# Bats in the Bronx: An Acoustic Survey

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**Abstract:**

Populations of many bat species are in serious decline. Although some bat species can adapt to urban environments, little is known about urban bat ecology, particularly in the Northeastern U.S. My study documented the presence of bats in The Bronx, New York, to determine which species use this urban environment and how species composition changes across seasons. I surveyed bats at four sites in The Bronx: the New York Botanical Garden, the Rose Hill campus of Fordham University, the highly urbanized Arthur Avenue neighborhood, and the Bronx Zoo. I surveyed each site using passive and active acoustic recorders designed to record ultrasonic bat vocalizations. During the summer of 2012, I conducted active surveys weekly at each site for two hours, beginning at sunset. From May 2012 until March 2013, I used passive recorders placed on rooftops to record from civil twilight to civil twilight. I determined species presence using Sonobat, an acoustic analysis software program. I confirmed the presence of the eastern red bat (*Lasiurus borealis),* big brown bat (*Eptesicus fuscus),* silver-haired bat (*Lasionycteris noctivagans),* hoary bat (*Lasiurus cinereus)*, little brown bat (*Myotis lucifugus)*, the eastern pipistrelle (*Perimyotis subflavus)*, and small-footed myotis (*Myotis leibii)* in The Bronx. In addition, Sonobat identified recordings from two species not previously documented in New York State: the evening bat (*Nycticeius humeralis)* and Rafinesque's big-eared bat (*Corynorhinus rafinesquii).* Overall bat activity was highest during July and August. I also documented winter activity of both silver-haired bats and hoary bats. Determining the presence and seasonal variation in activity of bat species in The Bronx will greatly contribute to overall knowledge of urban bats and aid in improving management of urban spaces for bat conservation efforts.

**Background:**

Urbanization is a threat to many species due to lowering species richness of populations and lowering access and availability of resources (McKinney 2002, Czech et al. 2000). Cities appear to have lower abundance and diversity of bat species (Kurta and Teramino, 1992). However, some bat species are able to adapt to and even flourish in urban environments (McKinney 2002). The effect of urbanization on insectivorous bats is significant, but varied (Threlfall et al. 2011). However, species show differences in their ability to adapt to urban and suburban habitats (Duchamp et al., 2004). Increasing bat activity in urban areas and urban-rural interfaces is correlated with some bat species, such as the big brown bat, which use lower range echolocation, faster flight, and forage in open areas (Threlfall et al. 2011, Duchamp et al., 2004).

Adaptations to urban environments observed in bats include the use of city streetlamps for foraging (Rydell 1992), use of man-made structures for roosting (Brigham 1991, Gaisler et al., 1998), and use of urban parks for foraging (Avila-Flores and Fenton, 2005). Large urban parks are particularly conducive to foraging for some bat species when compared with highly urbanized centers and agricultural land (Avila-Flores and Fenton 2005, Walters et al., 2007). Among urbanized areas, the best predictor of bat abundance and diversity at urban-rural interfaces is at the microhabitat level rather than overall landscape level (Gehrt et al., 2004). Therefore, effective bat conservation in urban areas must include an understanding of the species present, their relative ability to adapt to urban environments, and their use of urban microhabitats.

Many bat populations in the Northeastern U.S. are in serious decline, largely due to the emergence and spread of white-nose syndrome (Blehert et al., 2009). White-nose syndrome is a fungal disease affecting hibernating bats, particularly little brown bats, eastern pipistrelles, and northern long-eared bats (Blehert et al., 2009). Between 2006 and 2008, researchers conducting bat population surveys in the Northeast estimated a 75% decline in population size (Blehert et al., 2009). White-nose syndrome poses a serious threat to Northeastern bats; and in face of increasing urbanization, species affected by this disease that are less able to adapt to urban environments are in danger.

