing more at night from many song posts. Additional research is needed to determine if females may time nesting so they are fertile when there is limited

moonlight. Whip-poor-wills eggs begin to hatch during young waxing moons so that moonlight-enhanced foraging will be at its greatest when the adults are providing food for the young (Mills 1986).

Chats exhibit several behaviors that may lead to the need to continually engage in extra-territorial forays. During the course of the breeding season, new males and females will arrive at breeding sites (Thompson and Nolan 1973). Over the course of the breeding season at Kennekuk, several males did arrive mid-season, were present for a short period of time, and then left the area. Also, nest predation rates are very high; only four of 32 (12.5%) of chat nests were successful on the study site (Alessi unpub. data). Because of these dynamics, females may frequently engage in forays to assess potential males and subsequently engage in extra-pair copulations to increase female fitness. Mays and Ritchison (2004) found that males and females engaged in 0.8 forays/hour during daylight hours. During their study, they noticed that males would occasionally "herd" females that were attempting to engage in extra-territorial forays. Furthermore, females were more successful in leaving their territory without harassment in territories with denser vegetation. Evans et al. (2008) found that male and female Wood Thrush (*Hylocichla mustelina*) pairs would engage in forays together when the female was fertile. Yet, lone males more frequently engaged in forays when their mates were not fertile, thus possible trading mate guarding with extra-pair tactics. There are significant costs associated with males detecting the females leaving their territory, and nocturnal forays may be the ideal strategy to gain the benefits of acquiring knowledge about potential males and engaging in extra-territorial copulations without the cost of the mate knowing about their behavior. For example, it has been documented that Great Grey Shrikes (*Lanius excubitor*) engage in extra-pair copulations in secluded areas (Tryjanowski et al. 2007) so their mates do not know their behavior.

Movements on dark nights may also be associated with predation as several studies have found that several species are more active on dark nights due to predation pressure (Mougeot and Bretagnolle 2000, Duriez et al. 2005).  However, none of the radio-tagged chats were lost to predation and it is unlikely that nocturnal predation is very frequent.  I observed no evidence that nocturnal movements are associated with birds leaving the study site.  Nine of the 12 (75%) adult birds with transmitters did not leave the study area and still exhibited nocturnal activity.  Therefore, it appears that adult chats are not moving nocturnally in preparation for departure, but I cannot rule out that the three individuals that did leave Kennekuk engaged in nocturnal activity in preparation of nocturnal migration.

## ACKNOWLEDGEMENTS

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TABLES

Table 1.  The results from the Generalized Linear Mixed Model I conducted.  Significant models are bolded.  Birds were moved more on dark nights and when the females were receptive.

| Effect | DF | $F$ | $P$ |
|---|---|---|---|
| Sex | 1, 7 | 0.19 | 0.674 |
| **Moon phase** | **3, 240** | **15.64** | **<0.0001** |
| **Receptive** | **1, 240** | **41.38** | **<0.0001** |
| Sex × moon phase | 3, 240 | 1.68 | 0.1717 |
| **Sex × receptive** | **1, 240** | **5.8** | **0.0168** |

Table 2. The differences among moonphases. Significant differences between two phases are highlighted in bold. Moonphase 1=0-25% illumination, 2 =26-50%, illumination, 3= 51-75% illumination, and 4= 76-100% illumination.

| Moonphase | Moonphase | DF | T | P |
|---|---|---|---|---|
| **1** | **2** | **240** | **2.53** | **0.0122** |
| **1** | **3** | **240** | **3.74** | **0.0002** |
| **1** | **4** | **240** | **6.65** | **<0.0001** |
| 2 | 3 | 240 | 1.09 | 0.2769 |
| **2** | **4** | **240** | **3.52** | **0.0005** |
| **3** | **4** | **240** | **2.33** | **0.0204** |

FIGURES

Figure 1.  The relationship between distance from the receiver and signal strength.  Each point

