

# **Use and Distribution of Roosts by Florida Bonneted Bats in Miami Dade County, Florida, USA: Addition to Webb et al. 2021**

Frank N. Ridgley, Kirsten M. Bohn, Israel Salazar,  
Sonya Thompson, and Melquisedec Gamba-Rios



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**Cover Photograph:** Male Florida Bonneted Bat "Clyde" rehabilitation case found roosting in a home in the City of Miami in 2014. Photograph © Dustin Smith, Zoo Miami.

# Use and Distribution of Roosts by Florida Bonneted Bats in Miami-Dade County, Florida, USA: Addition to Webb et al. 2021

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**Abstract** - In Miami-Dade County, FL USA, Florida Bonneted Bats, *Eumops floridanus*, have been documented to utilize a wide array of both natural roosts and artificial structures, including bat houses. Here, we provide a more comprehensive summary of day roosts for the Florida Bonneted Bat in Miami-Dade County as an addition to the data included in Webb et al. 2021 and provide suggestions for improving the comparison of body condition scores for the species across diverse landscapes. These additional data suggest new conclusions on day roost selection, characterization of day roosts, and range for the species. This species has been found to roost across the heterogeneous urban, suburban, semi-natural, and agricultural landscapes found throughout Miami-Dade County, and their roosts are not confined to a particular area or region. Roost site selection does not appear to be associated with a particular architectural style in developed areas and potential roost cavities can be found in a diverse array of natural and artificial structures. This more comprehensive dataset will provide for a more accurate assessment of the species within developed landscapes and better guide conservation measures and strategies.

## Introduction

In the publication by Webb et al. 2021, the authors described the use of 14 day roosts by *Eumops floridanus* Allen (Florida Bonneted Bat) in the greater Miami area based on previous and new reports. Here, we provide information on 31 additional roosts that were not included in Webb et al. (2021) that represent a more diverse representation of natural and artificial structures utilized by the species. Webb et al. (2021) characterize roost selection and roost distribution by this endangered species and conclude that the Florida Bonneted Bat regularly selects buildings of a similar architectural style in a relatively small (40 km<sup>2</sup>) portion of the city. However, their study utilized a small and incomplete data set, which resulted in possible mischaracterization of day roost use, selection, and distribution by the species in this urban setting. It is crucial to provide the most accurate data and analyses in the scientific record since peer-reviewed publications are often influential in shaping policy, making management decisions, developing a recovery plan, conservation strategies, and have the potential for curbing human-bat conflict within urban environments (Oliver and Cairney 2019). Here, we present a complete data set for Miami-Dade County, which provides a more comprehensive description of known day roost selection, characterization, and distribution within the county. Even though the combined data set represents decades worth of records, the sample size is still relatively small, and caution should be utilized when interpreting these data as possibly representing all of the day roost types, preferences, and distribution for such an adaptable species as the Florida Bonneted Bat.

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The additional data that we compile here and that was not included by Webb et al. (2021) come from additional cited publications and records from the University of Florida, Zoo Miami, Bat Conservation International, and the Florida Power and Light Bat Lab that had been shared electronically and verbally with the United States Fish and Wildlife Service and the Florida Fish and Wildlife Conservation Commission.

In addition, we provide suggestions on improving body condition scoring evaluations and comparisons across the range of the Florida Bonneted Bat. This includes the use of consistent established methodologies and controls as well as appropriate spatial scale sampling to account for and include the diversity of landscapes and habitats in which the Florida Bonneted Bat occurs.

### Historical Roosts

The final rule listing the Florida Bonneted Bat as federally endangered includes historical records prior to 2013 (USFWS 2013). Some of these records were not included by Webb et al., (2021). In the final rule, natural roosts in Miami-Dade County in the shafts of royal palm trees were documented by Belwood (1992) and rocky crevices and outcroppings by Timm and Genoways (2004). Gore et al. (2015) also described roosting in pine and palm trees within the City of Coral Gables area of Miami-Dade County in the mid to late 1990s (Supplemental Table 1, available online at <https://eaglehill.us/URNAonline2/suppl-files/urna-199-ridgley-s1.pdf>).

