

Journal of Fish and Wildlife Management

Exceptional Longevity in Little Brown Bats Still Occurs, despite Presence of White-nose Syndrome --Manuscript Draft--

Manuscript Number:	JFWM-20-039R1
Article Type:	Notes
Keywords:	banding; hibernation; <i>Myotis lucifugus</i> ; white-nose syndrome; survival
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1 **Exceptional Longevity in Little Brown Bats Still Occurs, despite Presence of**
2 **White-nose Syndrome**

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33 **Abstract**

34

35 White-nose syndrome is an introduced fungal disease that has reduced the size of
36 hibernating populations of little brown bats (*Myotis lucifugus*) by 90% across much of
37 eastern North America since 2007. Herein, we report the recapture of eight banded
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41 apparently healthy males are in their seventh season of exposure to the disease.
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47 Received: May 18, 2020; Accepted: July 27, 2020; Published Online Early: August
48 2020; Published: xxx

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50 Citation: Kurta A, Foster RW, Daly BA, Wilson AK, Slider RM, Rockey CD, Rockey JM,
51 Long BL, Auteri GG, Collins JD, White JD, Kaarakka HM, Redell JA, Reeder DM. 2020.
52 Exceptional longevity in little brown bats still occurs, despite presence of white-nose
53 syndrome. *Journal of Fish and Wildlife Management* 11(2):xx-xx; e1944-687X.

54 <https://doi.org/10.3996/JFWM-20-039>

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56 This Online Early paper will appear in its final typeset version in a future issue of the
57 Journal of Fish and Wildlife Management. This article has been accepted for publication
58 and undergone full peer review but has not been through the copyediting, typesetting,
59 pagination and proofreading process, which may lead to differences between this
60 version and the Version of Record. The findings and conclusions in this article are those
61 of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife
62 Service.
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Introduction

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Methods

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Despite the small size of bats, these mammals have exceptional lifespans (Lagunas-Rangel 2020; Wilkinson and Adams 2019). Thirty-three species have a maximum recorded longevity of 20 or more years, and 13 of these species are small-bodied animals (6–20 g) within the genus *Myotis*. White et al. (2019) recently reported five records of little brown bats *M. lucifugus* from Wisconsin with minimum ages between 18 and 32 years. However, each of these bats was last seen in 2016, which was the first year that an introduced disease, white-nose syndrome, was detected in their hibernacula. This disease, caused by the psychrophilic fungus *Pseudogymnoascus destructans*, has reduced most populations of bats that hibernate underground in eastern North America by about 90% (Frick et al. 2015; Turner et al. 2011), and because of the malady, White et al. (2019:N45) suggested that “longevity records of this magnitude may never be recorded again.” However, in this note, we provide eight records of little brown bats living more than 18 years, even though these animals apparently have been exposed to the fungus for the past seven winters.

Our study site was the hollow concrete spillway of Tippy Dam, a hydroelectric facility on the Manistee River, near Wellston, Manistee County, Michigan (44.2183°N - 85.9599°W). Approximately 20,000–24,000 bats currently hibernate in the spillway, which is one of just three hibernacula for bats in the Lower Peninsula of Michigan, the nearest of which is a concrete tunnel sheltering only about 100 animals and located 230 km northeast of Wellston (Kurta 2008; Slider and Kurta 2011). Historically about 97% of bats overwintering at the dam were little brown bats, and most of the remainder were

87 northern long-eared bats *M. septentrionalis* (Kurta et al. 1997). Although northern long-
88 eared bats apparently have disappeared from the spillway following introduction of *P.*
89 *destructans*, the number of little brown bats appears stable.

90 Placing a metal band on the forearm of a bat is standard technique for identifying
91 individuals, tracking migratory movements, determining survivorship, and helping
92 establish longevity (Ellison 2008; Kunz and Weise 2009; Rockey et al. 2013). To
93 discover the summering grounds of animals that overwintered at Tippy Dam, biologists
94 from Eastern Michigan University banded 5,524 bats, between February 1995 and
95 September 2008. Most (94%) banded animals were little brown bats, and 72% of these
96 were male; a preponderance of males is typical of bats at northern hibernacula
97 (Humphrey and Cope 1976; Keen and Hitchcock 1980). Each bat received a lipped
98 band (Baker et al. 2001) that was 2.9 mm in diameter and manufactured by
99 Lambournes or Porzana (United Kingdom). Each band was stamped with a unique
100 four-digit number and the letters “EMU YPSI MI,” indicating the university (EMU), as
101 well as the city (Ypsilanti) and state (Michigan) where the school is located.