represents 200 locations from 8 known nest locations.
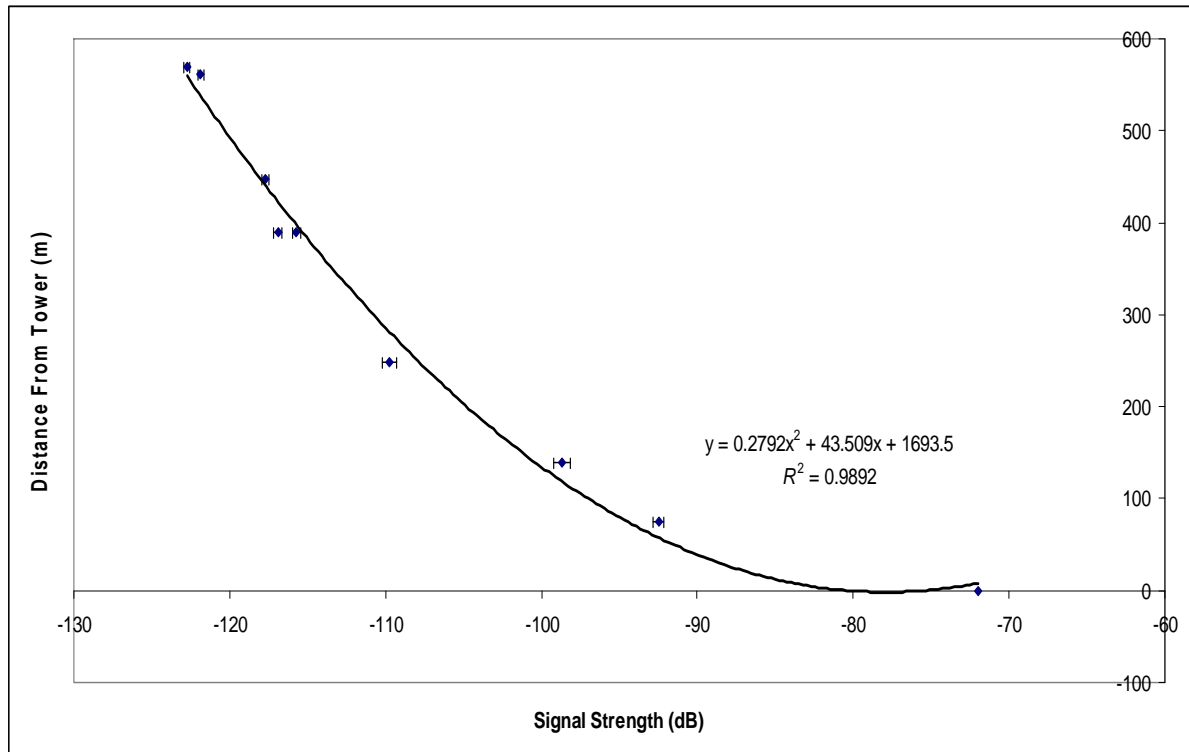
Figure 2. Average signal strengths for varying heights (0, 3, and 6 meters) and distances (10, 200, 400, and 600 meters) at Kennekuk County Park, Illinois. Averages were computed using a transmitter in a stationary location.
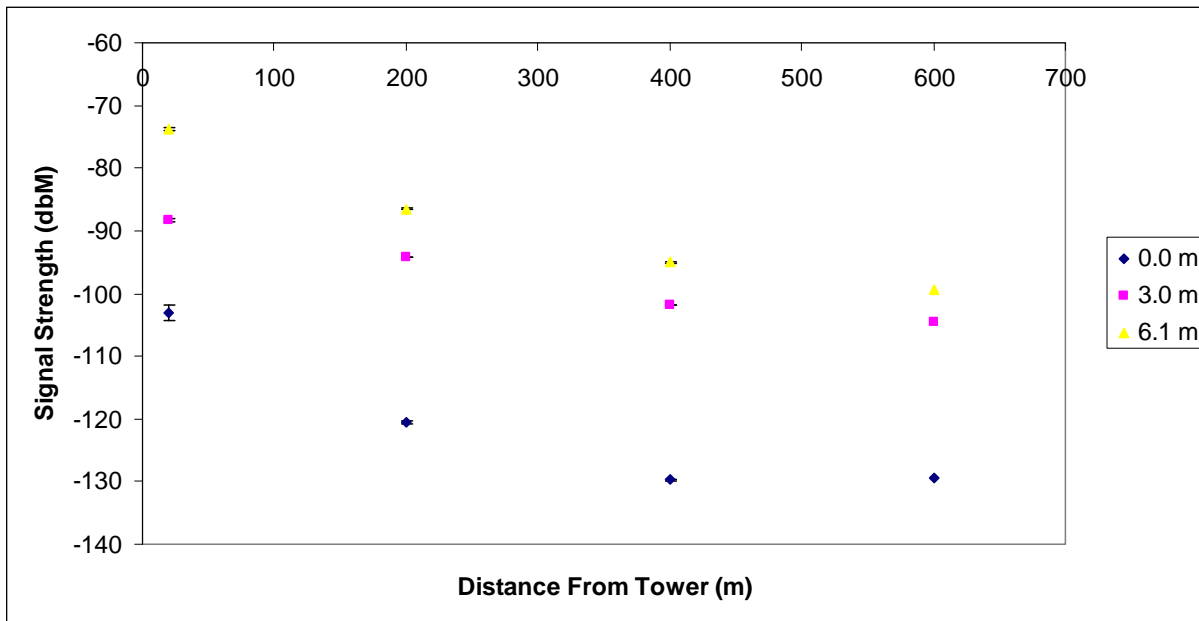
Figure 3. Each figure represents a male's diurnal 60% core-use area using Kernel estimator in ArcView 3.3. Each core-use area is elongated towards the tower (white circle) due to the effect of height on signal strength. As a male would go higher in the vegetation, the signal strength would increase; thus, the "distance" function would show the male closer to the tower than he actually was.