The bats found in the Northeastern U.S. are insectivorous echolocating mircrobats. Species currently known to be present in New York State are the eastern red bat (*Lasiurus borealis),* big brown bat (*Eptesicus fuscus),* silver-haired bat (*Lasionycteris noctivagans),* hoary bat (*Lasiurus cinereus)*, little brown bat (*Myotis lucifugus)*, Indiana bat (*Myotis sodalis)*, eastern pipistrelle (*Perimyotis subflavus)*, northern bat (*Myotis septentrionalis)*, and small-footed myotis (*Myotis leibii)* (Stegemann and Hicks, 2008). The three bat species documented to be heavily affected by white-nose syndrome are all present in New York (Blehert et al., 2009). Of these species, the big brown bat, eastern pipistrelle, and the little brown bat show positive adaptation to urban environments (Coleman and Barclay 2012, Avila-Flores and Fenton, 2005, Rydell 1992) whereas urbanization has a negative effect on silver-haired bats, hoary bats, and eastern red bats (Coleman and Barclay 2012).

Despite the decline in Northeastern bat populations and the varying responses of bat species to urbanization, I am aware of no published studies of bats in New York City. Due to the varied response of the species found in New York State to urbanization, a better understanding of populations of bats in New York State cities is essential for managing bat conservation in the state. My study attempts to determine which bat species are present in a major urban area of New York in order to provide information necessary for effective urban bat conservation.

**Methods:**

Because observing and tracking bats is difficult due to their small size and nocturnal nature, previous studies used ultrasonic recording devices to identify bat species based on distinctive characteristics of their vocalizations (MacDonald et al., 1994). Echolocating bats have multiple types of calls including navigational calls, prey-detecting calls, and social calls (Altringham, 1996). Prey-detecting calls especially differ between species in frequency range and call duration, and these differences can be used to identify species based on echolocation calls (Altringham, 1996). Therefore, bat populations can be surveyed acoustically. My study used recordings of vocalizations to survey a population of bats in The Bronx, NY, as well as to examine seasonal changes in bat species' presence and activity.

I used passive and active acoustic monitoring to survey bats at four sites in The Bronx, NY: the Rose Hill Campus of Fordham University, the New York Botanical Garden, the Bronx Zoo, and the Hughes Avenue neighborhood of the Bronx (also known as Little Italy) (Figs 1 and 2). I conducted passive recording with SM2BAT+ acoustic recoding units (Wildlife Acoustic, Concord, MA). The SM2BAT+ units use a trigger system to automatically record ultrasonic echolocation passes picked up by the microphone at a range of approximately 10 meters. SM2BAT+ recorders stored each echolocation pass, consisting of multiple pulses, as one file. I used rechargeable D batteries changed biweekly to power the units and stored the data on removable SD cards.

I placed SM2BAT+ recorders on the roof of Larkin Hall at Rose Hill, the roof of the Pfizer Lab at the New York Botanical Garden, the roof of the former World of Darkness exhibit at the Bronx Zoo, and the roof of a Hughes Avenue apartment building. I elevated microphones approximately two meters from the rooftop. All buildings I used in this study were 3-4 stories tall. I began deploying passive units in May 2012 and continued recording until mid-March 2013.

I conducted active surveys consisting of a weekly walking transect survey at each site using an Echometer 3 (EM3) unit (Wildlife Acoustics, Concord, MA) (Fig. 1). The EM3 uses a trigger system to detect echolocation passes which, along with recording the passes, transforms the frequency by dividing it by 12 to make echolocation audible to humans. In addition, the EM3 displays a visual representation of calls with a sonogram on the screen. The data from these active surveys will be analyzed at a later date and are not presented here.

Bat vocalizations were recorded as individual files. Each file constitutes a pass, which consists of multiple short echolocation pulses (continuous segments on a sonogram) (Fig. 3). Passes are separated by a minimum of 1.0 sec. I analyzed the acoustic data using Sonobat 3.1.3 NE acoustic analysis software (Sonobat, Arcada, CA). Sonobat examines each pulse in a pass individually and makes a final identification based on having at least two high quality pulses identified to the same species. I programmed Sonobat to consider any pulse above a quality level of 0.7 (out of 1.0) and accepted any classification with a threshold probability discrimination above 0.8 (out of 1.0), which measures each pulse against species-specific reference pulses. I manually examined sonograms of passes from species more difficult to identify, including the little brown bat, the Indiana bat, and two species included in Sonobat's reference library that are not normally found in New York State, the evening bat and Rafinesque's big-eared bat.

