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Bats Of Skydusky Hollow, Bland County, Virginia

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ABSTRACT

During the period 22 November 1999 – 11 October 2001, winter hibernacula surveys, spring staging/autumn swarming surveys, and summer surveys for bats were completed in caves of Skydusky Hollow, Bland County, Virginia. During winter, 12 caves were entered and 16,185 bats counted: 235 *Myotis sodalis* (Indiana bat), 14,475 *Myotis lucifugus* (little brown myotis), 12 *Myotis septentrionalis* (northern myotis), 7 *Myotis leibii* (eastern small-footed myotis), 1,441 *Pipistrellus subflavus* (eastern pipistrelle), and 15 *Eptesicus fuscus* (big brown bat). *Myotis sodalis* hibernated in thermally stable areas of 7 - 9°C. The largest concentration of *M. lucifugus* (n = 4,280) hibernated in an area that was cooler (6.5°C) than areas used by *M. sodalis*. The remaining 6,300 *M. lucifugus* hibernated at temperatures similar to, or slightly cooler than, temperatures used by *M. sodalis*. Intra-cave (and possibly inter-cave) movements of *M. lucifugus* and *M. sodalis* during the season of hibernation concentrated bats in cooler areas of the caves. An unusually large concentration of *P. subflavus* (n = 920) hibernated in Coon Cave in a warm (8.6 – 9.7°C), stable environment. Proportions of species of bats captured during spring staging and autumn swarming varied from proportions found during winter hibernation. Mating and perhaps other social functions affect patterns of autumn use. No concentration of bats used the caves during summer.

INTRODUCTION

The association between bats and caves is well known. Although a few species of bats from temperate regions use caves during summer, use of caves as hibernacula is more common. Winter ranges of many species, including federally endangered *Myotis sodalis* (Indiana bat) and *Corynorhinus townsendii virginianus* (Virginia big-eared

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bat), are restricted to areas of well-developed karsts such as are found in western Virginia (Barbour and Davis 1969).

Few studies have examined use of a cave or cave system by bats across seasons. In addition to hibernation, bats use caves in other ways. Autumn swarming is a phenomenon exhibited by microchiropterans in North America (Cope and Humphrey 1977) and Europe (Parsons et al. 2003). Swarming is the use and visitation of hibernacula and nearby habitats in late summer and early autumn, and for many species swarming is associated with the opportunity for sexes to meet and mate (Cope and Humphrey 1977; Thomas et al. 1979; Parsons et al. 2003). During spring staging, bats often remain near hibernacula caves for a few days before leaving for summer maternity areas. In summer, some species, for example *C. t. virginianus* and *Myotis grisescens* (gray myotis), form maternity colonies in warm areas of caves (Barbour and Davis 1969), or caves may be used by a bachelor colony (LaVal and LaVal 1980), a loose aggregation of males, of these species. Bats sometimes also use caves as stopovers during the spring and autumn migration/transient period (Parsons et al. 2003), and bats visit a variety of habitats and situations during all seasons, apparently searching for suitable habitat (Fenton 1969; Kurta et al. 2002).

We studied bat use of caves of the Skydusky Hollow Cave System and other nearby caves within the same karst system in Bland County, Virginia. Studies included (1) surveys for hibernating bats, including temperatures used by concentrations of bats, winter intra-cave movements, and a search for accumulations of guano that indicate summer nursery use, (2) spring staging and autumn swarming, and (3) a summer survey for nursery colonies.

Background on bat populations.—Unpublished data from previous visits to Skydusky Hollow caves by several individuals influenced the design and completion of our studies. These data (Table 1) provide background information that might otherwise be lost. A group of cavers organized by authors Carol and Joe Zokaites completed a bat count in five caves of Skydusky Hollow on 8 February 1992 when 7,470 bats were found, providing background information on portions of caves where bats concentrate during winter. Winter visits have been made to Newberry-Bane Cave by many individuals. In 1986, probably from the Bane entrance, Ginny Dalton (Radford University, personal communication) found 159 bats of 5 species, including two endangered species: *C. t. virginianus* and *M. sodalis* (Table 1). On each of four visits (1990, 1992, 1995, and 1999) Gary Nussbaum and students (Radford University, personal communication) reported from 120 to 4,203 bats of 1 to 6 species (Table 1). In 1993, author Richard Reynolds, Chris Hobson (Virginia Department of Conservation and Recreation), and colleagues surveyed from both Newberry and Bane entrances and found six species of bats, and recorded for the second time the presence of *C. t. virginianus*.