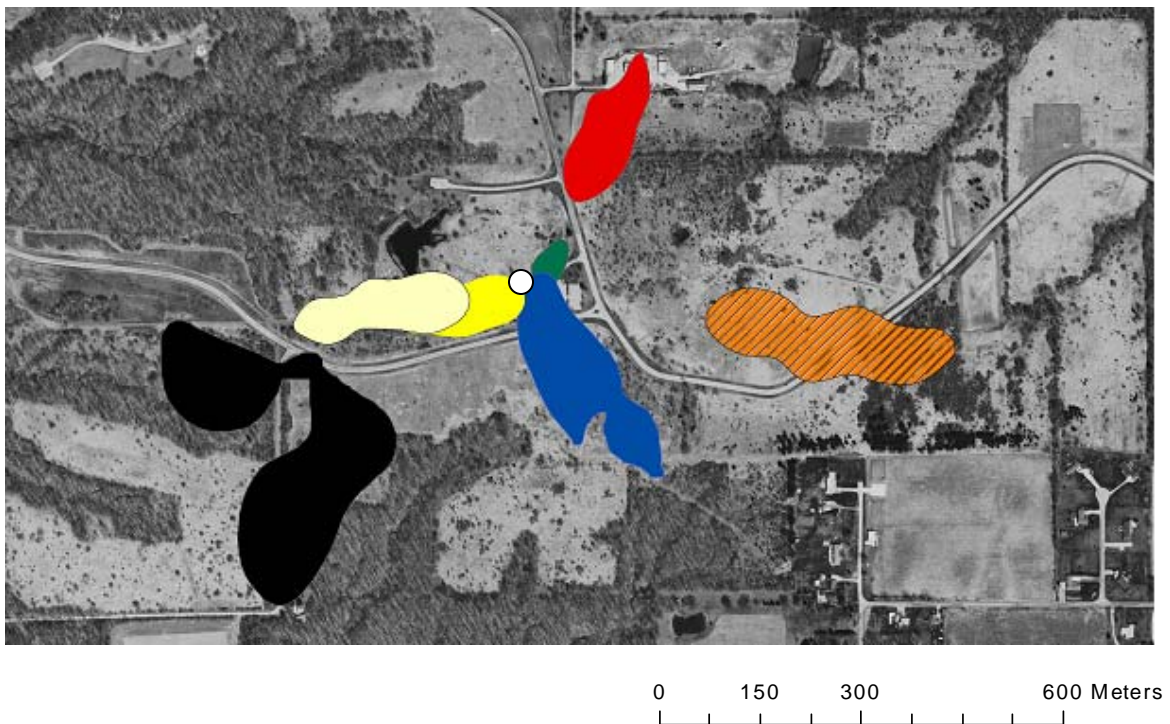
Figure 4.  Non-receptive nocturnal locations of a female during the non-receptive (blue dots) and receptive (green dots) phase.  Many movements, during both the receptive and non-receptive phase, occurred within the border, but this figure represents long-distance movements during the receptive phase.
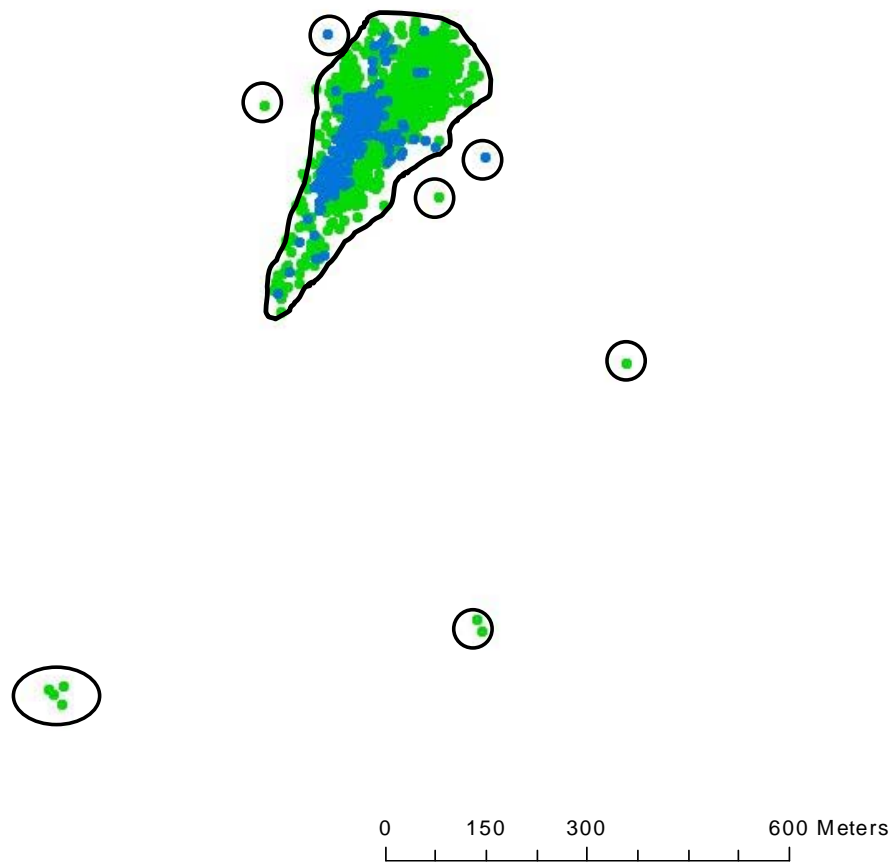
Figure 5. Effect of receptive stage and sex on the average number of movements per night for Yellow-breasted Chats. Mated female and male chats were significantly more active during the female's receptive stage than her nonreceptive stage. ** *P*<0.01, *** *P*<0.0001.
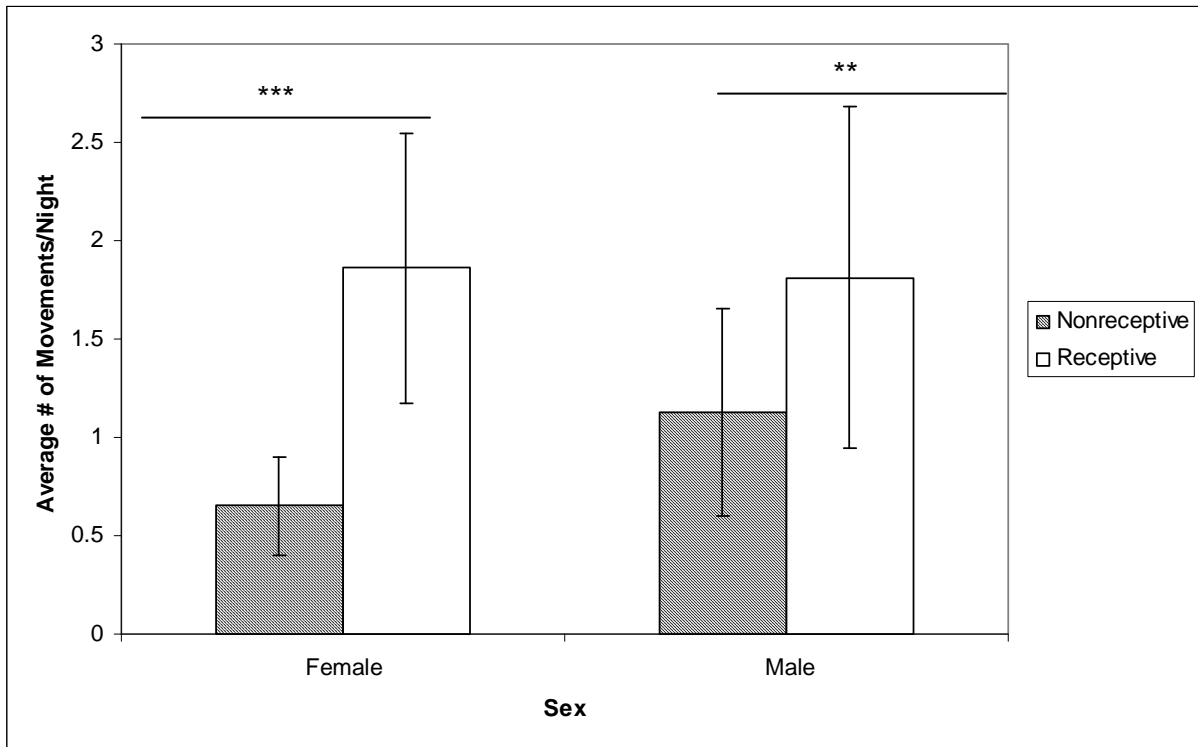
Figure 6.  Relationship between nocturnal movements and moon phase.  There was a significant