I examined the total number of passes per species at each site, number of species present at each site, and relative species composition at each site. To compare activity levels between sites, I used a one–way ANOVA for total number of calls recorded at each site for the duration of the study.

The acoustic survey method I used for this study cannot be used to determine or estimate bat population size. SM2BAT+ units record all passes detected but cannot distinguish between individual bats. Thus, only relative bat activity can be quantified. All activity data presented in this study is relative bat activity based on number of calls recorded.

**Results:**

Sonobat identified nine bat species from recordings at all sites from my passive detectors: the little brown bat, big brown bat, silver-haired bat, small-footed bat, eastern pipistrelle, eastern red bat, hoary bat, Rafinesque's big-eared bat, and evening bat. (Table 1, Fig. 4). I documented bat activity, defined as number of passes recorded, for all species at all sites and found two peaks in overall activity: one in August and one in October (Fig. 5). The most active species was the eastern red bat (Fig. 6). The silver-haired bat and hoary bat were active during winter months at the New York Botanical Garden and Hughes Avenue sites (Fig. 5), with the greatest winter activity at the Hughes Avenue site. I detected silver-haired bats in January and February and hoary bats in December, January, February, and March.

I found a significant difference in overall bat activity between sites, with higher amounts of overall activity at the Bronx Zoo and Rose Hill sites and the least amount of activity at the New York Botanical Garden site ($p<0.001$) (Fig. 7).

**Discussion:**

Out of the nine bat species known to be present in New York State, I documented seven species of bat at one or more of the Bronx sites I surveyed. Additionally, Sonobat identified calls belonging to Rafinesque's big-eared bats and evening bats, species not known to occur in New York State.

I confirmed that Bronx bat populations are composed of multiple species and generally represent the diversity of species found in the State. The two New York species I did not detect are the Indiana bat, which is an endangered species rarely found in New York, and the northern bat, which is typically found in cluttered forests (Stegemann and Hicks, 2008). Any conservation efforts involving New York bats should not discount urban areas as potential breeding, foraging, and migration sites. While the presence of Rafinesque's big-eared bat and the evening bat cannot be conclusively confirmed based on this study alone, further efforts should be made to determine their presence or absence in New York State and their ability to adapt to Northeastern urban areas.

The peak activity for the majority of the species detected was in the months of July and August. Some of this trend may be due to error bias due to the detectors being deployed later at Hughes Avenue and the Bronx Zoo as well as detector malfunction that occurred at the New York Botanical Garden during the middle of July, the temporary loss of the microphone at the New York Botanical Garden during Hurricane Sandy in October, and the theft of the microphone at Hughes Ave which prevented recording during the last two weeks of June and the first week of July. However, the overall trend in the data suggests that bats are most active in The Bronx during July and August which likely corresponds to the breeding season, rather than autumn months, which might correspond to the migratory season.

Most surprising was the detection of bat activity in December, January, and February. White-nose syndrome causes bats to emerge from hibernacula at abnormal times, such as winter (Blehert et al., 2009). However, the two species detected in winter, the hoary bat and the silver-haired bat, are species that are not currently thought to be affected by white-nose syndrome. I documented the greatest winter bat activity at the most urbanized of my study sites: Hughes Avenue. Urban landscapes are generally warmer than non-urban areas, and this phenomenon is known as the urban heat island effect (Bornstein 1968). Perhaps the more urbanized Hughes Avenue site was warmer than my other sites which may have affected winter bat activity. At this time, I cannot say what is causing these bats to be active during the winter, but I will correlate this activity with weather data to examine possible associations with temperature or other weather variables.

