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SEX RATIOS OF THE BIG BROWN BAT, *EPTESICUS FUSCUS*, AT AN URBAN-RURAL INTERFACE

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ABSTRACT. Wildlife responds to urbanization in a variety of ways. Some species, including the big brown bat (*Eptesicus fuscus*), take advantage of anthropogenic landscapes and can thrive in association with humans. The species is often found in association with humans, and is known to exploit urban environments. Females of many bat species, including the big brown bat, are sexually segregated during summer when females roost communally and males individually. The purpose of this study was to examine if there is gender bias in the distribution of this otherwise ubiquitous species across an urban/rural interface associated with conservation lands owned by the Indianapolis International Airport. Using a long-term data set, we compared sex ratios of big brown bats captured from a rural area south of Interstate 70 to the more urbanized northern region north of Interstate 70. Both areas were dominated by female big brown bats, but a greater proportion of males were captured in the rural area.

Keywords: Urbanization, big brown bat, *Eptesicus fuscus*, sex ratio, habitat

INTRODUCTION

Urbanization is known to affect wildlife in different ways (McKinney 2002; Duchamp & Swihart 2008). Many species can be negatively impacted by human development (McKinney 2006), while some species are known to take advantage of man-made structures (i.e., dwellings, outbuildings) and act as exploiters and/or adapters (Whitaker & Gummer 1992; Ordenana et al. 2010). While several studies have focused on community diversity and how urbanization impacts large portions of local fauna (Kurta & Teramino 1992; Sparks et al. 1998; Gehrt & Chelsvig 2004; Whitaker et al. 2004; Ulrey et al. 2005; Marchetti et al. 2006; Ordenana et al. 2010), there is limited research explaining how urbanization and urban sprawl affect the sexual distribution of different wildlife.

Bat diversity can serve as a reliable indicator of habitat quality and level of disturbance (Medellín et al. 2000). Some species thrive in an anthropogenically-disturbed environment (Gehrt & Chelsvig 2004; Oprea et al. 2009), while others are rarely found in association with humans. The big brown bat (*Eptesicus fuscus*) is relatively adaptable to human presence and development (Williams & Brittingham 1997; Duchamp et al. 2004; Neubaum et al. 2007), and is often found using human-made structures such as homes, barns, and outbuildings (Whitaker & Gummer 1992; Duchamp et al. 2004; Whitaker et al. 2004).

The Indianapolis International Airport (IND) began funding annual bat assessments as early as 1991 as part of mitigation for the federally endangered Indiana myotis (*Myotis sodalis*). Associated with additional airport development in 2001, a Habitat Conservation Plan (HCP) was designed (by American Consulting, Inc. in concert with the Indianapolis Airport Authority, IAA), approved by U.S. Fish & Wildlife Service, and implemented shortly thereafter. Due to the consistency of net site protocol since the HCP began, IAA has much data on the distribution, abundance, and richness of the bat species at this urban-rural study site (Whitaker et al. 2004; Ulrey et al. 2005; Damm et al. 2011; Whitaker et al. 2011), as well as bat foraging (Duchamp et al. 2004; Sparks et al. 2005a, 2005b; Walters et al. 2007) and roosting habits (Ritzi et al. 2005; Whitaker et al. 2006).

None of the prior studies examined whether urbanization influences sex ratios among bats

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captured at the site. Big brown bats are a reasonable choice for such a study because unlike some other local species, there are no larger-scale differences amongst the sexes in migratory behavior (Whitaker et al. 2007), and many individuals are captured each year (Whitaker et al. 2004).

METHODS

Study area.—The Indianapolis International Airport (IND; 39°42′57″N, 86°16′07″W) is situated on the southwestern edge of Indianapolis, a major US metropolis. The study area was located to the southwest of IND on lands purchased by the Indianapolis Airport Authority and was bordered by US Highway 40 and Indiana Highway 67 to the north and south, respectively (Fig. 1). Indiana Highway 267 bordered the study site to the west. Interstate Highway 70 (I-70) was chosen as a halfway point as it bisected the study site into northern and southern sections, with the area north of I-70 being more developed owing to an increasing warehouse district and the sample sites are immediately adjacent to the airport. The percentage of urban ground cover within 2 km of the net site to the north ranged from 27.6–43.1 percent (Table 1). The area south of I-70 is a matrix of agricultural and residential parcels with many small, scattered woodlots ranging approximately 30–40 ha in area. Urban ground cover in the south ranged from 4.4 to 19.4 percent. All 10 of the net sites used in this study were located along the East Fork of White Lick Creek (WLC), a medium-sized perennial stream which runs north to south through the study area. The terminal sites measure approximately 10.7 km apart. This stream bisects the study area from the east side of Mooresville in the south to the west side of Indianapolis to the north. The banks of WLC are mostly wooded, with the dominant woody species being box elder (*Acer negundo*), eastern cottonwood (*Populus deltoides*), hackberry (*Celtis occidentalis*), sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), and black walnut (*Juglans nigra*). Most open areas are either cultivated or developed. The woodlots that are not adjacent to the WLC are dominated by black walnut (*Juglans nigra*), bitternut hickory (*Carya cordiformis*), shagbark hickory (*Carya ovata*), shellbark hickory (*Carya laciniosa*), northern red oak (*Quercus rubra*), white oak (*Quercus alba*), sugar maple (*Acer saccharum*), honey locust (*Gleditsia triacanthos*), and American elm (*Ulmus americana*). As part of the airport's mitigation activities, properties have been purchased and small (30–40 acre) woodlots planted along the WLC.