negative trend in the average number of movements per night in regards to the moon phase- birds

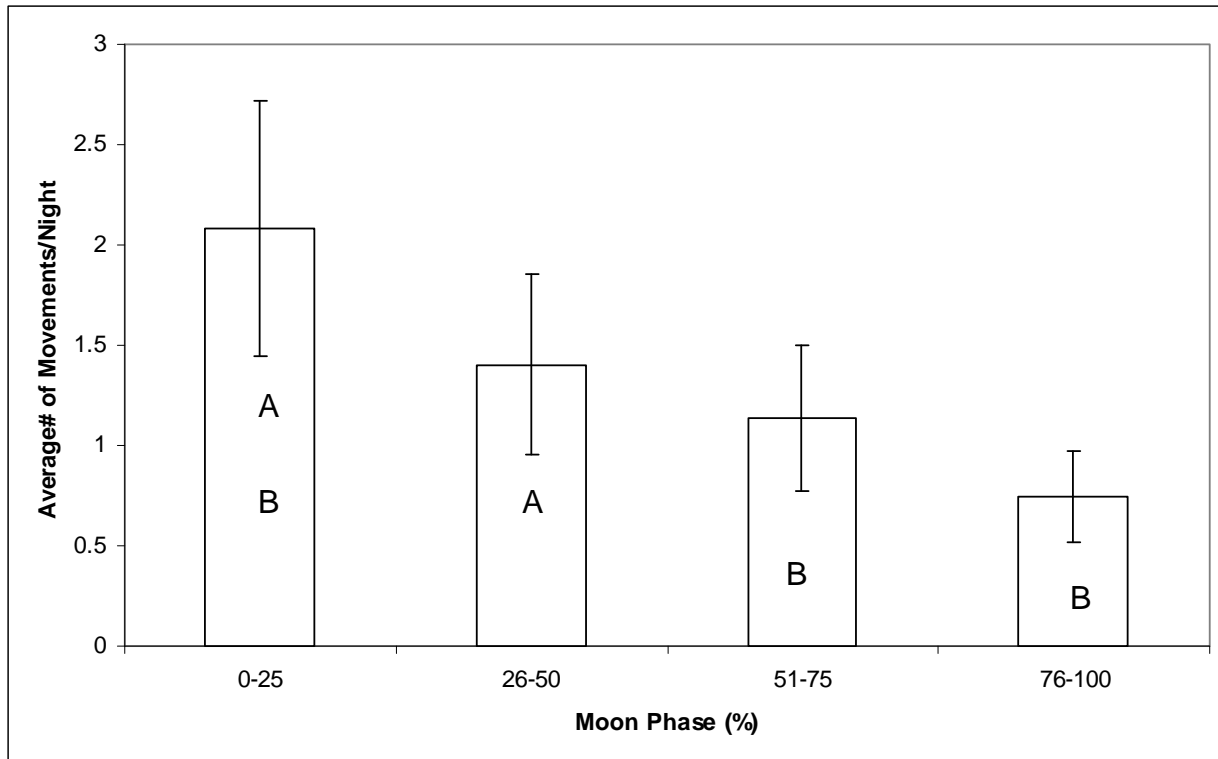moved less during moonlit nights.  "A" <.05 significance, "B" <.01 significance