MATERIALS AND METHODS

Study area.—The Skydusky Hollow Cave System is in Walker Creek Valley between Brushy and Big Walker mountains, Bland County, in western Virginia, about 90 km west of Roanoke. It is in the Valley and Ridge Physiographic Province, with elevations of 649 - 1,160 m. The Skydusky Hollow Cave System includes, from west to east, Coon, Paul Penley (and Harmans Avalanche Pit), Buddy Penley, Newberry-

TABLE 1. Unpublished data of bats found during previous winter surveys of caves in Skydusky Hollow, Bland County, Virginia. Bats counted but not identified to species are recorded as Unknown. When species identification was tentative, the name is followed by (?).

Year	Cave	Location in Cave	No. of bats by Species
[redacted]	Newberry-Bane		4 *C. t. virginianus*
			90 *M. sodalis*
			2 *M. leibii*
			1,800 *M. lucifugus*
			62 *P. subflavus*
1990[2]	Newberry-Bane		120 *M. sodalis*
			90 *M. lucifugus*
			6 *M. septentrionalis*
			4 *E. fuscus*
			11 *P. subflavus*
1992[3]	Paul Penley	Whisper Hall	524 - Unknown
		Big Room	138 - Unknown
		South of Big Room	135 - Unknown
		Victory Room	122 - Unknown
		Upper Level	121 - Unknown
		Harman's Metro	280 - Unknown
	Buddy Penley	Entrance Passage	40 *P. subflavus*
			11 *M. lucifugus*
		Main Pit (Pit 1)	3,100 *M. lucifugus*(?)
		Lower Passage	10 *P. subflavus*
			525 *M. lucifugus*
	Bane Spring	Main areas	278 *P. subflavus*
			543 *M. lucifugus*
			5 *E. fuscus*
			3 *M. sodalis*(?)
			1 *M. leibii*
		Back pits	21 *P. subflavus*
			66 *M. lucifugus*
	Spring Hollow	Entrance area	160 Unknown
	Newberry-Bane	Tourist Connection	163 Unknown
		T-Intersection	528 Unknown
		Straddle Pit and	90 *M sodalis*
		Connection area	553 *M. lucifugus*
			63 *P. subflavus*
1992[2]	Newberry-Bane		100 *M. sodalis*
			4,000 *M. lucifugus*
			3 *M. septentrionalis*
			100 *E. fuscus*
1993[4]	Newberry-Bane		5 *C. t. virginianus*
			107 *M. sodalis*
			13 *M. leibii*
			988 *M. lucifugus*
			10 *E. fuscus*
			30 *P. subflavus*
1995[2]	Newberry-Bane		110 *M. sodalis*
			11 *M. leibii*
			8 *M. lucifugus*
			2 *M. septentrionalis*
			6 *E. fuscus*
			9 *P. subflavus*
1999[2]	Newberry-Bane		120 *M. sodalist*

1 Ginny Dalton (Radford University, personal communication)
2 Gary Nussbaum and students (Radford University, personal communication)
3 Data from simultaneous surveys of the caves by a group of cavers organized by Carol and Joe Zokaites
4 Richard Reynolds (Virginia Department of Game and Inland Fisheries), Chris Hobson (Virginia Department of Conservation and Recreation), and colleagues

Bane, Bane Spring, and Spring Hollow caves. These caves are hydrologically connected (Wright 1995), although physical connections have not always been established.

A description and map of the Skydusky Hollow Cave System was provided by Zokaites (1995), and maps of three caves, Newberry-Bane, Buddy Penley, and Paul Penley, were provided by Zokaites and Zokaites (1995) and Devine (1995a, 1995b). Newberry-Bane Cave, largest and most complex of the system, has two entrances, the Newberry and Bane entrances. Where the two entrance passages intersect is a maze of passages referred to as the Junction (area), with Upper and Lower Junction areas. In addition to caves of the Skydusky system, six caves in the same karst system were also surveyed: Munsey #1 and #2, Munsey Twins (#1 and #2 entrances), Morehead's Pit, and Springhouse Cave.