Given how little is known about urban bats in the Northeastern U.S., further studies are necessary to better understand these populations. This study should be expanded to include other parts of The Bronx as well as the other boroughs of New York City and, eventually, other major urban centers. Further study into seasonal patterns to determine which species are using urban areas for breeding, foraging, and migration is also important. Information on where the bats we documented roost or hibernate is needed. Finally, as previous studies in other parts of the world showed that urban microhabitats can affect insectivorous bat activity, it could be useful to determine which New York City microhabitats are most suited to bat use.

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## Figures:

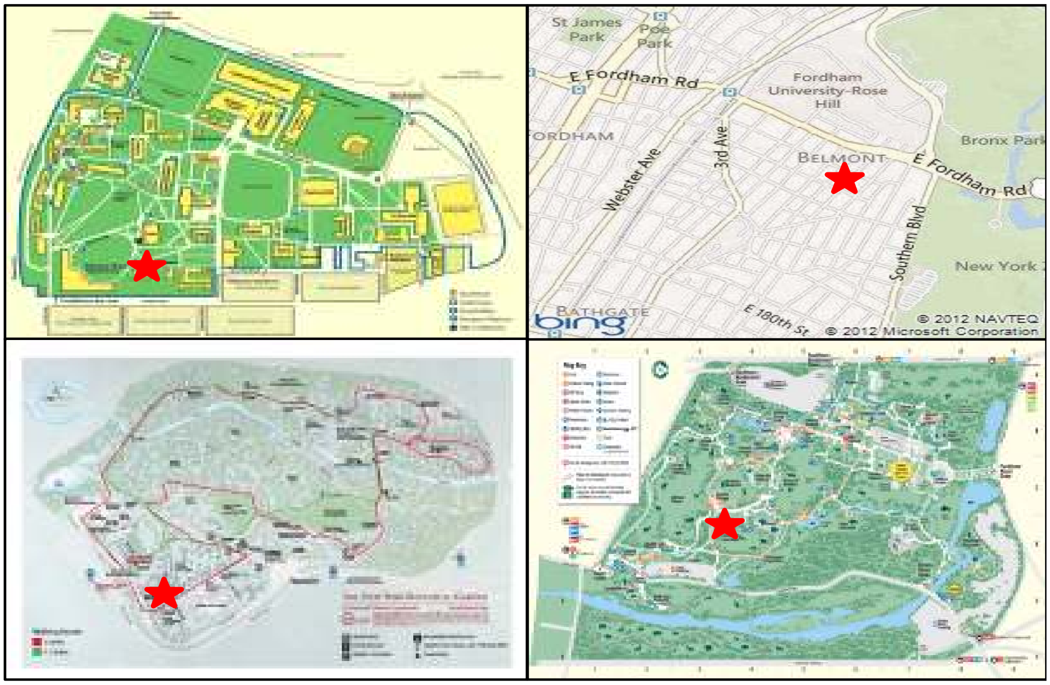


Fig. 1: Locations of passive ultrasonic acoustic recorders: Rose Hill (top left), New York Botancial Garden (top right), Hughes Avenue (bottom left) and Bronx Zoo (bottom right) survey sites. Red star indicates location of the passive recorder at each site.