Figure 7.  The effect of time on the average number of nocturnal movements.  There was no

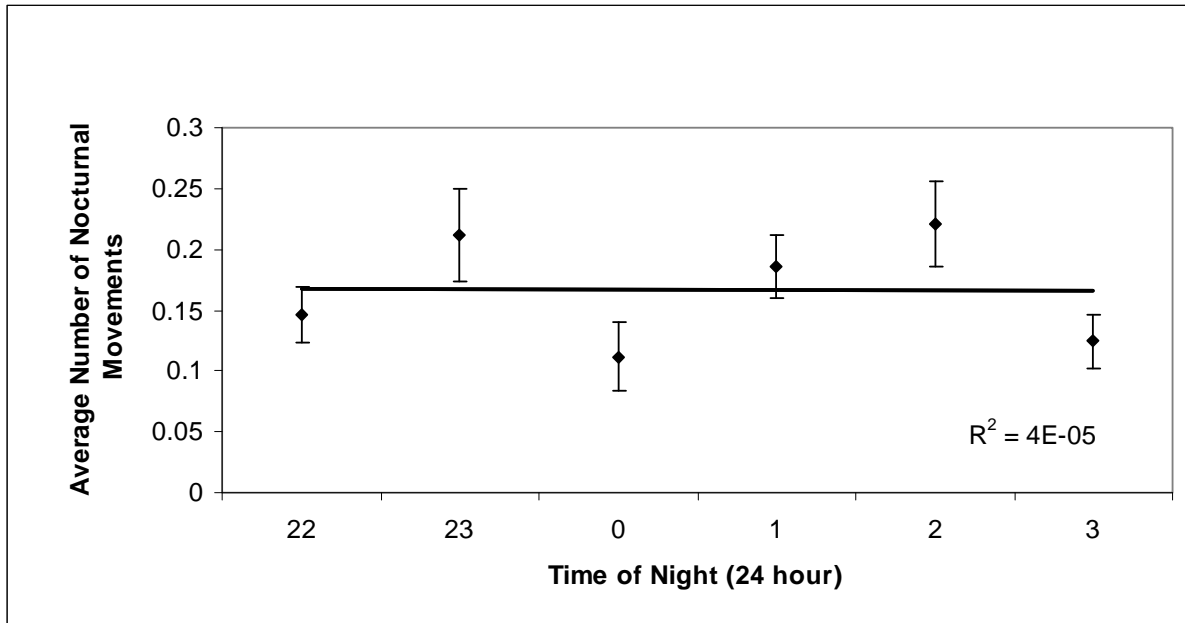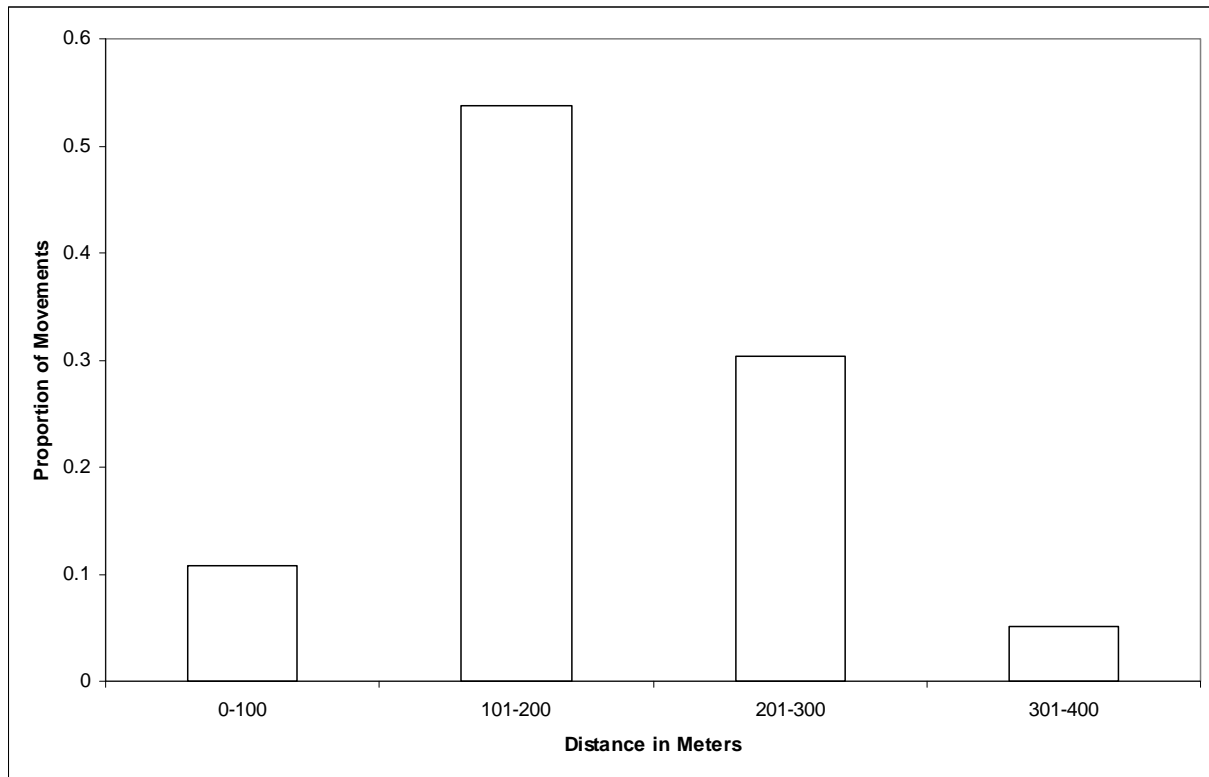trend associated with the time at which birds (*n=12*) moved nocturnally.



