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Bats of St. Kitts (St. Christopher), Northern Lesser Antilles, with Comments Regarding Capture Rates of Neotropical Bats

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ABSTRACT.—Only four species of bats have been previously reported from the Antillean island of St. Kitts—*Noctilio leporinus*, *Artibeus jamaicensis*, *Molossus molossus*, and *Tadarida brasiliensis*. Our field research reported herein adds three species to this list—*Monophyllus plethodon, Ardops nichollsi*, and *Brachyphylla cavernarum*. These efforts included mist netting in a variety of foraging habitats and extensive surveys of natural and anthropogenic roost sites. We discuss the difficulty in accurately reporting mist-netting effort and capture rates. The average rate of fruit bat captures during 2001 on St. Kitts (1.11 bats per net-night - BNN) falls towards the lower end of the range (0.65-2.47 BNN) reported from nearby islands in the northern Lesser Antilles and the lower end of the range (2.20-5.93 BNN) reported for mainland populations of neotropical fruit bats. We discuss possible causes of these decreased population levels, such as the impact of recent hurricanes and competition from the large population of vervet monkeys (*Cercopithecus sabaeus*) found on St. Kitts.

KEYWORDS.—fruit bats, capture rates, natural disasters, St. Kitts, Chiroptera

INTRODUCTION

No comprehensive survey of the chiropteran fauna of the Antillean island of St. Kitts had been undertaken in the past. Only four species of bats have been reported in the literature from the island—*Noctilio leporinus*, *Artibeus jamaicensis*, *Molossus molossus*, and *Tadarida brasiliensis*—and these appeared in scattered reports. The first species of bat reported from St. Kitts was *Tadarida brasiliensis* by Miller (1902; see also G. M. Allen 1911; Shamel 1931; Koopman 1968). This was followed by a report in 1904 of *Artibeus jamaicensis* by J. A. Allen (1904: 231; see also Andersen 1908: 267 and Anthony 1918: 354). In 1913, Miller (1913) described the new species *Molossus debilis* as occurring on Nevis, Antigua, and Montserrat, with a type locality of St. Kitts. This taxon is now considered a junior synonym of *Molossus molossus*. Finally, Jones (1951) lists St. Kitts among a group of islands for which there are specimens of *Noctilio leporinus* in the British Museum (Natural History).

The first systematic survey of the bats of St. Kitts and the adjacent island of Nevis was performed by Morton and Courts in 1999 (Pedersen et al. 2003). Although mist-netting was performed in 1999, this survey focused primarily on roost surveys for future work concerning conservation efforts and further study. The survey conducted by Pedersen, Genoways, and Kwiecinski in July 2001 provided the first significant results from mist-netting data on bats foraging in a variety of habitats on St. Kitts. Goals of the 2001 survey were to provide new species records for St. Kitts, comparative data for ongoing research on Lesser Antillean bats on islands north of Guadeloupe, and data for local agency conservation efforts. Herein, we provide previously unpublished records for three species of bats from St. Kitts—*Monophyllus plethodon, Brachyphylla cavernarum*,

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and *Ardops nichollsi*—as well as data on the distribution and natural history of all species currently known from the island.

Methods and Materials

Study area

St. Kitts is a small island located at 17°15′N, 62°40′W in the northern Lesser Antilles. St. Kitts is joined politically with the island of Nevis in the nation of St. Kitts and Nevis. St. Kitts has an area of 176 square kilometers, being a relatively long (37 km), narrow (8 km at widest point) island that is dominated by the volcanic cone of Mt. Liamuiga at 1155 m, active most recently in 1843. Nevis and St. Eustatius lie across shallow channels 3.5 km wide to the southeast and 14.5 km wide to the northwest, respectively. St. Kitts has a mild tropical climate with high temperatures averaging to 26 °C in August and September and 23 °C in February. The island receives an average of 140 cm of rain per year.

St. Kitts has a relatively high mountainous backbone running in a northwest to southeast direction surrounded by an apron of fertile valleys and low volcanic coastal areas, which are either under intensive cultivation for sugarcane or are covered with secondary scrub and thorn-bush, known in the West Indies as ruinate vegetation (Beard 1949). Hurricane Georges caused considerable damage on St. Kitts and Nevis when it made landfall southeast of Basseterre, St. Kitts, on September 21, 1998. In subsequent years, Hurricanes José (1999), Lenny (1999), and Debby (2000) have impacted St. Kitts.

Mist-netting efforts

The first mist-netting on St. Kitts occurred during March 16 to May 3, 1999 and consisted of ten nights (Morton and Courts). At each netting site, five six-meter mist nets were erected in a circle with radius of 30 m with two nets forming a "V". Other nets were set singly or in groups depending on local features (e.g., water bodies, forest edge). Within this circle, nets were placed to take advantage of features likely to attract bats (e.g., fruiting trees, fresh water). Nets were opened between 6:00 and 6:30 PM and closed between 11:00 and 11:30 PM each night. The second mist-netting period consisted of nine nights during July 12 to 20, 2001, and was performed by Pedersen, Genoways, and Kwiecinski. Mist-netting for bats in 2001 was conducted in a variety of habitats, including naturally vegetated guts, fruit plantations, ponds, rivers, reservoirs, covered flyways, and access roads. Many locations had significant amounts of fruit on the ground. Five to eight mist-nets of varying lengths were erected at each location frequently situated diagonally across a trail or stream at 20 to 100 m intervals and monitored for four to six hours depending on activity and weather. In both surveys, bats were measured and examined at the end of the evening: weight (g), length of forearm (mm), reproductive status, tooth wear, presence of scars, and external parasites. We followed the methods of Findley and Wilson (1983) in determining the capture rates of bats (bats per net-night – BNN) because the dimensions and orientation of the mist nets are not always provided in the literature (Findley and Wilson 1983; see also LaVal 2004).

Roost surveys

Based on a literature review and interviews with personnel at the St. Christopher Historical Society, several roosts were identified as being likely occupied by bats. Morton and Courts used the Directorate of Overseas Surveys 1:25,000 map of St. Kitts (6th ed. 1984) to identify potential roost sites (caves, tarrish pits, ruins, disused buildings, churches, houses, bridges, and culverts). A total of 172 potential roosting sites at 79 separate localities were checked for evidence of bats in 1999.

Voucher specimens

A survey of existing collection materials in natural history museums (American Museum of Natural History, AMNH; Field Museum of Natural History, FMNH; Museum of Comparative Zoology, Harvard

University, MCZ; Museum of Vertebrate Zoology, University of California, Berkeley, MVZ; National Museum of Natural History, NMNH) yielded an additional 51 specimens of bats from St. Kitts. All voucher specimens from the 2001 survey were deposited in the research collections at the University of Nebraska State Museum (UNSM). Length of forearm and cranial measurements (mm) were taken from museum specimens using digital calipers and weights were recorded in grams. Measurements were taken following Hall (1946), except that greatest length of skull included the incisors, and length of forearm is the distance from elbow joint to tip of carpals with the wing in retracted position. StatView® software package (Sager 1992) provided standard statistics for each sample and paired t-tests were used to test for differences in group means.