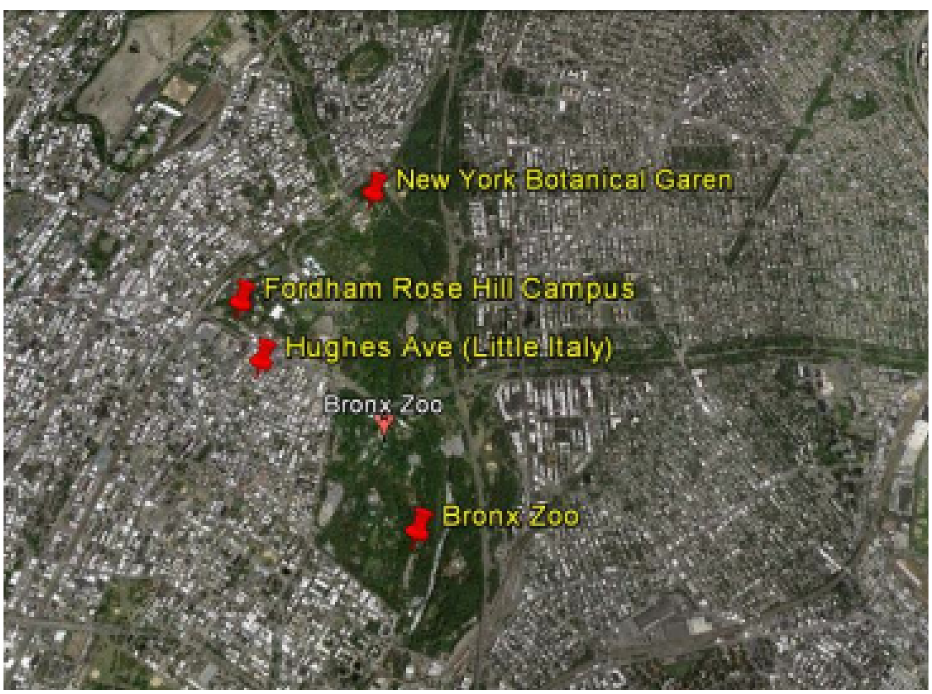


Fig. 2: Location of passive ultrasonic recorder sites in The Bronx.

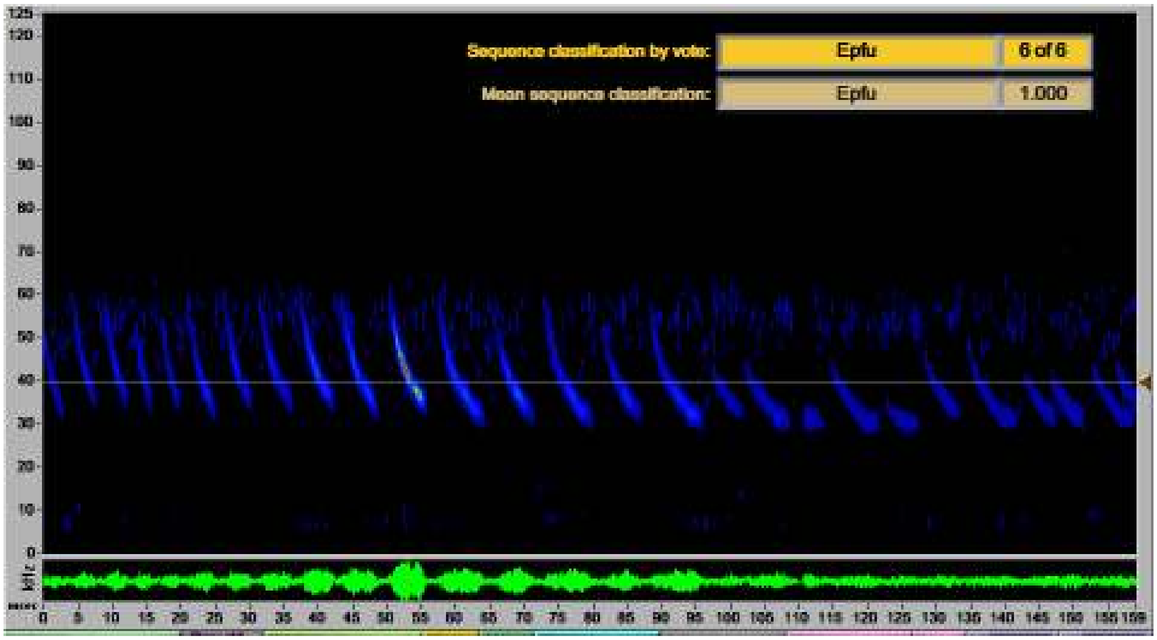


Fig. 3: A big brown bat (Epfu) pass recorded on Fordham University's Rose Hill campus, displayed as a sonogram in Sonobat.