$R^2 = 4E-05$

Figure 8. Females moved 100-200 m most often but more than 30% of the movements were greater than 200 meters (*n=277*). There were probably many more short movements; however, the conservative values I used to define a movement excluded most short movements.

CHAPTER 2

NOCTURNAL SOCIAL CUES ATTRACT MIGRATING BIRDS

ABSTRACT

Nocturnally migrating birds use a suite of cues to navigate from their wintering to their breeding grounds yet, how these birds select specific stopover and breeding habitats is largely unknown.  One factor that may influence habitat selection are social cues, specifically conspecific vocalization.  Although most songbirds sing at dawn, dusk, or periodically throughout the day, some diurnally active songbirds also sing at night.  Males may sing at night in order to attract females or to defend their territories, but regardless of the reason why a male may sing, the song may be a cue for migrating birds signaling the presence of appropriate habitat.  I tested the hypothesis that migrating birds may use nocturnal conspecifc song when selecting a habitat using the Yellow-Breasted Chat (*Icteria virens*).   I broadcast nocturnal song in unsuitable habitat on certain nights and on night no song was boradcast.  I predicted that migrating chats would use male nocturnal song as an indicator of suitable habitat and would land at the site and evaluate the site.  Once they determined there was no appropriate habitat they would leave the site.  I caught significantly more individuals (eight males, seven females) on mornings following treatments relative to control nights when no songs were broadcast and not new birds were captured (2.5 vs. 0.0 birds/morning, respectively).  Only one bird was recaptured at the site and only one male was detected singing at the site, suggesting that individuals quickly left the area after determining the habitat was unsuitable.  Conspecific nocturnal songs appear to be an important cue used when chats are selecting stopover and breeding habitat.

## INTRODUCTION

Reliable cues of high-quality habitat are imperative for migratory birds because energetic and fitness costs of not locating suitable habitat can be high (Cochran and Wikelski 2005). Migratory birds use a suite of navigational cues to migrate between their wintering and breeding grounds (Able and Bingman 1987); however, the specific cues used to select stopover and breeding habitat remain largely unknown. Studies suggest that both visual (Moore et al. 1995) and acoustic cues (Ward and Schlossberg 2005; Mukhin et al. 2008) may be involved. However many nocturnal passerine migrants select stopover locations prior to sunrise (Cochran et al. 1967; Moore and Aborn 2000) when visual cues may be absent or difficult to evaluate. Therefore, cues that facilitate locating suitable habitat are likely highly valuable for migrating birds, and one such cue may be nocturnal song.