RESULTS

Mist-netting

Our mist-netting surveys (Tables 1, 2) included 107 net-nights and yielded 184 captures of 5 species of bat—*Monophyllus plethodon, Brachyphylla cavernarum, Artibeus jamaicensis, Ardops nichollsi*, and *Molossus molossus*. During March 16 to May 3, 1999, 39 bats were captured in 50 mist-nets. Twenty of those nets were closed early in the evening without captures, due to high wind and rain, effectively limiting the captures to 39 bats in 30 nets, giving an average capture rate of 1.30 bats per net per night (BNN) in 1999. During the second survey, July 12 to 20, 2001, 145 bats were captured in 57 mist-nets nights (average capture rate of 2.54 BNN). If these two surveys are combined, then we observe an overall rate of 2.11 BNN. *Artibeus jamaicensis* were not captured during the 1999 survey, yet *A. jamaicensis* contributed 30% of all mist-net captures in the 2001 survey. In contrast, 28% and 25% of all captures were *Ardops nichollsi* in 1999 and 2001, respectively. The gross differences in overall capture rates for *A. jamaicensis* in the two surveys may be attributed to several factors ranging from seasonal differences, differences in how mist-nets were placed at each site, differences in localities sampled in each survey, and the possibility that there was an actual increase in the bat population.

Roost Surveys

A total of 172 potential roosting sites at 79 separate localities were checked for evidence of bats in 1999 (Figs. 1, 2). Overall, 21 roosts were occupied (12%) of which 57% were used solely by molossids and a single roost housed both *M. molossus* and *A. jamaicensis*. Bats or evidence of their occupancy (typically feces) were found in 12 of the 44 churches checked on St. Kitts. Molossids were noted in each of these 12 roosts and fecal evidence of phyllostomid habitation was found at St. George's Anglican Church, Basseterre, in 1999. Churches (in-use, disused-but not ruined) were used out of proportion (27%) to their availability compared with other roost types such as all other buildings, bridges, culverts, and tunnels (9 of 128: 7%).

TABLE 1. Bat captures by species on St. Kitts, northern Lesser Antilles.

		Roost captures		Habitat captures		
Species	Other	1999	2001	1999	2001	Total
Noctilio leporinus	1	—	—	—	—	1
Monophyllus plethodon	1	—	—	—	3	4
Brachyphylla cavernarum	1	20	10	2	—	33
Artibeus jamaicensis	7	—	—	—	44	51
Ardops nicholsi	2	—	—	11	37	50
Tadarida brasiliensis	21	—	—	—	—	21
Molossus molossus	18?	15	—	26	61	120
Totals	51	35	10	39	145	280

TABLE 2. Length of forearm and cranial measurements for six species of bats occurring on the northern Lesser Antillean island of St. Kitts.

Catalog numbers, statistics, and sex	Length of forearm	Greatest length of skull	Condylobasal length	Zygomatic breadth	Postorbital breadth	Mastoid breadth	Length of maxillary toothrow	Breadth across upper molars
			Monophyllus plethodon luciae					
NMNH 543070, Male	—	23.2	21.6	10.1	4.6	9.7	7.9	5.6
UNSM 27630, Male	42.3	24.1	22.2	10.6	4.7	9.8	8.4	5.7
UNSM 27644, Male	41.5	23.1	21.3	10.5	4.7	10.1	7.7	5.8
UNSM 27578, Female	42.1	22.8	21.4	9.7	4.8	9.4	7.8	5.5
			Brachyphylla cavernarum cavernarum					
UNSM 27624, Male	67.6	32.3	28.7	18.1	6.5	15.0	11.0	11.9
UNSM 27625, Male	65.5	31.7	28.3	17.3	6.5	15.3	11.0	11.7
UNSM 27628, Male	61.7	31.4	27.8	17.0	6.6	14.3	10.9	11.8
UNSM 27620, Female	64.8	30.9	28.0	17.7	6.5	15.0	10.8	11.6
			Ardops nichollsi montserratensis					
NMNH 543072, Male	50.0	23.0	20.2	15.4	5.8	12.4	7.4	9.9
UNSM 27579, Male	49.0	23.4	19.9	15.3	6.1	12.5	7.5	10.0
UNSM 27597, Male	50.3	23.5	20.3	15.4	6.3	12.5	7.7	10.2
UNSM 27576, Female	51.6	24.6	21.5	15.7	6.0	13.0	8.3	10.6
UNSM 27599, Female	54.8	24.4	21.5	15.9	6.2	13.1	8.3	10.8
UNSM 27600, Female	52.1	24.0	20.7	15.6	6.2	13.2	7.7	10.6
			Artibeus jamaicensis jamaicensis					
UNSM 27571, Male	59.0	28.0	24.6	16.5	7.1	14.4	9.7	12.5
UNSM 27572, Male	63.6	28.7	25.6	17.1	7.4	15.0	10.1	12.6
NMNH 526250, Female	58.4	28.9	25.6	16.6	7.2	14.6	9.9	12.7
UNSM 27587, Female	61.4	28.6	25.5	16.7	7.2	15.0	10.0	12.4
UNSM 27588, Female	59.5	27.8	24.8	16.5	7.6	14.6	9.8	12.0
UNSM 27591, Female	60.8	28.0	25.2	17.3	7.5	14.6	10.0	12.6
			Tadarida brasiliensis antillularum					
Males								
N	8	8	8	6	8	8	8	7
Mean ± SE	37.9 ± 0.39	15.9 ± 0.09	14.8 ± 0.09	9.2 ± 0.08	3.7 ± 0.02	8.8 ± 0.07	5.6 ± 0.03	6.6 ± 0.04
Range	(36.0-39.3)	(15.7-16.2)	(14.4-15.2)	(8.9-9.4)	(3.6-3.8)	(8.5-9.1)	(5.5-5.7)	(6.5-6.7)
Females								
N	4	4	4	4	4	4	4	4
Mean ± SE	38.2 ± 0.09	15.6 ± 0.23	14.4 ± 0.19	9.0 ± 0.18	3.6 ± 0.05	8.7 ± 0.19	5.6 ± 0.09	6.3 ± 0.11
Range	(38.0-38.4)	(15.1-16.1)	(14.0-14.7)	(8.7-9.5)	(3.5-3.7)	(8.2-9.1)	(5.4-5.8)	(6.1-6.6)

TABLE 2. Continued.