102 During the hibernating season of 2019–2020, we began a study of
103 thermoregulatory patterns of bats overwintering in the spillway, to help determine why
104 this particular population of little brown bats has not been devastated by white-nose
105 syndrome. We entered the spillway on three dates (6 December 2019, 14 February
106 2020, and 6 May 2020) to conduct that project, but during each visit, we also briefly
107 looked for any banded bats that might be present on the interior walls and ceilings.
108 Banded individuals were removed from their roosting location by hand or with the aid of

109 a long-handled net and examined for the presence of obvious abnormalities, such as
110 frostbite damage, wing tears, open wounds, or emaciated appearance.

111 For each recovered animal, we calculated elapsed time between banding and
112 recapture, using an online program (<https://www.calculator.net/date>). Age of bats at the
113 time of banding was unknown. To calculate minimum age at the time of recapture, we
114 assumed that all marked bats were young-of-the-year when first caught and that all
115 were born on 1 July, at the end of the preceding maternity season (Kurta 1980).

116 Results

117 We recaptured eight marked individuals, 0.145% of the total banded, and all
118 were male little brown bats (Table 1). One band was chipped along its bottom edge so
119 that only the first two digits (3 and 1) were legible. Nevertheless, all bands numbered
120 from 3100 to 3199 were applied on the same day, allowing us to determine time since
121 banding for this individual, as well as the others. Minimum ages that were calculated for
122 the eight bats ranged from 18.6 to 25.6 years.

123 During each of our visits, many bats roosting in the spillway displayed white
124 patches of apparent fungal growth on the ears, snout, forearms, or feet, suggesting an
125 active infection with *P. destructans*. However, all banded bats appeared to be in good
126 physical condition, barring some tooth wear; for example, upper and lower incisors and
127 the lower premolars were worn to the gums in bat #4840. We detected no white
128 patches on the eight recovered animals and no obvious fungal damage to their wings,
129 such as tears, holes, or depigmented areas (Reichard and Kunz 2010).

130 Discussion

131 Two correlates of extreme longevity in bats are the use of hibernation and the
132 habit of overwintering in caves or cavelike locations, especially at high latitudes where
133 winters are long (Wilkinson and Adams 2019). The resulting prolonged period of
134 inactivity in a protected site presumably reduces extrinsic mortality factors such as
135 accidents and predation. At Tippy Dam, a torpid population begins building in mid-to-
136 late September, and thousands of bats, mostly males, are still present 7.5 months later
137 in early May (Kurta et al. 1997). Although our data are not sufficient to estimate
138 average annual survival rates at Tippy Dam, 0.145% of the 5,524 bats that were initially
139 banded lived at least another 18 years—an extraordinary lifespan for a mammal
140 weighing only 7–10 g (Kurta 2008). Our data are similar to those obtained for little
141 brown bats in northern Wisconsin, where 0.158% of 3,173 marked individuals survived
142 18 years or more after banding (White et al. 2019).

143 The little brown bats that we recovered were all males. Similarly, the five old
144 bats found by White et al. (2019) in Wisconsin were male, as was the oldest little brown
145 bat on record, a 34-year-old individual from New York reported by Davis and Hitchcock
146 (1995). Although recapture of predominantly old males at Tippy Dam and other sites
147 may reflect the greater number of males that were originally banded, our results are
148 consistent with long-term survivorship studies indicating that males live longer than
149 females in northern populations of insectivorous bats (Hitchcock et al. 1983; Keen and
150 Hitchcock 1980).

151 Presence of white-nose syndrome at Tippy Dam was first documented during a
152 routine survey by the senior author in winter 2014–2015 (Kurta and Smith 2014).
153 Evidence included visible fungal growth on many bats, histopathology performed on two

154 dead animals that were collected (D. O'Brien, Michigan Department of Natural
155 Resources, in litt.), and identification of DNA from *P. destructans* on swab samples (W.
156 Frick, University of California Santa Cruz, in litt.). Fungal DNA was detected on 18 of 19
157 bats and on 9 of 12 samples obtained from the walls of the spillway. Discovery of *P.*
158 *destructans* on the walls of a hibernaculum often lags 1 year behind detection on the
159 bats themselves (Verant et al. 2017), so it seems likely that the fungus was present in
160 Tippy Dam during winter 2013–2014. Although a survey of the spillway did not occur
161 during the hibernating season of 2013–2014, infected bats were found elsewhere in the
162 state during that winter (Kurta and Smith 2014).