Nocturnal song by dirunal active birds is uncommon, however recent research suggests that nocturnal song may be an important cue (Mukhin et al 2008). Also several diurnally active species that do sing at night have specific nocturnal songs. For example, research on Nightingales (*Luscinia megarhynchos*) suggests that males sing at night primarily to attract females (Amrhein et al. 2002). The whistle song of male Nightingales (Glutz von Blotzheim 1988) appears to function primarily for mate attraction, and female Nightingales assess males at night while they are using these songs (Roth et al. 2009). The nocturnal song of Yellow-Breasted Chats (*Icteria virens*) is also given at a frequency and amplitude that may allow detection farther away than their diurnal song (Canterbury 2007). If the function of nocturnal song is to attract females, then females would use this song as an indicator of suitable habitat. However relative importance of conspecific vocalization vs. habitat cues is unknown.

I broadcasted the nocturnal song of male Yellow-Breasted Chats, a song that is consistently sung at night during spring migration (Canterbury 2007), in unsuitable habitat during chat migration. Because the shrubland habitat in which chats breed is patchy, the probability of a migrating individual quickly locating suitable habitat at dawn is unlikely, and birds would benefit by using pre-dawn cues to locate appropriate areas. I hypothesized that both male and female chats use nocturnal song as an indicator of suitable habitat and that both males and females would select areas with conspecific nocturnal song regardless of habitat suitability. Further, I predicted that chats attracted to unsuitable habitat would quickly leave the site.

METHODS

This experiment was conducted on University of Illinois property in southeast Urbana, Champaign County, Illinois, USA (Fig. 1a) during spring migration between 29 April and 15 May 2009. The site was a $210 \times 30$ m linear strip of six rows of apple (*Maylus* spp.) trees spaced 6.5-m apart with mowed strips of grass between each column of trees (Fig. 1b). The habitat north and east of the site was residential and commercial property while the habitat to the west and south was a mixture of agricultural land with additional patches of apple trees. The area was selected because it offers woody vegetation, but lacked the size and dense shrub layer that chats require for both breeding habitat (Thompson and Nolan 1973) and stopover habitat (Parnell 1969). Chats have never been recorded at this site and the site was repeatedly treated with pesticides and mowed to facilitate fruit production.

I alternated between control nights, when no songs were broadcast, and treatment nights with song playbacks when the weather allowed (not raining). I used a mixture of commercially available chat songs (Stokes 2000) and chat songs I recorded from individuals in eastern Illinois.

The recording included a male whistle song, the song only used at night (Canterbury 2007). The entire recording was 100 sec long and was repeated continuously using a Fox Pro FX3 playback system. I placed the system in the center of the site in a weatherproof plastic container and aimed the device at a 45-degree angle southward toward the sky. On treatment nights, songs were broadcast from sunset to 1.5 hr after sunrise. I placed mist nets approximately every 30 meters on the site to increase the probability of capturing all chats moving through the vegetation; nets were numbered 1 (South net) to 6 (North net) and were opened for 1.5 hr before and after sunrise each morning for both treatment and control nights. I sexed and banded all captured chats with a USGS band, and recorded the net in which each individual was captured prior to releasing them back into the site. To supplement the capture data after closing the nets, I conducted 5-min, unlimited-radius point counts each morning in two locations at the site to quantify the number of singing chats. One point was located at the southernmost end of the strip while the other was located at the northernmost end (Fig. 1b). I conducted a one-tailed t-test to examine whether I captured more chats on treatment mornings than on control mornings.

RESULTS

I captured 15 chats (8 males, 7 females) during 4 of the 6 mornings that I broadcasted chat song at night, and I captured no new individuals during any of the 5 control mornings (Fig 2a; $t_9$=2.02, $P$= 0.04). Eight of 15 chats (53%) were captured in the nets closest to the speaker (chat song), while seven of 15 (47%) were captured in the southernmost nets (Fig. 2b). Over the course of 11 mornings, only one male chat was heard singing during point counts and it was during the morning he was captured. No male chats were recorded singing on control days,

which emphasizes that this location was not suitable habitat. I only recaptured one individual; a female three days after her initial capture.

<p style="text-align:center">DISCUSSION</p>

Migrating chats were captured only on mornings following treatment nights and no birds were captured during the mornings following control nights. Both migrating male and female chats responded to experimental addition of nocturnal male song, suggesting that male chat song functions as a cue for stopover or potentially breeding habitat selection. Male chats did not establish territories and likely continued migration until suitable habitat was found. It appears that the lack of appropriate habitat does not preclude chats selecting a site as long as conspecific songs are present.

Nocturnal song of diurnally active birds has been documented primarily in species that breed in patchy or ephemeral habitat (Barclacy et al. 1985, Walk et al. 2000). For example, male common Nightingales breed in ephemeral habitat (Hewson et al. 2005) and also sing nocturnally for mate attraction (Amrhein et al. 2002). Similar to Nightingales, male chats appear to primarily use long-range whistle songs only at night (Canterbury 2007). Further, male chats will sing continuously at night for up to six days after arrival on the breeding grounds, potentially providing abundant social cues early in the season when most females are returning from their wintering locations (Canterbury 2007).