Catalog numbers, statistics, and sex	Length of forearm	Greatest length of skull	Condylobasal length	Zygomatic breadth	Postorbital breadth	Mastoid breadth	Length of maxillary toothrow	Breadth across upper molars
Molossus molossus molossus								
AMNH 213938, Male	38.8	17.1	14.5	10.1	3.3	9.7	5.7	7.3
NMNH 110928, Male	—	15.8	13.8	9.9	3.3	9.1	5.4	7.0
AMNH 213941, Female	39.2	16.3	14.6	10.2	3.8	9.8	5.8	7.3
NMHN 110927, Female	—	15.1	13.0	9.0	3.0	8.7	4.9	7.0
UNSM 27635, Female	37.4	16.3	14.3	10.0	3.3	9.7	5.7	7.2
UNSM 27636, Female	38.4	16.3	14.4	10.2	3.3	9.5	5.6	7.4

Which is the most common species of bat on St. Kitts? If one bases their answer on the number of occupied roost sites, *M. molossus* and *A. jamaicensis* are the most common; however, if the actual number of bats located within various roosts is considered, then *B. cavernarum* is the most abundant species (Table 1). If mist-netting data are considered, the most commonly encountered species on St. Kitts would be ranked as *M. molossus*, *A. jamaicensis*, and *A. nichollsi*. Mist-netting capture rate data for St. Kitts and the surrounding islands are provided in Table 3. Three "permanent" roosts on St. Kitts have historical records of bat occupancy that span decades and are recommended for conservation and management:

Roosts at Brimstone Hill Fortress.—This is a large, 18th-century fortress that sits atop a 245 m high volcanic cone and was abandoned in the mid-1800's, until parts of it were restored in the 1960's (Fig. 1). The ruins provide hundreds of roosting locations, many of which have been occupied historically by free-tailed bats—*M. molossus* and *T. brasiliensis*. One of the rooms in the Citadel building contained evidence of long-term occupancy by large numbers of bats, but few bats were present during the 1999 and 2001 site surveys.

Roost at Stone Fort Cave.—This "cave" can best be described as a natural rock shelter beneath several huge boulders that fill the bottom of a narrow, deep gut (6 by 14 m), 1.5 km inland from the coast along the Stone Fort River (Fig. 1). Although water has obviously flowed with great force through the ravine during major rain storms, the riverbed was dry in 2001. Pregnant *B. cavernarum* were netted and released at the Stone Fort roost in April 1999, suggesting the presence of a nursery roost. However, nine of the 10 animals captured in the roost in July of 2001 were non-scrotal males. Pedersen and Kwiecinski estimated the population to be 350 to 400 individuals in 2001. The paucity of such cave-like structures on St. Kitts likely restricts the distribution of *B. cavernarum*. On nearby Antigua, radio-tracking of several *Brachyphylla* indicated an average foraging distance of 15 km away from the roost (Pedersen field

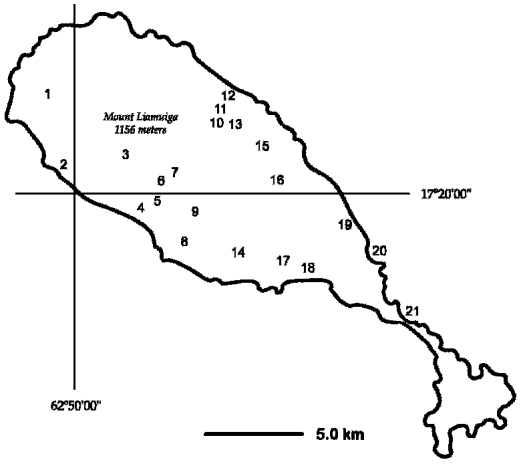

FIG. 1. Capture localities and roost sites of note on St. Kitts, northern Lesser Antilles. Numbers refer to locations shown in the figure (listed West to East): 1) Fahies Land Settlement tank, 2) Cookhouse at Brimstone Hill Fort, 3) Godwin Gut, 4) Romney's—Wingfield Manor Estate, 5) Wingfield Manor Estate, 6) Wingfield Manor Estate Track, 7) Wingfield Manor Estate Track (upper), 8) Stone Fort Cave, 9) East River, 10) Estridge Gut (upper), 11) St. Georges Gut, 12) Tabernacle, 13) Baker's Gut, Estridge Estate, 14) West Farm Gut, 15) Ottley's Estate, 16) Greenhill Estate, 17) Buckleys Estate Reservoir, 18) Basseterre (Ft. Thomas Hotel, other unspecified locations), 19) Caves west of Key, 20) Conaree Shrimp Farm, 21) South Friars Bay Pond.

observation 2000). Given the location of the *Brachyphylla* roost on St. Kitts, the size of the island, and the elongate mountain ridge that dominates the topography on St. Kitts, this geographic feature may tend to restrict distribution of this species to the Caribbean side of the island.

Cave roosts near Key.—The two cave roosts near the small village of Key are the remains of simple pit mines—"tarrish pits" (Fig. 1). Previously, these two cavities were reported to house hundreds of bats, including *A. jamaicensis*, *M. molossus*, and *T. brasiliensis*. Only three *A. jamaicensis* were present in 1999, and no evidence of bats was noted during the 2001 survey. These cavities face northeast and predictably would have been damaged significantly by Hurricane Georges in 1998. In addition, trash found near the entrance to the caves suggests disturbance by human activity.

Species Accounts

Noctilio leporinus mastivus (Vahl, 1797)

Other record.—Parish Unknown: no specific locality (Jones 1951).

Davis (1973) assigned all specimens from the Antillean islands and circum-Caribbean mainland to the subspecies *N. l. mastivus*, which he recognized based on its large-size for the species.

The only published record of the greater fishing bat from St. Kitts is T. S. Jones' report of specimens in the British Museum of Natural History (1951). Paula Jenkins (pers. comm., September 3, 2001) indicated that the basis of this record is an individual preserved in fluid and catalogued in 1934 as BM(NH) 1934.5.27. This specimen was donated by C. S. D. Noakes, serving aboard the *HMS Malaya.* Although several mangrove sheltered salt ponds located along the southeast portions of St. Kitts would seem to provide foraging habitat for this species, no *N. leporinus* were captured or observed during our surveys.

Monophyllus plethodon luciae Miller, 1902

Specimens examined (4).—St. Thomas Middle Island Parish: Wingfield Manor Estate Track, 1.8 km N, 1.2 km E Old Road Town, 425 m, 2 (UNSM). Christ Church Nichola Town Parish: Bakers Gut, Estridge

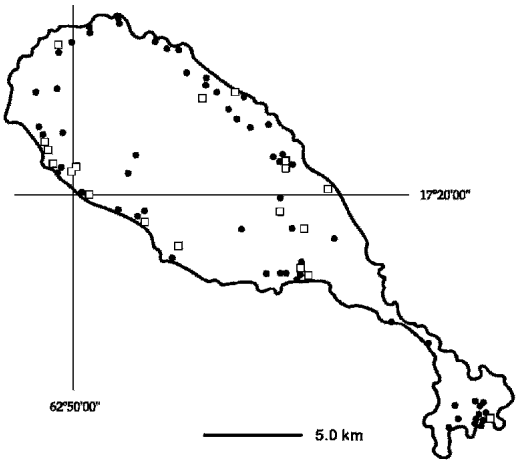

FIG. 2. Localities searched to identify potential roost sites indicated by closed circles. Sites found to be inhabited by bats are indicated by open squares.