Mist netting.—The bat community was sampled annually from 15 May–15 August of 2002 – present day. Data from 2002–2010 is used in this study. Mist-netting was conducted for two reasons: 1) to monitor and annually assess the overall bat community at the airport, and 2) to radio-tag Indiana myotis for roosting and foraging data. Standardized data taken from every bat included species, sex, reproductive status, length of right forearm, and body mass in grams. Each individual also received an individually numbered aluminum wing band (Porzana Ltd., United Kingdom) placed on the right or left forearm for male and female, respectively.

Netting sessions were conducted at 10 sites along White Lick Creek, four to the north and six to the south of I-70. Each site was sampled three times in a season. At each site, two mist nets were placed in such a way as to seal the flyway along the creek. All nets were set in place by dusk (approximately 2100 hr) and consisted of two and/or three 9 m × 2.6 m mist nets. Nets remained in place until at least 0115 hr, unless adverse weather required them to be taken down earlier.

Data analysis.—Sex ratios of the big brown bat were categorized based on sex and region in Microsoft Excel 2007. Ratios were then compared to look for differences in the number of each sex which could possibly be due to greater urbanization. Sex ratios for the big brown bat were compared using a G-Test for independence in program R v.2.13.0 (R Development Core Team). Recaptures were excluded from analyses. The G-Tests were run using code written by Peter Hurd (http://www.psych.ualberta.ca/~phurd/cruft/g.test.r) and were corrected using a William's correction. Similar G-Tests tests were also run to examine the difference within each sex in the two regions.

RESULTS

Female big brown bats were the dominant sex in nearly all years for both north and south (Fig. 2); in 2009 in the southern area both male and female totals equaled 24 individuals each (Table 2). The ratio of female to male big brown bats from 2002–2010 was 3.25:1 in the