For artificial roosts, Gore et al. (2015) describe the use of a utility pole, and the final listing rule records the use of Spanish tile roofs, chimneys, attics, and a large open-air concrete structure, the Asian elephant barn, at Zoo Miami in 2004 (Belwood 1992, Timm and Arroyo-Cabrales 2008, USFWS 2013) (Supplemental Table 1). The elephant barn roost is significant due to it being unique in construction to any other known Florida Bonneted Bat roost that has ever been recorded. It was situated in the seam of two concrete t-beams supported by a large concrete column that in construction resembles many bridges and other infrastructure that can be found throughout the species' known range (Fig. 1). Also, this record confirms the species presence in Miami between the years 1998 to 2013 when Webb et al. (2021) had suggested that no records of roosts existed within this time period.

### Recent Roosts

We present 31 records not included by Webb et al. (2021) from natural and artificial roosts documented in Miami-Dade County (Supplemental Table 1). The records were documented from rehabilitation and human/wildlife conflict cases reported to the Florida Fish and Wildlife Conservation Commission (FWC) and United States Fish and Wildlife Service (USFWS). Also, a bat house designed for smaller species was discovered occupied by a Florida Bonneted Bat by a University of Florida student while mist-netting at Zoo Miami in 2017. Omitted from Webb et al. (2021), we have also included data from an array of bat houses designed for the Florida Bonneted Bat, installed by Zoo Miami and Bat Conservation International from 2018–2021, whose occupation status is updated frequently to USFWS (Fig. 1).

In late 2013, a natural roost was discovered in an urban park. A non-volant pup was found below a tree cavity in a *Quercus virginiana* Mill (Virginia Live Oak) bisected by park workers hours previously (F. Ridgley, Zoo Miami, Miami, FL, 2013 unpubl. data). These records contrast the conjecture of Webb et al. (2021) and demonstrate the species continues to use natural and artificial structures within Miami-Dade County.

### Roost Characterization

In Table 2, we provide a summary of the types of roosts that have been documented to be utilized by the Florida Bonneted Bat within Miami-Dade County into subcategories for

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comparison. This summary shows that natural roosts have been the least identified and least utilized category of documented roosts in Miami-Dade County. Buildings have been the most documented type of structure being utilized by the species with 22 different buildings in at least 6 different architectural styles. Apart from residential and office buildings, other artificial structures have been documented to have been used 5 times, with colony sizes ranging from



Figure 1. Composite image showing four different types of artificial roosts found within Miami-Dade County, FL USA. A. A two-story residential home with barrel-tile roof. B. An artificial roost installation with back to back single chamber bat boxes. C. A roost behind a fascia board on a four story condominium. D. The elephant barn at Zoo Miami. The arrows indicate entrances to the roosts.

a single individual up to 15 bats. With the installation of bat houses from 2018 to the present by Bat Conservation International and Zoo Miami as part of a species conservation strategy to provide conflict free roosts in the urban environment, bat houses have since become the second most documented type of occupied structures and the most utilized by the species in Miami-Dade County with a population of 134 individuals at the time of writing this manuscript.

**Body Condition Scoring**

Body condition scoring has been widely used for physiological comparison between individuals, groups, and populations. We welcome the first attempt by Webb et al. (2021) to compare the Florida Bonneted Bat populations found in natural and developed habitats. We agree with their judgment that 10 individuals are a small sample size and is not adequate to analyze and compare these populations. In addition, 80% (8 individuals) were

Table 2. Summary of day roost structures by architectural style and roost type.

Roost Structure	Number of Roosts	Number of Bats
<b>Buildings</b>		
Mediterranean Revival Style Residential Building <sup>1,2,3,4,5</sup>	10	27
1980's Cluster Style Condominium <sup>5, 10</sup>	4	18
Norman Romanesque Style Residential Building <sup>1,5,6,7,8</sup>	2	8
Unknown Style Residential Building <sup>3,5</sup>	2	2
Miami Modern Style Large Building <sup>1,8</sup>	1	4
Masonry Vernacular Style Residential Building <sup>5</sup>	1	1
Unknown Style Large Office Building <sup>9</sup>	1	1
Unknown Style Building <sup>1</sup>	1	1
<b>Building Total</b>	<b>22</b>	<b>62</b>
<b>Other Artificial Structures</b>		
Open Air Shelter <sup>5,11,12</sup>	2	8
Bell Tower <sup>13</sup>	1	15
Utility Pole <sup>2</sup>	1	1
Artificial Snag <sup>5</sup>	1	1
<b>Other Structure Total</b>	<b>5</b>	<b>25</b>
<b>Bat House Total<sup>5,14</sup></b>	<b>16</b>	<b>134</b>
<b>Natural Roost Total<sup>2,5</sup></b>	<b>2</b>	<b>2</b>
<b>Grand Total</b>	<b>45</b>	<b>223</b>

