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Note

Summer movements of a radio-tagged Hoary Bat (*Lasiurus cinereus*) captured in southwestern Ontario

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Abstract

Hoary Bat (*Lasiurus cinereus*) is a migratory species known to travel long distances during migration. Little is known about its movement patterns during other periods. An adult male Hoary Bat that we radio-tagged in southwestern Ontario in summer was tracked using the Motus Wildlife Tracking System. It travelled a minimum of 827 km in a circular route over a 2-week period and was last recorded 46 km from the original capture site. Hoary Bat is highly vulnerable to being killed at wind turbines and its propensity to travel great distances during summer and migration may exacerbate the impacts of wind farms.

Key words: Hoary Bat; *Lasiurus cinereus*; summer movement; Motus; radio-tracking; southwestern Ontario

Hoary Bat (*Lasiurus cinereus*) is widely distributed throughout the Western Hemisphere, and may be common in the Great Lakes Region. However, it is among the least frequently encountered species in studies of regional bat communities (e.g., Jung *et al.* 1999).

Hoary Bat travels long distances through its life cycle (Cryan *et al.* 2014). Migratory movements of this species have mostly been inferred from the seasonal distribution of museum specimens (Cryan 2003; Cryan *et al.* 2014), but there are several biases in these data. Kurta (2010) demonstrated that studies based on museum specimens did not match actual distribution and sex ratios of Hoary Bats captured by mist-netting in Michigan. This species is frequently studied through acoustic inventories (e.g., Barclay *et al.* 1999) and mortality studies at wind power facilities (e.g., Kunz *et al.* 2007). Such studies provide no information on individual movement patterns, which can only be determined through physical handling and tracking of individuals. Only one study has documented the long-distance movements of Hoary Bats in North America (Weller *et al.* 2016), and it was conducted in autumn rather than summer.

The non-migratory movements of males have not been well documented. Banfield (1974) stated that males seem to wander erratically during spring and summer and do not associate with females while the latter are caring for their young. Here we provide data on the short-term movements of a radio-tracked male Hoary Bat during mid-summer.

On 9 July 2016, we captured an adult male Hoary Bat in a 12-m triple high mist net near a Little Brown Myotis (*Myotis lucifugus*) maternal roost near Branchton, Ontario (43.2986°N, 80.2900°W). The Hoary Bat was 29.2 g at the time of capture and had a forearm length of 51 mm. A Nanotag radio transmitter (Lotek, Newmarket, Ontario, Canada) was affixed to the back of the bat by shaving a small area and applying a small amount of Osto-Bond (Montreal Ostomy Inc., Vaudreuil-Dorion, Quebec, Canada) glue to the bat and the tag. The mass of the tag reported by the manufacturer was 0.33 g, representing 1.1% of the body mass of the bat, less than the maximum of 5% recommended by Aldridge and Brigham (1988). This brand of skin cement is effective for adhesion of the tag to the bat for at least several days (Carter *et al.* 2009), and the transmitter battery life is expected to be as long as 21 days. Once the glue had dried, the bat was released at the capture site.

We attempted to relocate the bat by driving roads within 5 km of the capture site for seven days after capture, using two 4-element Yagi antennae fixed in opposite directions to the roof of a truck and connected to an SRX800 receiver (Lotek). The bat was

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never detected from the ground; thus, tracking its movements relied on detections on the Motus Wildlife Tracking System.

The Motus system is an international collaborative research network that uses coordinated automated radio telemetry arrays to study movements of small animals (Taylor *et al.* 2017); it has been used for tracking migratory bats (Lagerveld *et al.* 2017). Bird Studies Canada maintains an array of more than 100 automated radio telemetry stations in Ontario, and The Ohio State University maintains other stations in Ohio used by this study. Although these do not provide complete coverage of all areas and are not suitable for precise triangulation, detections show large landscape movements. Detection of tags at a receiver station could be within 15 km of the station depending on station strength and whether the animal is flying in the open or near obstructions (Taylor *et al.* 2017). The nearest receiver station to the capture site (Onondaga) was ~2 km south, but it was not activated until 12 July 2016 (seven days after we tagged the bat); the bat was never detected at this station.