The Skydusky Hollow karst is part of a linear belt of karsts extending from the northwest flank of Walker Mountain northward to Walker Creek Valley, developed in Cambro-ordovician limestone and dolomite. Streams and talus springs draining the north flank of Walker Mountain sink at or near the upper limestone contact, and flow through a complex network of caves before emerging at springs along Walker Creek. Extensive, accessible cave passages are restricted to upper limestone formations that lie beneath or near the upper limestone contact. Sinking streams from east and west ends of the hollow converge in the lowest section of Newberry-Bane Cave.

Hibernacula surveys.—Four caves in Skydusky Hollow were visited 22 - 24 November 1999, to document autumn intra-cave use and to help establish which cave areas, as based on temperature, morphology, and concentrations of bats, were most likely to contain endangered bats during winter hibernation. Winter surveys, 17 January - 5 March 2000, were conducted in areas of 12 caves (1) that contained concentrations of bats, (2) where temperatures were $\leq 9°C$, a range typically suitable for hibernation by concentrations of bats, particularly *M. sodalis*, and (3) that had morphology typical of caves that cool appropriately for hibernation.

Bats were tallied by species and location in the caves. Individuals and bats in small clusters were counted directly, but large clusters of *Myotis lucifugus* (little brown myotis) were estimated in groups of 5 or 10 bats. Searches were made for accumulations of guano, indicative of summer use. Temperatures were taken at cave entrances, in twilight areas, near clusters of endangered bats, near concentrations of other species, and at intervals along the survey route. Temperatures were taken using Raytek infrared thermometer model ST2 or Raynger® ST20, with a range of -18 or -32 to 400°C, an accuracy of ±2 and ±1% of reading, and a display to the nearest 1.0 and 0.2°C, respectively. Brack et al. (2003a) discussed advantages and disadvantages of point and shoot infrared thermometers.

Spring staging and autumn swarming.—A bat trap was used to capture bats in spring and autumn. Bats were trapped from dusk until 0000 – 0200 h at Buddy Penley Cave 17 - 20 April 2000. Trapping in autumn was on 8, 11, and 26 September and 11 October 2001 at the Bane entrance of Newberry-Bane Cave, and ran from dusk to 0100 h on 8 September and until 2300 h on the other nights.

Bats were identified to species and sexed. When time allowed, weight, right forearm length, time of capture, and reproductive status were recorded. During autumn, the rate of capture was so great that about 150 – 200 bats were released without data collection on 8 September, and about 50 bats were released on 11 September. Using

Chi-Square analysis, percentages of each species in the winter survey (expected ratio) were compared to percentages of each caught in autumn (observed ratio) for species where the catch was sufficient to test.

Summer cave use.—To determine summer use by a maternity colony or aggregation of male bats, most notably *C. t. virginianus*, autumn and winter intra-cave surveys included searches for accumulations of guano. In late May 2000, caves were searched for concentrations of bats, including the Attic of Buddy Penley Cave where a moderate accumulation of guano was noted during winter surveys.

RESULTS

Wintering bats.—During autumn trips in four caves, >7,000 bats of four species were found (Table 2). Most were *M. lucifugus*, and most were in Newberry-Bane (5 species) and Buddy Penley (4 species) caves. Only *M. lucifugus* and *Pipistrellus subflavus* (eastern pipistrelle) were found in Paul Penley and Coon caves. During winter, 12 caves were searched and 16,185 bats counted (Table 2); 89% (n = 14,479) were *M. lucifugus*. Newberry-Bane (6 species) and Buddy Penley (3 species) caves again contained the greatest number of bats. More bats were in Newberry-Bane (48% more than in autumn), Buddy Penley (197%), Paul Penley (107%) and Coon (285%) caves in winter than in autumn. About half the increase of bats in Newberry-Bane Cave and about a third of the increase in Buddy Penley Cave resulted from increases in areas surveyed in those caves. Paul Penley and Coon caves again had *M. lucifugus* and *P. subflavus*, and a single *Myotis septentrionalis* (northern myotis) was also found in Coon Cave. Munsey #1, Bane Spring, and Paul Penley caves had 100 - 1,000 bats. No bats were found in Munsey Twin #2. No endangered *C. t. virginianus* were found during autumn and winter cave surveys.