TABLE 3. Capture rates of Neotropical bats—bats captured per net per night (BNN).

Localities	Fruitbat BNN	Non-fruitbat BNN	Total BNN
Northern Lesser Antillean Faunas			
Saba*	0.32	0.64	0.96
Nevis*	0.92	0.16	1.09
St. Maarten*	0.83	0.67	1.51
St. Kitts*	0.91	0.80	1.70
Antigua*	1.55	0.18	1.73
St. Eustatius*	0.77	1.11	1.89
Montserrat*	2.27	0.67	2.91
Mainland Faunas			
Belem, Brazil			2.59
Panama Canal Zone	2.20	0.15	2.71
BCI, Panama	2.85	0.13	2.98
Monteverde, Costa Rica			3.14
La Pacífica, Costa Rica	4.11	0.35	4.46
La Selva, Costa Rica			5.02
Osa, Costa Rica	5.68	0.19	5.87
San Vito, Costa Rica	5.93	0.72	6.65
Disturbed Site Faunas			
Montserrat: 1978*	44.40	42.00	86.40
Montserrat: 1984*	10.41	0.17	10.58
Montserrat: 1993, 1994* (disturbed)	1.94	1.61	3.55
Montserrat: 1995-2000* (disturbed)	1.17	0.78	1.94
Montserrat: 2001-2002* (recovery)	3.00	0.07	3.07
St. Kitts: 1999* (disturbed?)	0.26	0.53	0.79
St. Kitts: 2001* (recovery)	1.47	1.07	2.54
Fenton et al. 1992			
Akumal, Mexico (disturbed)	3.29	0.62	3.91
Akumal, Mexico (undisturbed)	4.20	1.13	5.33

Tabular data from Findley 1993.
*Survey efforts by Pedersen et al. in 1993, 1994, 1997, 1998, 1999, 2000, 2001, 2002.

Estate, 220 m, 1 (NMNH); St. Georges Gut, 0.5 km S Tabernacle, 100 m, 1 (UNSM).

Although *M. plethodon* is known from several islands in the northern Lesser Antilles, we report herein the first records of this species from St. Kitts. Schwartz and Jones (1967) reviewed the genus *Monophyllus*, recognizing a single species in the Lesser Antilles, with a fossil subspecies from Puerto Rico. The nominate subspecies is confined to Barbados with the remainder of the Lesser Antilles being represented by the subspecies *M. p. luciae*. Forearm and cranial measurements of our three males and one female are given in Table 2. These measurements fall into the range of specimens published by Baker et al. (1978) and Genoways et al. (2001) based on series of these animals from Guadeloupe and Dominica, respectively.

All *Monophyllus* were captured in protected microhabitats with abundant fruit. The field tag of the specimen from Estridge Estate noted that it was taken at "edge of wet forest." Our two specimens were taken along the Wingfield Manor Estate Track (the highest elevation sampled during our survey: Fig. 1) within a small banana patch with ripening fruit and flowers at the upper end of the gut near its source. Surrounding the edge of the gut was a narrow stand of ruinate rainforest. There was a light mist, relatively heavy fog, and strong winds on the two nights that we netted at this site. The male taken near Tabernacle was netted around 10:30 PM under a large fig tree adjacent to a deep gut bordered by dry scrub woodland and open sugar cane fields. Such woodlands are common on the dry eastern peninsula and at lower elevations (100 m)

and are composed of gum tree (*Bursera simaruba*), loblolly (*Pisonia fragrans*), dogwood (*Lonchocarpus latifolius*), and acacia (*Acacia*) (Beard 1949), but have become ruinate by the heavy impact of humans and domestic animals. The gut was filled by many cultivated fruit trees such as banana, mango, and fig that must provide an abundant food supply for fruit- and nectar-feeding bats at certain times of the year.

The males taken on July 18 and 19 had testis lengths of 5.0 and 4.0, respectively. The female taken on July 14 evinced no gross reproductive activity. The three males weighed 15.7, 16.0, and 16.1, whereas the female weighed 14.2.

Brachyphylla cavernarum cavernarum Gray, 1834

Specimens examined (11).—Trinity Palmetto Point Parish: Stone Fort Cave, 0.75 km N, 0.25 km E Challengers, 105 m, 10 (UNSM). St. George Basseterre Parish: Ft. Thomas Hotel, Basseterre, 30 m, 1 (MVZ).

Specimens captured/released (22).—St. Thomas Middle Island Parish: Wingfield River, 45 m, 2. Trinity Palmetto Point Parish: Stone Fort Cave, 0.75 km N, 0.25 km E Challengers, 105 m, 20.

Although *Brachyphylla* is known from many of the islands surrounding St. Kitts in the northern Lesser Antilles (Swanepoel and Genoways 1978), the specimens reported herein are the first records of this species from St. Kitts. Swanepoel and Genoways (1978) analyzed geographic variation in this species and assigned specimens from St. Croix to St. Vincent to the nominate subspecies *B. c. cavernarum*, with its type locality on St. Vincent. Measurements of three males and one female from St. Kitts are presented in Table 2. The measurements of the specimens from St. Kitts fall within the range of those presented by Swanepoel and Genoways (1978) for samples of *B. c. cavernarum.*

On October 26, 1985, William E. Rainey mist-netted a single male *B. cavernarum* on the grounds Ft. Thomas Hotel, Basseterre, on a promontory 6 km ESE of the *Brachyphylla* roost at Stone Fort Estate (Fig. 1). The net was set along a hedge in an otherwise vegetatively depauperate site. On the evening of April 12, 1999, two male *Brachyphylla* were netted along the lower Wingfield River with two specimens of male *A. nichollsi* and a female *M. molossus*. The river at this time was dry, but was lined with large trees described as ruinate rain forest or dry evergreen forest by Beard (1949). All remaining *Brachyphylla* were taken in Stone Fort Cave, (see Results section). During the April 1999 survey, nine males and 11 females were captured at Stone Fort Cave, whereas in the July 2001 survey, nine males and a single female were captured.

Fruit bats on the neighboring island of Montserrat have contended with the deposition of volcanic ash on leaves, fruits, and flowers during eruptions of the Soufrière Hills Volcano, 1995-2004. Several sub-lethal pathologies associated with the ingestion of ash have been noted in *Brachyphylla* from Montserrat (alopecia, dental attrition; Adams and Pedersen 1999; Pedersen 2001). Although St. Kitts has received wind-blown ash from Montserrat during the larger eruptive events (1997-1998), only two *B. cavernarum* captured on St. Kitts in April 1999 exhibited substantial hair-loss and one of these animals was pregnant.