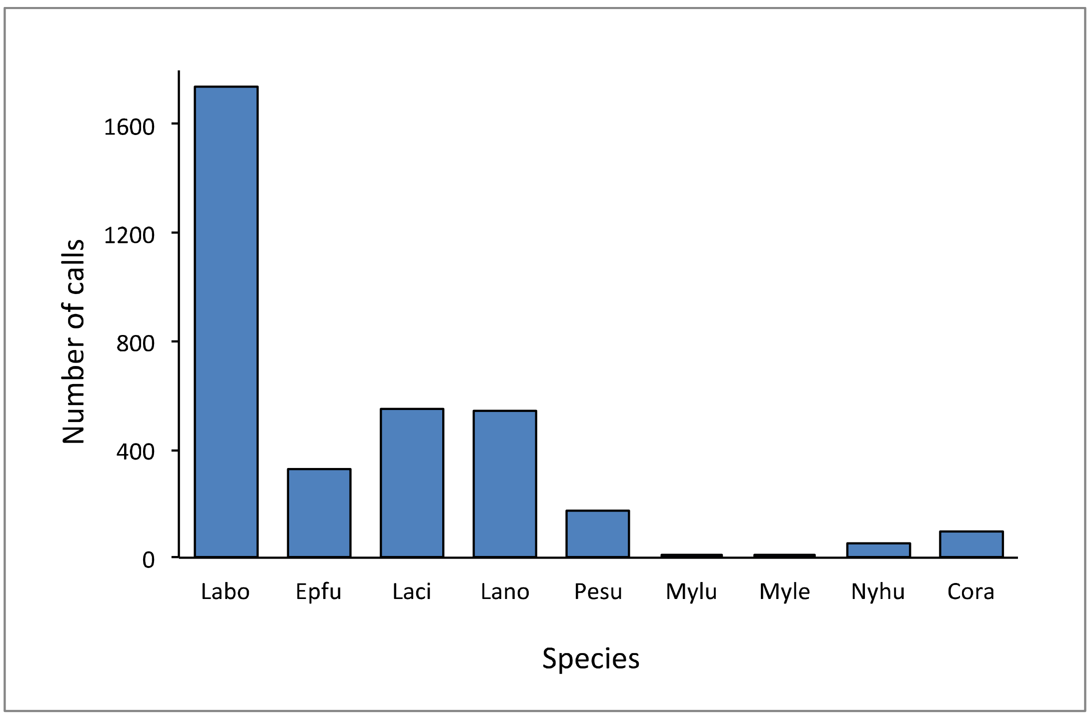


Fig. 4: Total bat activity of each species at all sites. Species are eastern red (Labo), big brown (Epfu), hoary (Laci), silver-haired (Lano), eastern pipistrelle (Pesu), little brown (Mylu), small-footed (Myle), evening (Nyhu), and Rafinesque's big-eared (Cora).