Figure 1 depicts the movements of the bat, although it did not necessarily travel in a straight line between stations. The specific locations of the stations where it was detected are provided in Table 1 along with the dates and times when the bat was detected. Over two weeks, the Hoary Bat travelled a minimum distance of 827 km and was last detected only 46 km from the banding location. The landscape that it moved through was predominantly agricultural with scattered remnants of forest and wetland.

The male Hoary Bat made significant movements within short periods (Table 1): the longest were a minimum of 253 km over one night and 316 km over three nights (although it is unknown how long the

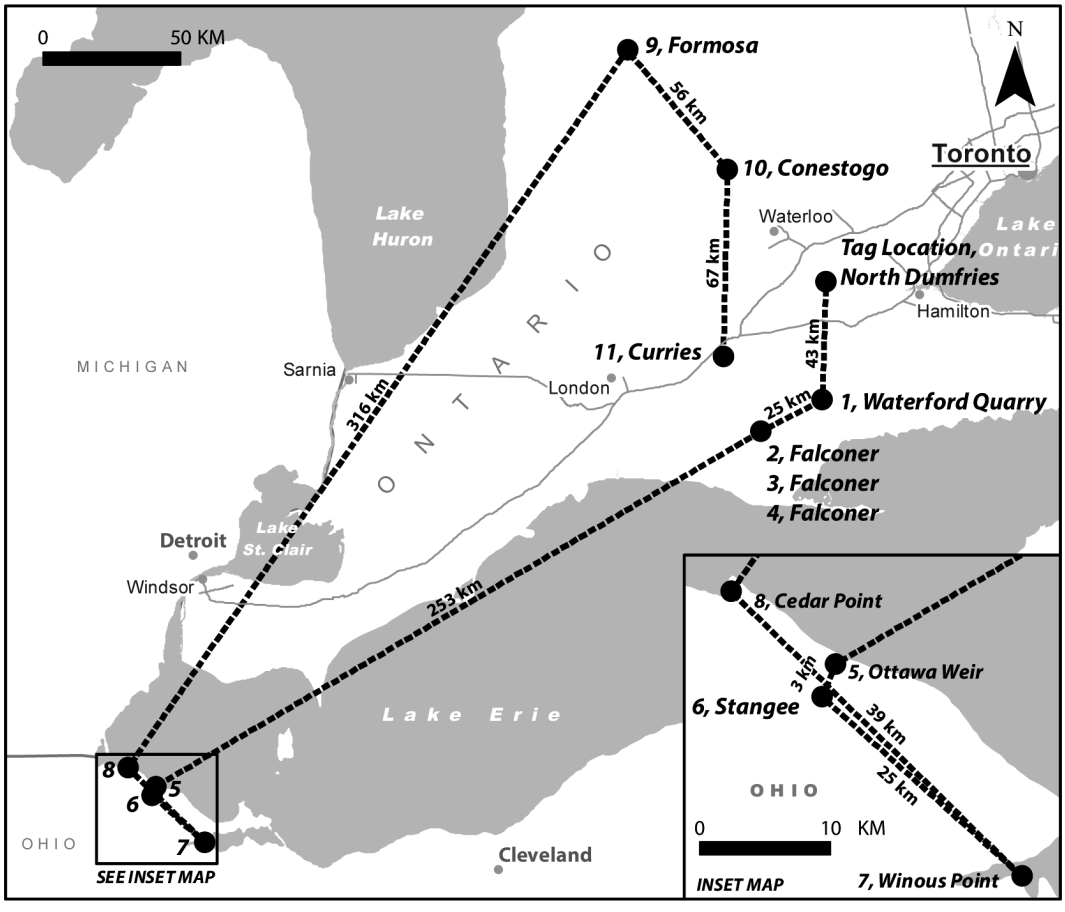

Figure 1. The map indicates the location where the male Hoary Bat (*Lasiurus cinereus*) was tagged on 9 July 2016 (North Dumfries) and its subsequent detections at the various Motus stations: 1. Waterford Quarry; 2, 3, 4. Falconer; 5. Ottawa Weir; 6. Stangee; 7. Winous Point; 8. Cedar Point; 9. Formosa; 10. Conestogo; 11. Curries. The inset map shows its movements in Ohio on 19 July 2016.