Of the 11 females collected at Stone Fort Cave on April 9, 1999, seven were pregnant, one was post-lactating, and three showed no signs of reproductive activity. The one female obtained at this site on July 18, 2001, appeared non-reproductive. These data indicate that at least during March through May, Stone Fort Cave serves as a nursery colony for these cave bats. Eleven males taken on April 9 and 12, 1999, were non-reproductive. Five males taken on July 18 had testes that averaged 5.7 (5.0-6.5) in length, whereas a male taken on October 26 had testes that measured 9.5 in length. The nine males taken in July weighed an average of 44.6 (42.1-49.3), whereas the one female taken in July weighed 41.6.

Ardops nichollsi montserratensis (Thomas, 1894)

Specimens examined (25).—St. Thomas Middle Island Parish: Wingfield Manor Estate, 105 m, 2 (UNSM); Wingfield Manor

Estate Track, 1.5 km N, 0.75 km E Old Road Town, 365 m, 3 (UNSM); Wingfield Manor Estate Track (upper), 1.8 km N, 1.2 km E Old Road Town, 425 m, 1 (UNSM). Christ Church Nichola Town Parish: Estridge Gut, 1 mi. S Tabernacle, 220 m, 2 (NMNH); Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 4 (UNSM); St. Georges Gut, 0.5 km S Tabernacle, 100 m, 2 (USNM). Trinity Palmetto Point Parish: West Farm Gut, 1.25 km N, 0.75 km E Boyd's, 183 m, 9 (UNSM). St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 2 (UNSM).

Specimens captured/released (25).—St. Thomas Middle Island Parish: East River, 2.5 km N, 0.75 km E Challengers, 425 m, 2; Godwin Gut, 3.0 km N, 0.3 km W Wingfield Manor Estate, 365 m, 7; Wingfield Manor Estate, 105 m, 2; Romney's—Wingfield Manor Estate, 45 m, 1. Christ Church Nichola Town Parish: Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 2. St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 11.

Although *Ardops* is known from the adjacent islands of Nevis (Pedersen et al. 2003), St. Eustatius (Jones and Schwartz 1967), and Montserrat (Pedersen et al. 1996), we report herein the first records of this species from St. Kitts. Jones and Schwartz (1967) recognized a single species in the genus *Ardops*—*A. nichollsi*—which is confined to the Lesser Antilles. Jones and Schwartz (1967) recognized five subspecies, with *A. n. montserratensis* now being reported from Montserrat, Nevis, and St. Eustatius as well as St. Kitts.

Forearm and cranial measurements of three male and three female *A. nichollsi* are presented in Table 2. The measurements of these specimens are clearly larger than those reported by Genoways et al. (2001) for specimens of *A. n. nichollsi* from Dominica and larger, although not as noticeably, from specimens of *A. n. annectens* on Guadeloupe (Baker et al. 1978). Interestingly, the measurements of a male from Montserrat (Pedersen et al. 1996) and those of a male from Nevis (Pedersen et al. 2003) are smaller than the males we captured on St. Kitts, but measurements of a female from Montserrat are equal to, or larger than, females in our sample and those of a female from Nevis fit well within the range of those from St. Kitts. This species displays striking secondary sexual variation with males being smaller than females. Preliminary observations suggest that males and females are exhibiting geographic variation in slightly different patterns throughout the northern Lesser Antilles and points to the need for a comprehensive reexamination of geographic variation of this species.

Occurring together on many islands of the Lesser Antilles, *Artibeus jamaicensis* and *Ardops nichollsi* are closely related frugivores. On the islands of which we are familiar, *Artibeus* populations are more abundant than those of *Ardops*, but this situation was not the case on St. Kitts in 2001. In 2001, 38 *Ardops* and 51 *Artibeus* were captured, but the abundance of *Ardops* approached, and in some cases exceeded, that of *Artibeus jamaicensis* at many localities: Ottley's Estate (6 *Ardops* to 5 *Artibeus*), West Farm Gut (9 to 5), and Greenhill Estate (13 to 4). Only at St. Georges Gut (2 to 7) and the locality with the highest elevation, Wingfield Manor Estate Track, 425 m (1 to 12), were *Artibeus* clearly more abundant than *Ardops*. It is unknown to what extent, if any, interspecific competition for fruit resources occurs between *Artibeus* and *Ardops* and the large population of Vervet monkeys (*Cercopithecus sabaeus*) that was introduced from West Africa in the mid-seventeenth century. At Greenhill Estate, Ottley's Estate, St. Georges Gut, and 1.5 km N, 0.75 km E Old Road Town, the vegetation in the immediate vicinity of where nets were placed was dominated by mangos, bananas, and other cultivated fruits. During the work in 2001, the mangos were ripening and the ground was covered by fruits that had been partially eaten by bats and birds. At West Farm Gut and Wingfield Manor Estate, 105 m, the streambed was lined with large trees in what is best classified as ruinate secondary rain forest described by Beard (1949). The large trees in this vegetation include gumlin (*Dacryodes excelsa)*, white box (*Symplocos martinicensis*), birdlime (*Sapium caribaeum*), blue box (*Ilex sideroxyloides*), and blue mahoe (*Guatteria caribaea*). The collector's field notes (unpublished) indicated that the two specimens

collected in 1977 along Estridge Gut were netted at "edge of wet forest" (Fig. 1).

Males taken on February 11 and 12, 1982, had testes that measured 4.5 and 5.0, respectively, in length. Four females taken in April 1999 evinced the following reproductive activity: two pregnant (April 16); one post-lactating (April 26); one non-reproductive (April 16). Seven males taken between April 12 and 26, 1999, were non-reproductive. The reproductive status of 18 females collected in July 2001 was as follows: four pregnant; four lactating; four juveniles; three post-lactating; three non-reproductive. Two pregnant females taken on July 15 2001 had embryos measuring 13.5 and 30.0, whereas two females taken on July 17 both had embryos measuring 26.5. Lactating females were captured on July 15 and 16, 2001. Of the 19 males taken in July 2001, 13 were non-reproductive adults and six were juveniles. Ten adult males had testes that averaged 5.2 (4.0-6.0) in length. It appears that this population of *Ardops* exhibits bimodal polyestry, producing young between March-April and June-July.

Ten adult males taken in July weighed on average 23.1 (20.5-26.7). A non-reproductive female weighed 25.6 and six lactating and post-lactating females also weighed an average of 25.6 (23.9-28.5). The four pregnant individuals weighed 28.8, 31.3, 32.1, and 37.4.

A single male *Ardops* captured April 16, 1999, had noticeably scarred wings. An adult male (NMNH 543072) taken on February 12, 1982, exhibits a number of pits and openings in the secondary palate at the bases of the molars and premolars in both maxillae. In some cases the roots of the teeth are partially exposed. A similar condition was noted in a non-reproductive female taken at Mango Walk on July 12, 2001, but her condition was not as far advanced as in the male.