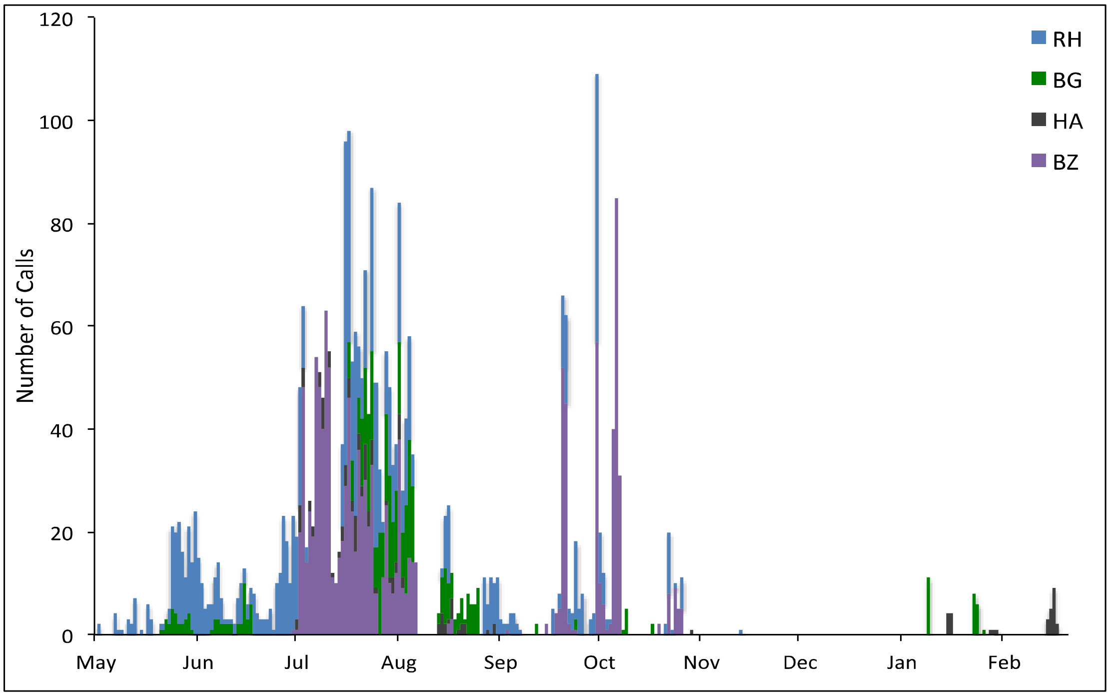


Fig. 5: Total bat call activity at Rose Hill (RH), New York Botanical Garden (BG), Hughes Avenue (HA), and the Bronx Zoo (BZ).

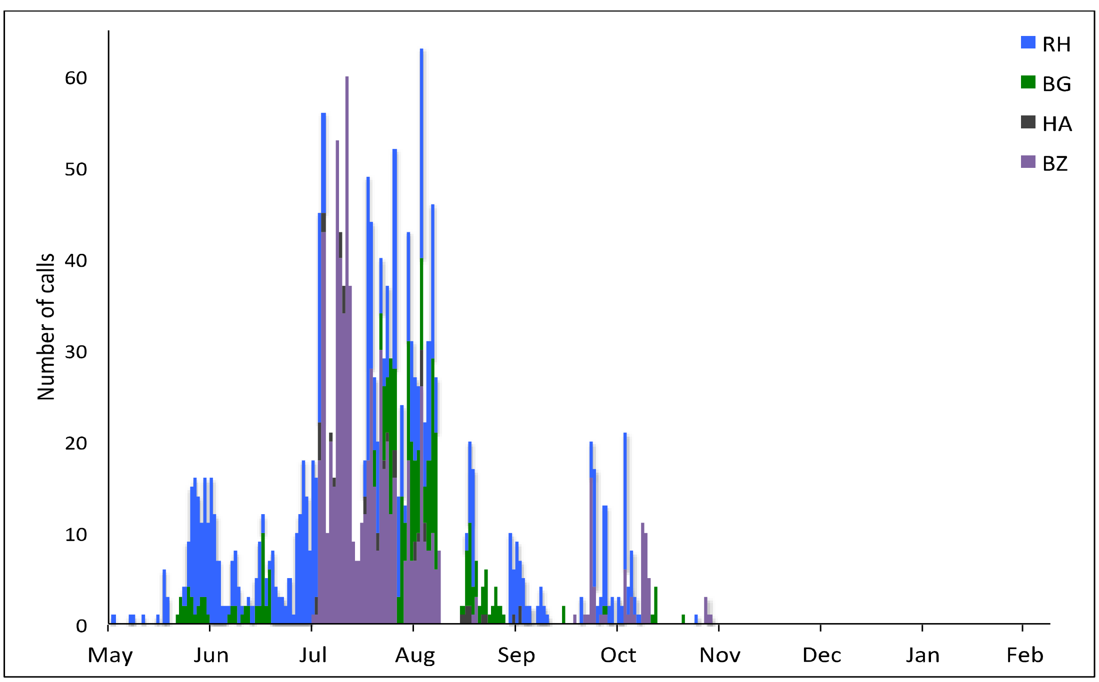


Fig. 6: Total eastern red bat call activity at Rose Hill (RH), New York Botanical Garden (BG), Hughes Avenue (HA), and the Bronx Zoo (BZ).