<sup>1</sup>Robson 1989, <sup>2</sup>Gore et al. 2015, <sup>3</sup>Webb et al. 2021, <sup>4</sup>Citizen scientists, Bohn personal observation 2016, <sup>5</sup>Ridgley electronic communication with USFWS 2012-2021, <sup>6</sup>Schwartz 1952, <sup>7</sup>Field Museum of Natural History, Chicago, IL, <sup>8</sup>Florida Museum of Natural History, Gainesville, FL, <sup>9</sup>Robson et al. 1989, <sup>10</sup>Salazar personal observation 2015–2017, <sup>11</sup>Marks and Marks 2008, <sup>12</sup>Thompson electronic communication with USFWS 2013, <sup>13</sup>Gamba-Rios personal observation 2019, <sup>14</sup>Webb electronic communication to USFWS 2017.

captured at a single site, which is unlikely representative of the species' status across a heterogeneous region like Miami-Dade County. Those individuals were captured at the Granada Golf Course, located in the City of Coral Gables. The city has one of the highest median household incomes and lowest poverty rates in all Miami-Dade County (US Census Bureau 2019). It is well established that there are correlations in bat species distribution and usage in heterogeneous urban environments regarding socioeconomic status and urban vegetation (Li et al. 2019, Li and Wilkins 2014). A 2016 assessment of The City of Coral Gable's urban tree canopy was estimated at 46.8% (the second highest out of the 79 areas assessed in the Urban Development Boundary [UDB]), while the average urban tree canopy across the entire UDB is only 19.9%, the lowest being 5.5% in the Medley area (Hochmair et al. 2016). It is critical to increase the sample size and utilize an appropriate spatial scale when sampling to have a comprehensive representation of the bats and areas present in Miami-Dade County. These efforts need to be conducted using the same methodology across the distribution range of this endangered species in order to allow for meaningful comparisons and analysis.

Another potential issue with drawing conclusions from body condition estimates in nocturnal aerial insectivorous bats is that body weight varies highly with a number of variables. For example, results will vary extensively with the time of capture within a night because bats can consume a significant percentage of their body weight each night in insects and water (Moiseienko and Vlaschenko 2021), which is then coupled with an extremely high metabolic rate for flight (Speakman et al. 2003). If comparisons are going to be made between groups' body condition indices utilizing a mass ratio, an attempt should be made to control for this variation by taking measures before feeding or drinking to avoid altering the animal's mass, resulting in an inaccurate analysis (Pearce et al. 2008). Additionally, season and reproductive status may also affect body condition (Furey et al. 2018, Speakman and Racey 2009). Thus, for any comparisons to be drawn among populations, at the very least, time of capture, sex, reproductive status, and date (season) must be presented and their effect on condition assessed.

## Discussion

The additional data included here show the use of multiple natural and artificial roost types by the Florida Bonneted Bat and across a wider distribution within Miami-Dade County. These additional data, though still limited in sample size, will provide policy makers and land managers with a more comprehensive list of known roosts for this endangered species in a developed landscape. Additionally, we detailed suggestions on how to help eliminate possible biases, methodology discrepancies, and spatial scale sampling considerations that could affect the comparison of body condition scoring of the Florida Bonneted Bat across its range.

The number of documented occurrences of Florida Bonneted Bats utilizing natural roosts in Miami-Dade County are limited, although there is clear evidence to show that historically and contemporaneously they will utilize these roosts, if available. The diversity of types of artificial roosts and their widespread use across Miami-Dade County through different landscapes demonstrates the adaptability of the species (Fig. 2). This is not surprising given the flexibility of roost use, particularly man-made structures, by many Molossidae species (Voigt et al. 2016) including the closest congener to the Florida Bonneted Bat, *E. glaucinus* Wagner. *E. glaucinus* has been found to roost in trees, corrugated-iron roofs, building cracks and inside dwellings, such as houses, attics, and sheds

(Best et al. 1997). These factors must be taken into account when evaluating possible impacts to this endangered species and not limit considerations to buildings with certain architectural styles.