Artibeus jamaicensis jamaicensis Leach, 1821

Specimens examined (33).—St. Thomas Middle Island Parish: Wingfield Manor Estate, 105 m, 4 (UNSM); Wingfield Manor Estate Track, 1.5 km N, 0.75 km E Old Road Town, 365 m, 4 (UNSM); Wingfield Manor Estate Track (upper), 1.8 km N, 1.2 km E Old Road Town, 425 m, 9 (UNSM). Christ Church Nichola Town Parish: Estridge Estate, 220 m, 1 (NMNH); Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 1 (UNSM); St. Georges Gut, 0.5 km S Tabernacle, 100 m, 2 (USNM). Trinity Palmetto Point Parish: West Farm Gut, 1.25 km N, 0.75 km E Boyd's, 183 m, 5 (UNSM). St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 1 (UNSM); caves west of Key on coastal road, 30 m, 2 (MVZ). St. George Basseterre Parish: Basseterre, 30 m, 2 (FMNH). Parish Unknown: no specific locality, 2 (1 AMNH, 1 NMNH).

Specimens captured/released (18).—St. Thomas Middle Island Parish: Wingfield Manor Estate, 105 m, 1; Wingfield Manor Estate Track, 1.8 km N, 1.2 km E Old Road Town, 425 m, 3; Romney's—Wingfield Manor Estate, 45 m, 2. Christ Church Nichola Town Parish: St. Georges Gut, 0.5 km S Tabernacle, 100 m, 5; Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 4. St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 3.

The Jamaican fruit-eating bat was first reported from St. Kitts when J. A. Allen (1904) described *Artibeus insularis* based on a single old adult male from the island. J. A. Allen (1904) believed that this new taxon was distinguished by a larger skull than *Artibeus jamaicensis*; however, just a few years later Andersen (1908) demonstrated that this was not accurate and placed bats from Jamaica, Hispaniola, and Puerto Rico to St. Kitts in the nominate subspecies *A. j. jamaicensis*. This placed *Artibeus insularis* as a junior synonym of *A. j. jamaicensis*, which is the arrangement that has been followed by subsequent authors. Genoways et al. (1998, 2001) and Timm and Genoways (2003) have presented morphometric analyses and Phillips et al. (1989) and Pumo et al. (1996) have presented mtDNA analyses of the relationships among Antillean populations of the Jamaican fruit bat. These studies support the arrangement of Andersen (1908) and extend the geographic range of the subspecies as far south in the Lesser Antilles as St. Lucia. Forearm and cranial

measurements of two males and four females from St. Kitts are presented in Table 2. These measurements closely match those of a sample reported by Genoways et al. (2001) from Dominica.

Our largest collection of *A. jamaicensis* on St. Kitts in 2001 was obtained at Wingfield Manor Estate Track, 1.8 km N, 1.2 km E Old Road Town, 425 m, which parallels a gut running in elevation from 275 to 450 m that is generally forested in elfin woodland and palm brake at its upper end. The unique habitat within this gut exists primarily due to protection as a forest reserve for over 100 years and is one of only two areas of rain forest on the island in which large trees are found (e.g., gumlin *Dacryodes excelsa;* Beard 1949). Additional nets were placed in a small banana plantation at the head of a small gut that ran directly into the upper end of the Wingfield River gut. A narrow fringe of native trees and other vegetation representing a badly degraded rainforest surrounded the banana patch, which represents the highest elevation that we netted. Above 550 m the vegetation is palm brake (Beard 1949) dominated by mountain cabbage (*Euterpe globosa*) and tree ferns (*Cyathea arbora*) covering an area of over 2,200 ha. We set nets nearby (1.5 km N, 0.75 km E Old Road Town) over a road as it passed through a mango plantation known locally as Mango Walk. *Artibeus jamaicensis* were captured at Ottley's Estate, St. Georges Gut, and Greenhill Estate where mangos and bananas dominated the nearby vegetation although acacia was noted along the edges of the guts. As indicated for *Ardops,* the ravines at West Farm Gut and Wingfield Manor Estate (105 m) were lined with large trees in what is best described as ruinate rain forest or dry evergreen forest. Jamaican fruit bats also were collected in 1985 from the caves west of Key (Fig. 1). When visited in 2001, there was evidence that the roof of the cave had recently collapsed and we observed no bats.

Seven *Artibeus* (3 lactating females and 4 scrotal males) captured during July 2001 exhibited distinctive facial stripes that were more noticeable than those found on the other 37 *Artibeus* captured during that survey. Males and females with distinctive stripes had significantly longer forearm lengths on average (62.3 and 62.4, respectively) than their counterparts (61.1 and 60.7, respectively). Males with stripes were heavier than males with faint stripes (43.6 and 40.0, respectively), whereas the reverse was true for females (44.6 and 39.8, respectively). We have observed this on other islands in the region and are currently evaluating this pattern using DNA markers.

The average testes length of 13 males taken between July 13 and 19 was 7.8 mm (5.5-10.0). A male taken on May 28 had a testis length of 6.0 mm, whereas one taken on October 28 measured 9.5 mm. Five pregnant females with single fetuses were recorded from St. Kitts on the following dates (embryo crown-rump length in parentheses): April 9 (36.0); July 14 (12.0, 40.0); July 16 (34.0, 35.0). A female collected on July 15 appeared to have just given birth because its uterus was greatly extended and flaccid. Two lactating females were captured each on July 14, 16, and 18. Individual females taken on July 15 and October 28 evinced no gross reproductive activity. A non-volant juvenile male with a forearm length of 50.2 mm was taken on June 7, 1937. Although these reproductive data are incomplete, they are consistent with the pattern of bimodal polyestry reported for this species elsewhere (Genoways et al. 2001; Wilson 1979; Wilson et al. 1991).

Thirteen adult males weighed an average of 41.9 (36.1-47.7). Two non-reproductive females weighed 39.0 and 41.0, whereas seven lactating females weighed on average 41.5 (36.4-44.6). Five pregnant females had a mean weight of 51.2 (45.5-57.3). The heaviest female was carrying a fetus that measured 35.0 in crown-rump length.

The dentition of Jamaican fruit bats from St. Kitts fit within the pattern for the presence or absence of M3/m3 described by Genoways et al. (2001). Specimens from Dominica and northward lack M3, whereas specimens from St. Vincent and southward had M3 present in an increasing percentage of individuals, reaching 100% in eight specimens examined from Trinidad. The six specimens examined from St. Kitts all lack M3. Using the criteria of Genoways et al. (2001), m3 would be considered present

in 66% (4) of the individuals. This is the lowest percentage of occurrence of m3 among eight island populations in the northern Lesser Antilles and Greater Antilles. In both of the individuals in which m3 was absent, the tooth was missing in only one of the lower jaws. A m3 is missing in the right dentary of UNSM 27588, whereas in UNSM 27587, the tooth is missing in the left dentary.