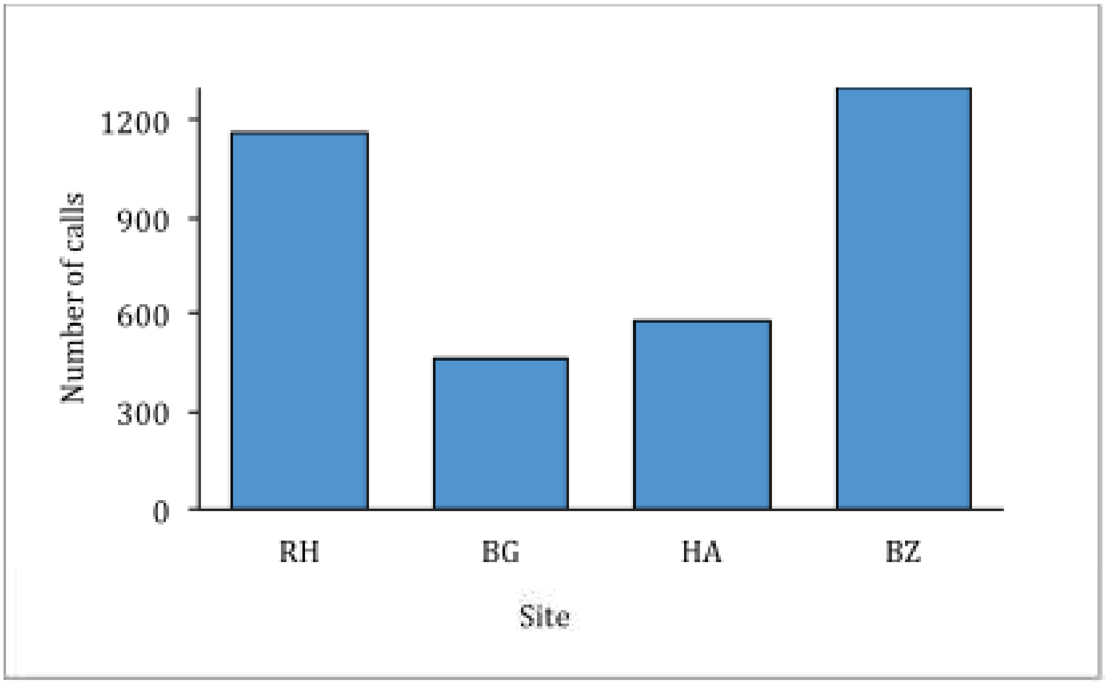


Fig. 7: Total call activity of all bat species at Rose Hill (RH), New York Botanical Garden (BG), Hughes Avenue (HA), and the Bronx Zoo (BZ) during an acoustic survey from May 2012 through March 2013.

**Table 1.** Total call activity of all bat species and activity of each species at Fordham University's Rose Hill Campus (RH), New York Botanical Garden (BG), Hughes Avenue (HA), and Bronx Zoo (BZ) field sites.

| Species | RH | BG | HA | BZ | Total |
|---|---|---|---|---|---|
| Eastern Red Bat (Labo) | 701 | 278 | 44 | 720 | 1743 |
| Big Brown Bat (Epfu) | 169 | 49 | 6 | 105 | 329 |
| Hoary Bat (Laci) | 50 | 19 | 437 | 45 | 551 |
| Silver-haired Bat (Lano) | 148 | 30 | 39 | 325 | 542 |
| Eastern Pipistrelle (Pesu) | 62 | 39 | 9 | 62 | 172 |
| Little Brown Bat (Mylu) | 2 | 2 | 0 | 2 | 6 |
| Small-footed Bat (Myle) | 0 | 1 | 0 | 4 | 5 |
| Evening Bat (Nyhu) | 3 | 15 | 12 | 19 | 49 |
| Rafinesque's Big-eared Bat (Cora) | 26 | 25 | 26 | 15 | 92 |
| **Total** | **1161** | **458** | **573** | **1297** | **3489** |

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