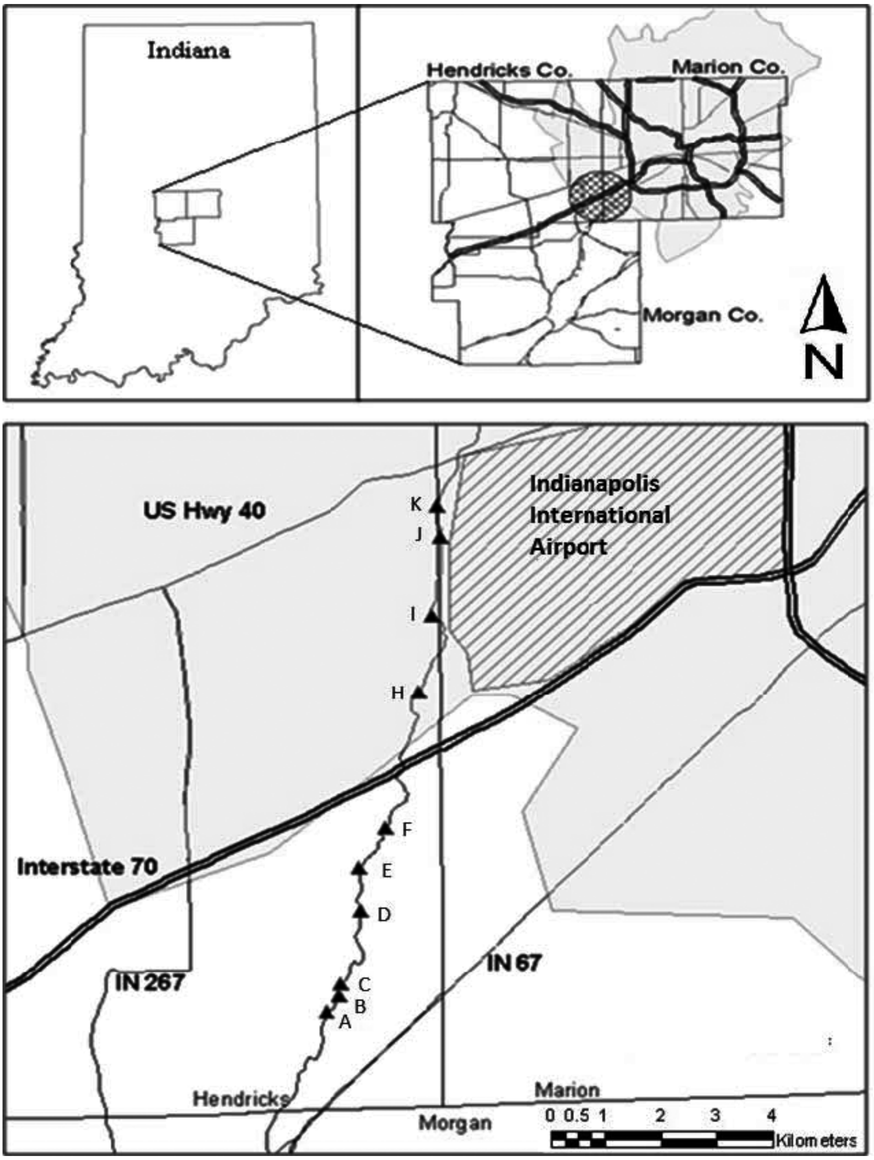

Figure 1.—Location of the study area within the state of Indiana (top left) and greater Indianapolis Metroplex (top right). Bottom shows an overview of the study area, with major roads and the East Fork of White Lick Creek. Net sites are denoted by black triangles. Thatched area represents the Indianapolis International Airport.

northern areas and 2.18:1 in the south. A total of 332 (76.5%) females and 102 (23.5%) males were captured in the north, and 325 (68.6%) females and 149 (31.4%) males were tallied in the south.

There was a significant female bias in all captures throughout the study area ($G = 7.15$, *d.f.* $= 1$, $p = 0.0075$). Comparatively, proportions of females within the urban north and rural south were similar ($G = 0.075$, *d.f.* $= 1$, $p = 0.78$), but males were proportionally more abundant in the south ($G = 8.84$, *d.f.* $= 1$, $p = 0.0030$).

DISCUSSION

To date, few studies have examined possible differences in sex ratio of vertebrates between an urban and rural area. These results show

Table 1.—Percent of urban and forested ground cover within 2-kilometers of each net site at the study area near the Indianapolis International Airport, Indianapolis, Indiana.

Net site	Percent urban	Percent forested
A	9.8	29.9
B	7.7	29.6
C	9.3	29.9
D	10.0	21.7
E	4.4	28.1
F	19.4	17.7
H	34.7	15.4
I	30.5	8.8
J	27.6	17.4
K	43.1	18.3

that at this location, urban landscape is a significant variable affecting the number of males present, while female ratios of this species did not change. This differs from the results of Kurta & Teramino (1992), who observed no difference in sex ratio with this same species in the Detroit, Michigan area. In another study, Kurta & Matson (1980) found that in Michigan, there was a significantly greater number of *E. fuscus* males than females. They attributed this to longer lifespan for males. Many members of this species seldom move very far from their natal colony (Mills et al. 1975), which implies that the ratios shown are reasonably representative of our study site.

Female big brown bat captures were approximately the same in both the urbanized north and more rural south areas of the project site. Female big brown bats often form maternity colonies in great numbers (Kurta & Baker 1990; Whitaker & Mumford 2009). The presence of maternity colonies in both the rural and urban portions of this study area (Duchamp et al. 2004; Whitaker et al. 2004) likely explains the overall