Molossus molossus molossus (Pallas, 1766)

Specimens examined (34).—St. Thomas Middle Island Parish: Romney's—Wingfield Manor Estate, 45 m, 9 (UNSM). Christ Church Nichola Town Parish: Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 4 (UNSM). Trinity Palmetto Point Parish: West Farm Gut, 1.25 km N, 0.75 km E Boyd's, 183 m, 2 (UNSM). St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 1 (UNSM); caves at Key, 4 (AMNH). St. George Basseterre Parish: Buckleys Estate, 1 (AMNH). Parish Unknown: no specific locality, 13 (NMNH).

Specimens captured/released (86).—St. Paul Capesterre Parish: Fahies Land Settlement tank, 60 m, 16. St. Thomas Middle Island Parish: Cookhouse at Brimstone Hill Fort, 183 m, 15; East River, 2.5 km N, 0.75 km E Challengers, 425 m, 6. Christ Church Nichola Town Parish: Ottley's Estate, 0.5 km S, 0.5 km W Ottley's, 170 m, 1. St. Mary Cayon Parish: Greenhill Estate, 1.25 km S, 0.6 km W Cayon, 245 m, 2. St. George Basseterre Parish: Buckleys Estate Reservoir, 43; South Friars Bay Pond, 1. St. Thomas Middle Island Parish: Romney's—Wingfield Manor Estate, 45 m, 2.

The previous record for St. Kitts of this widespread Neotropical species was the original description of *Molossus debilis*, with a type locality of St. Kitts with additional records from Nevis, Antigua, and Montserrat (Miller 1913). Husson (1962) restricted the type locality of *M. molossus* to the island of Martinique, which lead Dolan (1989) to apply the name *M. m. molossus* to this species throughout the Lesser Antilles. Table 2 presents forearm and cranial measurements for two males and four females from St. Kitts. These measurements closely match measurements of four specimens reported by Pedersen et al. (2003) from the adjacent island of Nevis.

This species is regularly reported by residents as occupying a wide variety of man-made structures across the island. Bats were located in 21 roost sites during the 1999 survey, of these, 12 (57%) were occupied by free-tailed bats—most likely *M. molossus* (Fig. 2). When school children on St. Kitts were surveyed, 22% reported having bats in their house. This is not surprising because this crevice- and cavity-dwelling species is known to utilize corrugated metal roofing, which is prevalent throughout the region, as a preferred roost site. This species was observed exiting an archway at Brimstone Hill Fort and from the ruins of the chimney and buildings at Wingfield Manor Estate in the evening twilight (Fig. 1).

Eight males taken in April 1999 and six males taken in July 2001 were not in reproductive condition. A male taken on March 12, 1963, had testes that measured 5.0 in length. Four females caught on March 12, 1963, evinced no gross reproductive activity. The reproductive condition of 33 females captured during April 1999 was as follows: 27 non-reproductive; 3 post-lactating; 2 pregnant; 1 juvenile. The reproductive status of 55 females taken in 2001 was as follows (crown-rump length of embryos in parentheses): July 15, 1 lactating, 1 pregnant (19); July 17, 1 lactating, 3 pregnant (20, 24, 25); July 19, 1 non-reproductive, 3 lactating, 8 pregnant (20, 26, 26, 28, 30, 32); July 20, 2 non-reproductive, 35 pregnant.

A non-reproductive female weighed 12.7, and five lactating females had an average weight of 12.6 (10.2-13.9) in July of 2001. Ten pregnant bats weighed an average of 14.5 (11.8-16.9). Three non-reproductive females exhibited heavily worn canine teeth in April 1999.

Tadarida brasiliensis antillularum (Miller, 1902)

Specimens examined (21).—St. Mary Cayon Parish: caves west of Key on coastal road, 30 m, 2 (MVZ). St. Thomas Middle

Island Parish: Brimstone Hill, 183 m, 7 (AMNH). Parish Unknown: no specific locality, 12 (4 MCZ, 8 NMNH).

Although this species was first reported from St. Kitts in 1902 and there are specimens in at least four museum collections, we did not capture any individuals during our surveys on the island. Miller (1902) first reported specimens from St. Kitts in the specimen examined section of his description of *Nyctinomus antillularum* [=*Tadarida brasiliensis antillularum*], which has its holotype from Roseau, Dominica. The St. Kitts specimens had been obtained by W. H. Alexander on June 13, 1896. G. M. Allen (1911) reported three additional specimens from St. Kitts and placed the taxon *antillularum* as a subspecies of *T. brasiliensis*. At least two of these specimens had been collected on St. Kitts in May 1879. Shamel (1931) in his revision of the genus *Tadarida,* re-examined Miller's original specimens and again considered *antillularum* as a distinct species. Schwartz (1955) returned to the currently accepted taxonomic arrangement in which *antillularum* is a subspecies of the widely distributed *T. brasiliensis*. Koopman (1968) reported seven specimens taken at Brimstone Hill March 13, 1963, by Clayton Ray. The most recently captured individuals of this free-tailed bat are two females taken in the caves west of Key by W. E. Rainey on October 28, 1985 (Fig. 1). As discussed in the account for *Artibeus jamaicensis*, no bats were observed in this cave during the 2001 survey.

Because we were not able to capture any *Tadarida* in our work, detailed information on this species is limited. Table 2 presents the measurements for eight males and four females. Males averaged larger than females in all measurements except length of forearm and length of maxillary toothrow, forearm length in females is greater than that in males, and the maxillary toothrow lengths were the same. Only for breadth across upper molars did the sexes differ significantly at the $P \leq 0.05$ level.

Natural history data on *Tadarida* on St. Kitts is limited. A male captured on March 13 had a testis that measured 2.0 in length. Single females taken on March 13 (NMNH 213927) and on May (MCZ 6019) and two females taken on October 28 (MVZ 172053-54) evinced no gross reproductive activity. Two adult females taken on October 28 each weighed 9.0.

Discussion

Faunal Composition

Data presented herein provide new and previously unpublished records of three species of bat for the island of St. Kitts—*Brachyphylla cavernarum, Monophyllus plethodon,* and *Ardops nichollsi.* Ecologically, this simple chiropteran fauna includes seven species representing three families—Noctilionidae, Phyllostomidae, and Molossidae—including one piscivore (*N. leporinus*), one omnivore (*B. cavernarum*), one pollenivore/nectarivore (*M. plethodon*), two frugivores (*A. nichollsi, A. jamaicensis*), and two insectivorous species *(T. brasiliensis, M. molossus*).