163 Our data complement those obtained from bats on their summer range, which
164 indicate that some little brown bats survive multiple years despite presence of white-
165 nose syndrome in regional hibernacula. For example, Reichard et al. (2014) and
166 Dobony and Johnson (2019) banded over 2,600 animals at maternity sites in New York
167 and New England, after arrival of white-nose syndrome, and they recaptured multiple
168 individuals in subsequent years on the same summering grounds. However, the
169 maximum interval between marking and recapture was about 6 years for five adults, all
170 of which were female. As in our study, the ages of these five bats were not known at
171 the time of original capture. If each animal had been banded as an adult in its second
172 summer, minimum age at recapture would be approximately 7 years—far less than the
173 minimum age of the eight males from Tippy Dam (Table 1).

174 Neither Reichard et al. (2014) or Dobony and Johnson (2019) knew where their
175 animals hibernated, but we are confident that our adult males overwintered each year at
176 Tippy Dam. Little brown bats seldom change hibernacula (Humphrey and Cope 1976,

177 Norquay et al. 2013), and this part of Michigan is covered in thick glacial till so that there
178 are no caves, rock crevices, or other alternative hibernation sites within hundreds of
179 kilometers of the dam (Kurta 2008, Slider and Kurta 2011). The fungus remains viable in
180 a hibernaculum throughout summer, even in the absence of bats (Reynolds et al. 2015)
181 and at temperatures of 24 °C or higher (Campbell et al. 2020), and no evidence
182 suggests that a site that harbors *P. destructans* can temporarily become free of the
183 fungus. Hence, it is likely that our banded individuals were surviving during their
184 seventh winter in a site that continually harbored *P. destructans*.

185 Tippy Dam is unusual. For example, the substrate is concrete and not natural
186 rock, and the internal ambient temperature is quite cold (0.5–2 °C) in mid-winter but
187 unusually warm (>20 °C) in summer (Kurta et al. 1997). In addition, the assemblage of
188 bacteria living on bats in the spillway is significantly different from the microbiome
189 present on bats in the Upper Peninsula or Kentucky (George 2009). These physical
190 and biological differences are well documented, but whether or how these differences
191 impact survival in the face of white-nose syndrome is unknown (Auteri and Knowles
192 2020, Cheng et al. 2019, Lilley et al. 2019). Nevertheless, our data from Tippy Dam
193 show that even bats that have lived for more than two decades may persist, despite
194 multi-year exposure to the fungus, suggesting that a long life in little brown bats and
195 presence of white-nose syndrome are not necessarily incompatible.

196 **Acknowledgments**

197 We thank Consumers Energy Corporation for allowing access to the spillway of
198 Tippy Dam and arranging support personnel. Funding was provided by a grant from the
199 U.S. Fish and Wildlife Service (F20AP00002) and a contract with the East Lansing Field

200 Office of the U.S. Fish and Wildlife Service (140F0319P0104). We also thank W. F.
201 Frick and D. O'Brien, for arranging analysis of swab samples and histopathology of
202 animals, respectively, that the senior author collected in 2014–2015.

203 Any use of trade, product, website, or firm names is for descriptive purposes only
204 and does not imply endorsement by the U.S. Government.

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Supplemental Material

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292

293 Table 1. Recaptures of eight little brown bats *Myotis lucifugus*, all males, that were
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 301

Band number	Date banded	Date recovered	Time after banding^a	Minimum age^{a, b}
1858	3/18/1995	2/14/2020	24 years 10 months 27 days	25 years 7 months 13 days
31??	9/9/1995	2/14/2020	24 years 5 months 5 days	24 years 7 months 13 days
4840	8/26/1998	5/6/2020	21 years 8 months 12 days	21 years 10 months 6 days
4976	8/27/1998	2/14/2020	21 years 5 months 18 days	21 years 7 months 13 days
5920	2/11/2000	12/6/2019	19 years 9 months 25 days	20 years 5 months 5 days
5940	2/11/2000	2/14/2020	20 years 0 months 3 days	20 years 7 months 13 days
6046	2/3/2001	2/14/2020	19 years 0 months 11 days	19 years 7 months 13 days
6707	2/7/2002	2/14/2020	18 years 0 months 7 days	18 years 7 months 13 days

302 ^a We determined time after banding and minimum age using an online calculator
 303 (<https://www.calculator.net/date>).

304 ^b Age of bats at the time of banding was unknown, but to calculate minimum age at time
 305 of recapture, we conservatively assumed that birth occurred on 1 July of the maternity
 306 season preceding banding.

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4976	8/27/1998	2/14/2020	21 years 5 months 18 days	21 years 7 months 13 days
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