In regards to Webb et al. (2021) suggesting that the Florida Bonneted Bat prefers to roost in Mediterranean Revival style architecture in Miami-Dade County, we suggest this conclusion may be due to the small sample size, sampling bias, and incorrect spatial scale sampling. The City of Coral Gables is not representative of the rest of developed Miami-Dade County as far as architectural style. The City of Coral Gables has unique Mediterranean Style Design Standards building codes (The City of Coral Gables 2021) and a Board of Architects that ensures the architectural style found within the city limits is consistent with the original Mediterranean style found throughout most of the city (The City of Coral Gables 2018). With the majority of the sampling by Webb et al. (2021) being conducted

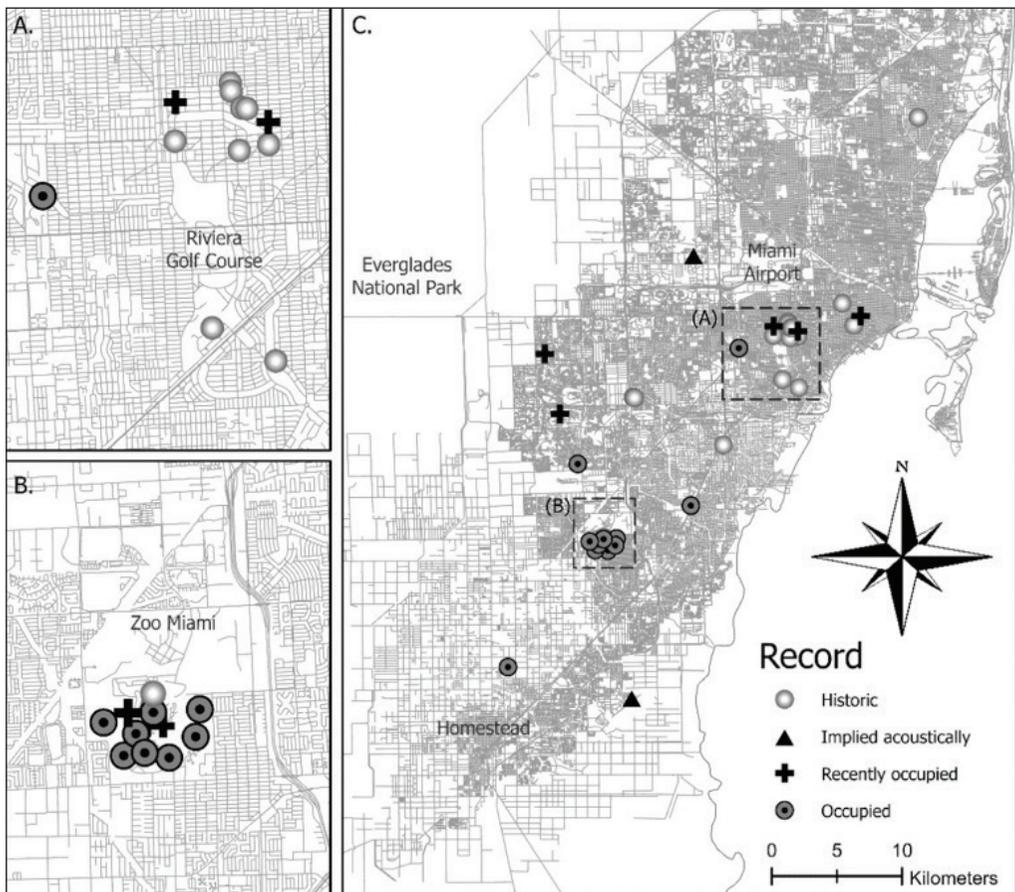


Figure 2. Maps showing the locations of historic roosts, recently occupied roosts, currently occupied roosts and approximate roost locations implied by acoustic monitoring studies in Miami-Dade County, Florida, USA (25.5516° N, 80.6327° W). Historic roosts are those of which there is a record of roosting but either the roost has since been destroyed or there has been no occupation documented within the last five years. Recently occupied roosts have had documented roosting activity within the last five years and the roost appears intact. Occupied roosts have had occupation confirmed within one month of this manuscript submission. Acoustically implied roosts are approximate locations where repeated acoustic surveys had Florida bonneted bats recorded near dusk with no other close roosts documented. A. Inset of the City of Coral Gables where many historic roosts have been documented. B. Inset of Richmond area where many occupied and recently occupied roosts have been documented.

in an area of the UDB of Miami-Dade County that is unique in architectural style, it is not surprising that the authors might conclude an association.