Natalus stramineus, known from nearby Nevis (Pedersen et al. 2003), was expected but was not found. Several Lesser Antillean endemic species, including *Chiroderma improvisum, Sturnira thomasi, Myotis dominicensis*, and *Eptesicus guadeloupensis* (Baker and Genoways 1976; Baker et al. 1978; Genoways 1998; Genoways and Baker 1975; Genoways and Jones 1975; Genoways et al. 2001; Jones and Baker 1979; Jones and Phillips 1976; Masson and Breuil 1992; Pedersen et al. 1996; de la Torre and Schwartz 1966) also are notable by their absence from both St. Kitts and Nevis (Pedersen et al. 2003), but these absences are consistent with Genoways et al. (2001) claim that islands north of Montserrat lay outside of the Lesser Antillean Faunal Core.

Capture rates

We have used a simple metric (BNN-bats captured per net-night) to approximate bat activity at our capture sites (Pedersen 2001; Pedersen et al. 1996, 2003) because we feel that the inclusion of additional variables (e.g., net dimensions, net-hours, etc.) may introduce unwarranted variation and a false precision of the data. Comparisons of data gathered in previous studies (Table 3) is confounded by the fact

that investigators used very different netting protocols. For example, Morton typically set five six-meter mist-nets in a circular/oblong grouping with a radius of 30 m placed to take advantage of fruiting trees and fresh water at randomly selected sites. Pedersen would set three to eight mist-nets in a variety of habitats that also included water sources and fruiting trees at sites selected to maximize bat captures. Furthermore, Pedersen selected net-lengths for their "best-fit" to the adjacent vegetation and these were typically set diagonally across paths/streams and separated by 20 to 100 m along the same feature. This latter approach sought to maximize habitat coverage and faunal diversity rather then establishing strict, repeatable net-sets. Details concerning this net/habitat-matching or observed animal behavior relative to the net itself are usually absent from the literature and often left to the imagination of the reader.

That being said, BNN is the only statistic that can be culled from the older literature as noted by Findley and Wilson (1983). Similarly, BNN may be the only way in which we can evaluate long-term studies of a single location involving numerous investigators or protocols (Pedersen et al. 1996; Pedersen et al. 2001; Pedersen et al. 2003; present study), or in the evaluation of survey work done by the same investigator over many years using new protocols or techniques as they appeared (Fenton et al. 1992; LaVal 2004). We use the BNN metric conservatively by avoiding its use as an estimate of populations size *per se*, but rather as an approximation of bat activity at a particular location.

Capture rates on St. Kitts.—If all feeding guilds are considered, bat captures on St. Kitts (1999: 1.30 BNN; 2001: 2.54 BNN) fall below capture rates reported from mainland populations but are comparable to those of other Antillean island populations (Table 3). If only fruit bats are evaluated, capture rates during our two surveys on St. Kitts (1999: 0.43 BNN; 2001: 1.47 BNN) are again comparable to those rates reported from adjacent islands in the northern Lesser Antilles (0.65-2.47; Table 3), but fall well below fruit bat captures per net-night in the Neotropics of Central America (2.20-5.93; Table 3).

Fenton et al. (1992) demonstrated that phyllostomid bats are useful indicators of habitat disruption; Fenton observed a 21% decrease (4.20 > 3.29 BNN) in phyllostomid capture rates in a comparison between undisturbed with disturbed habitats in Akumal, Mexico. Island populations of fruit bats appear more susceptible to habitat disruption than are mainland populations (Table 3). Indeed, if similar contrasts between pre- and post-disturbance surveys are made using comparable data collected on Montserrat in the northern Lesser Antilles, it would appear that captures rates decrease by as much as 60 to 80% after a natural disaster (Pedersen et al. 1996; Pedersen 2001; Table 3).

How does one interpret the obvious differences in capture rates between survey years and investigators on St. Kitts, and on other islands within our conjoined data base (Table 3)? We have already mentioned differences between mist-netting protocols employed by the various teams led by Morton and by Pedersen respectively—Pedersen's teams set more nets (typically) and captured more bats on each of the four islands presented in Table 3. Without objective head-to-head testing of these two net-protocols, it is difficult to say if these different results are due to sampling differences, or are biologically significant, such as population fluctuation in response to natural disasters.

Certainly, during the seven years of survey work covered in Table 3, at least five hurricanes (Luis, José, Lenny, Georges, Debby) have passed through the region and caused some damage on these 4 islands (Table 3). There is a pattern of pre-disaster survey by Morton et al., followed by post-disaster survey by Pedersen et al., for Antigua, Nevis, and St. Kitts; however the sparse capture data makes such comparison untenable except for the work on St. Kitts.

Hurricane Georges caused considerable damage on St. Kitts in September 1998, before our 1999 survey of the island made by Morton and Courts, which might help account for the low overall capture rate (1.30

BNN; Table 3). The damage inflicted on St. Kitts by Hurricanes José and Lenny (1999), and Debby (2000) may have begun its recovery in time for the 2001 survey by Pedersen, Kwiecinski and Genoways (2.60 BNN). Whatever the case, further study of these patterns seems warranted.

Roost sites

Clearly, bat population levels can drop to dangerously low levels in the aftermath of natural disasters and extensive deforestation because of the loss of foraging opportunities and roost sites. Recovery from population crashes may be slow, leaving the remaining animals susceptible to other environmental pressures.

Although St. Kitts has not been exhaustively explored, there is an apparent scarcity of natural and man-made caves and mines, as compared to other Antillean islands. Caves are critical roosting/maternity sites for several species of bat and are particularly important when they contain large numbers of bats, perhaps accounting for the entire population. *Brachyphylla cavernarum*, *M. plethodon* and *T. brasiliensis* are cave/mine dwelling species on other Antillean islands and their relative rarity may be attributed to the limited number of these sites on St. Kitts as is the absence of *Natalus stramineus*.

We consider *B. cavernarum* to be particularly vulnerable on St. Kitts because it seems to congregate at a single exposed cave roost. Although many species are vulnerable to deforestation (whether by human agency or via hurricane/volcano damage), *A. nichollsi*, *A. jamaicensis*, and *B. cavernarum* may be at higher risk because these species forage for fruits and flowers. In addition to caves, the Jamaican fruit-eating bat is known to use both permanent and temporary tree roosts (Handley et al. 1991), however, only temporary sites have been identified on St. Kitts. No roosts were located for *A. nichollsi* in either 1999 or 2001.

The presence of (surface) fresh water is important to bats. Free-tailed bats were observed and netted above swimming pools, open cisterns, and reservoirs on St. Kitts. Capping of natural springs may be a threat to bat foraging habitats because very few river valleys currently contain any permanent surface water. It is almost certain that hydrologic table of St. Kitts has been lowered and the island is drier today when compared to times prior to human occupation.

In summary, if conservation officials on St. Kitts wish to preserve the biological diversity represented by the chiropteran fauna of the island, action will be necessary. Caves and man-made structures, such as churches, with known bat population must be given high priority for protection. They must continue to protect the remaining forest along the mountainous backbone of the island and along some of the larger guts.

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