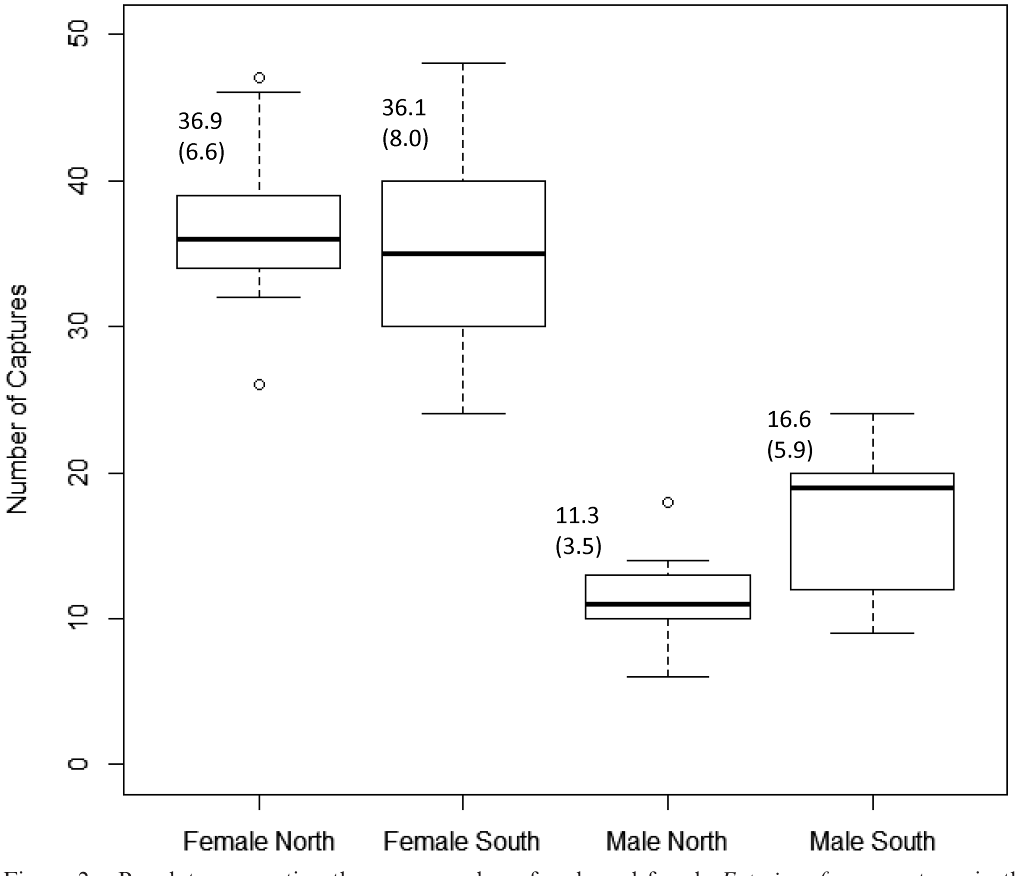

Figure 2.—Boxplot representing the mean number of male and female *Eptesicus fuscus* captures in the north and south regions of the Indianapolis International Airport Conservation Properties. Hollow circles represent outliers. Numbers represent the mean captures per year, with standard deviation in parentheses.

Table 2.—Number of male and females big brown bats captured from 2002 through 2010 in the north and the south portions of the study area near the Indianapolis International Airport, Indianapolis, Indiana.

		Year									
		2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Female	North	26	35	39	46	32	36	47	37	34	332
	South	48	46	33	35	40	30	29	24	40	325
	Total	74	81	72	81	72	66	76	61	74	657
Male	North	6	18	12	14	11	8	10	10	13	102
	South	24	12	12	19	20	10	19	24	9	149
	Total	30	30	24	33	31	18	29	34	22	251
Total		104	111	96	114	103	84	105	95	96	908

bias toward females. Males are typically solitary in the summer, and thus may be spread more evenly throughout the area. Furthermore, lactation requires both a high caloric diet and ready access to water, which may bias females to foraging along WLC where both resources are abundant. Males, conversely, may be just as abundant but are able to exploit smaller foraging and drinking patches. Such a behavioral difference might help alleviate competition with both female big brown bats and the other eight species of bats that occur along WLC.

Of particular interest is the potential for these data to provide insight into changes in big brown bat distributions following the January 2011 detection of White-Nose Syndrome (WNS) in Indiana. This fungal disease has caused marked declines in many cave-hibernating bats across the eastern United States and adjacent Canada (Turner et al. 2011; Francl et al. 2012). Some big brown bats are known to be killed by WNS (Blehert et al. 2008), but summer capture rates indicate the species is able to persist after the arrival of this disease (Francl et al. 2012). To date gender-bias in mortality has not been explored, but a changing sex ratio at the Indianapolis Airport may be an early sign that disruptive, differential mortality exists. Conversely, the rapid disappearance of other species from the community may allow male big brown bats greater access to foraging and roosting areas associated with WLC.

Finally, many species have the ability to control the gender of their offspring by either producing more juveniles of one gender (i.e., a difference in the primary sex ratio) or by behavioral activities that ensure differential survival of one gender. Big brown bats produce twin pups and have a balanced primary sex ratio (Burnett & Kunz 1982). Females have been observed nursing both male and female juveniles (D. W. Sparks unpublished), and thus have the opportunity to provide differential levels of care. Such ability may prove important if the adult in question has a compromised ability to forage or care for young following infection with WNS.

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