Mediterranean Revival style architecture in Miami-Dade County from the 1920s has the unique architectural feature of abundant capped chimneys. Supplemental Table 1 shows that <3% of all Florida Bonneted Bats recorded roosting within the county were found in chimneys of Mediterranean Revival style architecture. Another architectural feature often found on Mediterranean Revival style buildings is clay barrel tile roofs. This feature is not unique to Mediterranean Revival style buildings and is commonly found incorporated broadly into different structures and architectural styles across Miami-Dade County from some of the earliest modern structures and continued to be used on contemporary buildings. Supplemental Table 1 shows that around 16% of all Florida Bonneted Bats recorded roosting within the county were found under barrel tile roofs of structures with different architectural styles. Other roost selection influencing factors such as roost height and cavity size/availability likely warrant further analysis and evaluation.

Some *Eumops* spp. are known to utilize heterogeneous urban landscapes and show significantly higher activity than when compared to forest sites (Barquez and Diaz 2001, Jung and Kalko 2011, Pacheco et al. 2010, Sodr e et al. 2008, Torres et al. 2020). Surveillance of the currently occupied artificial roosts in Miami-Dade County appear to be demonstrating the area's fulfillment of the species' biological needs through a steadily increasing resident population, which is the second highest known across the species range at over 130 individuals with reproduction evident by the presence of pups (M. Gamba-Rios, Bat Conservation International, Austin, TX and F. Ridgley, Zoo Miami, Miami, FL, 2021 unpubl. data). The extensive history, study, and record of the Florida Bonneted Bat in Miami-Dade County should influence use of state, federal, NGO, and academic resources to equally focus on understanding the species ecology in both natural, semi-natural, and developed landscapes to better protect it into the future. There is nothing to indicate that Miami-Dade County is an exceptional circumstance for the species. The contrary is likely suggested by acoustic evidence obtained in Naples and Everglades City and an occupied bat house in Ft. Myers (USFWS 2013). The absence of robust data in developed areas in southern Miami-Dade County and outside Miami-Dade County for the Florida Bonneted Bat is most likely attributable to the lack of the study of urban ecology for the species in Florida.

The ongoing monitoring of Florida Bonneted Bat populations in Miami-Dade County has shown that, typically, a small number of individuals (<15) will occupy a single roost. The small number of bats using these structures, combined with the height at which roosts are usually located, makes identification of sites exceedingly challenging, even for trained professionals. The lack of additional identified roosts should not be an indication that bats are not present, simply that they have not been found. This is an important consideration for determining roost use and distribution patterns, as well as for conservation considerations with regards to development. If Florida Bonneted Bats are not suspected to be using a building, consultation with the USFWS is not required before any development work begins. While it is impractical to treat every building as a known bat roost, developers need to be aware of the possibility that a federally listed species is present, so they can identify signs of bats after they have started constructed/renovated work. The authors have observed that, when Florida Bonneted Bats are disturbed in a structure under renovation, they do not fly away, increasing the risk of injury and fatality. However, signs of guano are indicative that bats may be present and should be a key determining feature to stop any construction work until trained surveyors have assessed the site.

In general, developed areas present challenges to many bat species, such as increased human/wildlife conflict, increased pesticide use, physical obstructions to flight, noise pollu-

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tion, removal of snags, habitat conversion to agriculture, and chemical pollution, but many Molossidae species are considered synurbic and urban adapters (Frick et al. 2020, Jung and Kalko 2011, Jung and Threlfall 2016). Therefore, when evaluating a developed landscape for a Molossidae bat species, one must take into consideration positive factors such as increased roost availability, decrease in known natural predators, decrease in resource competition, and the urban heat effect when evaluating the suitability of the habitat and the fitness of the species found within it (Gore et al. 2018, Jung and Threlfall 2016, McKinney 2002, Voigt et al. 2016). Many of these aforementioned factors can influence data when evaluating a species' fitness, including body condition scoring, in a heterogeneous developed area; utilizing the correct, or multiple, spatial scale for sampling is required to garner meaningful conclusions about a species (Gallo et al. 2018, Li and Wilkins 2014). Given the known existing population size, diversity of roosts utilized, diversity of landscapes where roosts are present, and the range of the species across the developed regions of Miami-Dade County presented here, the data suggest that, like many other Molossidae, the Florida Bonneted Bat is an urban dweller that warrants further research into its urban ecology to better understand its fitness and requirements in developed landscapes (Fischer et al. 2015, Jung and Kalko 2011, McKinney 2002).

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