Table 1. Movements of a radio-tagged Hoary Bat (*Lasiurus cinereus*) over a 2-week period in July 2016 in southwestern Ontario.

Motus station*	Date and time detected	Distance from last station, km	Cumulative distance travelled, km
North Dumfries (tagging location)	9 July, 2350	0	0
1. Waterford Quarry	14 July, 1943–2200	43	43
2. Falconer	15 July, 2229–2303	25	68
3. Falconer	16 July, 2005	0	68
4. Falconer	18 July, 1912–1929	0	68
5. Ottawa Weir	19 July, 1728–1730	253	321
6. Stangee	19 July, 1732–1743	3	324
7. Winous Point	18 July, 1731–1736	25	349
8. Cedar Point	19 July, 1743–1744	39	388
9. Formosa	22 July, 1954–1955	316	704
10. Conestogo	22 July, 2129–2133	56	760
11. Curries	23 July, 2229–2349 24 July, 0156–0201	67	827

*Numbers correspond to those on the map in Figure 1.

bat took to fly these distances). The movements were not in a clear latitudinal direction. The bat initially moved to the southwest along or over Lake Erie, then flew quickly back to the northeast along or over Lake Huron and started another trip toward the southwest. It spent some time north of the Long Point area at Falconer and in the Cedar Point area of Ohio and was last detected at the Curries station (also near Long Point). The bat was detected consistently early in the night and often during daylight hours. If the bat was not moving at this time, we would have expected it to be detected repeatedly at individual stations until it moved out of the detection range. The bat did not appear to return to the location where it was captured during our sample period, because it was never detected at the Onondaga or other nearby stations.

Our study reports the first documented movements of an adult male Hoary Bat during the summer months. It has been widely believed that Hoary Bat makes long-distance movements during migration, but concrete evidence of this is sparse; even less information is available on local summer movements, such as those documented here. The few recoveries of banded Hoary Bats show maximum distances between banding and recovery sites of 150–450 km, representing more local movements (Davis 1969, 1970), although isotope analysis has shown that Hoary Bats make long-distance seasonal movements (Arias 2014; Baerwald *et al*. 2014).

In autumn in California, Weller *et al.* (2016) recovered three adult male Hoary Bats with global positioning system tags. One remained sedentary during the study, one made local movements of less than 100 km, and the third travelled over 1000 km in a month. Similar to the bat that we tracked, it moved in a circular manner and ended up less than 150 km from the original capture location. Results from this observation and Weller *et al.* (2016) indicate that male Hoary Bats may occasionally make circular or other long-distance movements lasting several days and covering distances as great as 1000 km. Although sample size is still very small (two of four tracked bats), this indicates that these bats have a large home range and, therefore, habitat protection or conservation for the species must similarly be on a large scale. The purpose of these flights is uncertain: bats may be searching for females to mate with before migration (Weller *et al.* 2016), although this bat was not scrotal (showing signs of sexual reproduction by having distended testes). More studies that use the Motus system or other methods capable of tracking Hoary Bats are recommended to better understand the space use by this fast, high-flying bat.

Hoary Bats are frequently killed at wind power facilities, particularly during late summer and autumn migration (Arnett *et al.* 2007; Bird Studies Canada *et al.* 2016). Hayes *et al.* (2015) concluded that Hoary Bats make up approximately 40–50% of all bat mortalities at wind farms; in Canada, this figure is 30.9% (Bird Studies Canada *et al*. 2016). Cryan (2011) estimated that as many as 225 000 Hoary Bats might be killed annually at North American wind farms, and it is predicted that the Hoary Bat population could decline by 90% in the next 50 years because of mortality related to wind turbines (Frick *et al.* 2017). Over the landscape that this bat travelled, a considerable number of wind turbines are in operation. Ontario has the greatest wind power generation in Canada with more than 4781 MWh of annual power production as of 2016 (Canadian Wind Energy Association 2017); many of the turbines are in southwestern Ontario. This bat either avoided those turbines or flew through them without being killed during the period that it was tracked. Our data provide

evidence that Hoary Bats are at risk of encountering a large number of wind turbines during their summer movements, not just during migration.

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