Because I broadcasted nocturnal song between sunset and 1.5 hours after sunrise, I attracted birds either during the night or shortly after sunrise. Selecting stopover habitats at sunrise may be adaptive if the increased visibility allows for better habitat assessment (Bolshakov and Bulyuk 1999); however, these results suggest that, at least for chats, individuals

are selecting habitat based on social cues rather than habitat suitability. The extent to which this mechanism is found in other species is currently unknown.

Conspecific attraction has received increasing attention in recent years, and is important for both habitat selection and planning conservation and management actions (Ahlering and Faaborg 2006). Several studies have demonstrated that birds use conspecific attraction to assess and select habitat (Serrano et al. 2004, Ward and Schlossberg 2004, Ahlering 2005, Mukhin 2004, Betts et al. 2006). To date, most conspecific attraction studies have not attempted to attract birds to unsuitable habitat, nor have studies focused exclusively on nocturnal song (but see Mukhin et al. 2008). Attracting birds to unsuitable rather than suitable habitat is a more reliable method of assessing the importance of acoustic social cues (Chernetsov 2006, Betts et al. 2006). Further, if this site had been suitable males may have defended territories and both males and females may have remained to breed at the site. Thus, this mechanism likely holds true for both stopover and breeding site selection.

If chat nocturnal song reflects the presence of high-quality habitat, heterospecifics may also use these cues (Mönkköen et al. 1999). In this study, I did capture other shrubland bird species on mornings following treatments, such as Orchard Orioles (*Icterus spurius*), Brown Thrashers (*Toxostoma rufum*), and Field Sparrows (*Spizella pusilla*). To fully assess the potential of nocturnal song for heterospecific attraction, a separate playback experiment would be necessary to determine if these species use chat song rather than vegetation structure to select suitable habitat. Since nocturnal song is prevalent in patchily distributed habitats such as wetlands, grasslands, and shrublands in North America (Barclacy et al. 1985, Walk et al. 2000), many of these bird species may be using nocturnal heterospecific song as a cue during migration,

and future research is needed to address conspecific and heterospecific attraction in shrubland birds.

## ACKNOWLEDGEMENTS

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## FIGURES

Figure 1. (**A**) Aerial photo of Champaign-Urbana. The circle indicates where the study site was located. (**B**) Aerial view of the site where I conducted the nocturnal song playback experiment. The agricultural field east of the orchard was residential and commercial property.
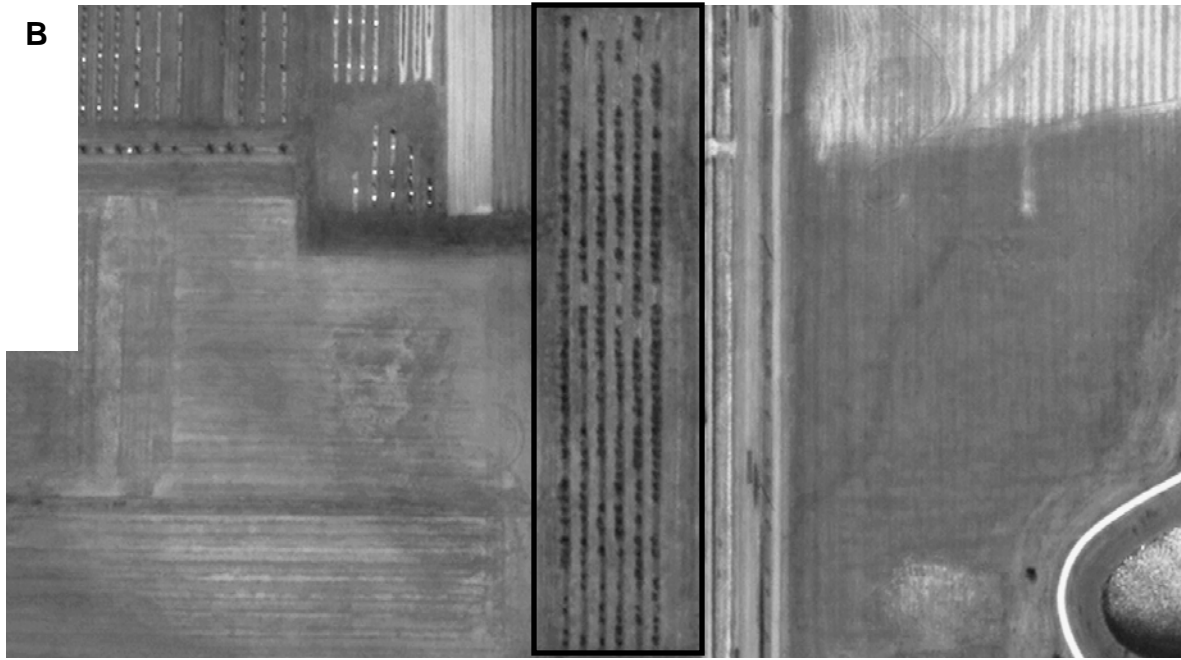
Figure 2.  (**A**) I captured significantly more chats after song playback nights (T- 2.5 birds per day) versus control nights (C- 0 birds per day).  (**B**) The majority of chats were captured at the two nets that surrounded the playback device.  The arrow indicates where the speaker was located.