Myotis sodalis was found only in Newberry-Bane Cave, with the exception of a single individual in Buddy Penley Cave on 23 November (Table 2). On 22 November, 26% of the population was in Lower Junction with 74% in Upper Junction. The temperature in both areas was $\geq 8.5^{o}C$. During winter, bats had changed location, abandoning Lower Junction entirely, and Upper Junction in large part, although temperatures in both areas had dropped (Table 3). Instead, 88% of the population was in a new area, the Bane Entrance Passage, at a temperature that was lower than either of the other two areas (Table 3).

Like *M. sodalis*, *Myotis leibii* (small-footed myotis) was found only in Newberry-Bane Cave (Table 2). In autumn, one individual was found in the Junction area (9°C), and in winter, seven *M. leibii* were found hibernating between the Bane Entrance Passage and the Junction area (5.7 – 6.8°C). No *M. septentrionalis* were found during the autumn survey, but 12 were found in winter, 9 in Newberry-Bane Cave, scattered throughout the survey area, most near 9°C. Autumn surveys located 9 *Eptesicus fuscus* (big brown bat) and winter surveys located 15 hibernating at a wide range of temperatures (1.2° - 13.3°C).

The largest concentrations of *M. lucifugus* were found in Newberry-Bane and Buddy Penley caves during both autumn and winter (Table 2). Numbers of *M. lucifugus* in Newberry-Bane Cave increased by 45% (n = 1,725) between November and February, but bats were less concentrated in the North Subway. There were three times more bats in Buddy Penley Cave in winter than in autumn (Table 2), but about one-third were from an area not visited in autumn. Nevertheless, the number of bats

TABLE 2. Bats found during autumn 1999 and winter 2000 visits to caves in the Skydusky Hollow Cave System and nearby caves in the same karst system in Bland County, Virginia. Four caves were surveyed in autumn and 12 caves in winter; "*n*" refers to sample size.

Cave	*M. sodalist*		*M. lucifugus*		*M. septentrionalis*		*M. leibii*		*P. subflavus*		*E. fuscus*		Total
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
22 - 24 November 1999													
Newberry-Bane	170	4.2	3,809	94.9			1	0.0	31	0.8	4	0.1	4,015
Buddy Penley	1	0.0	2,068	95.1					101	4.6	5	0.2	2,175
Paul Penley			370	85.8					61	14.2			431
Coon			312	54.1					265	45.9			577
Autumn Total	171	2.4	6,559	91.1			1	0.0	458	6.4	9	0.1	7,198
Mid-January - 5 March 2000													
Newberry-Bane	235	4.0	5,534	93.4	9	0.2	7	0.1	137	2.3	2	0.0	5,924
Buddy Penley			6,304	97.5	1	0.0			160	2.5			6,465
Paul Penley			833	93.5					58	6.5			891
Coon			1,296	58.4	1	0.0			920	41.5	2	0.1	2,219
Spring Hollow			21	84.0	1	4.0			3	12.0			25
Bane Spring			442	90.8					45	9.2			487
Munsey #1			44	36.1					78	63.9			122
Munsey #2									1	10.0	9	90.0	10
Munsey Twin #1									16	100.0			16
Munsey Twin #2													
Morehead's Pit			1	5.6					17	94.4			18
Springhouse									6	75.0	2	25.0	8
Winter Total	235	1.5	14,475	89.4	12	0.1	7	0.0	1,441	8.9	15	0.1	16,185

at Pit 1, the area of greatest concentration in both seasons, more than doubled (Table 3). Numbers of *M. lucifugus* in Paul Penley doubled between autumn and winter, and the number in Coon Cave increased by four times (Table 2); in both caves, locations used by the largest concentrations of bats changed between seasons (Table 3).

Although individual *M. lucifugus* were found across the range of temperatures available (1 – 14°C), concentrations in autumn were found at higher temperatures than were concentrations in winter (Table 3). In autumn, the largest concentrations were in Newberry-Bane Cave in North Subway (58% of the autumn total) at 9 - 9.5°C, and Pit 1 of Buddy Penley Cave (32%) at 7.9°C (Table 3). In winter, *M. lucifugus* were concentrated at Pit 1 (30% of the winter total) at 6.3 - 6.5°C and Guano Climb (10%) at 6.9°C in Buddy Penley Cave, in North Subway (20%) at 8.2 - 8.9°C and a portion of the Junction area (12%) at 7.4°C of Newberry-Bane Cave, and in Big Room of Coon Cave (9%) at 8.6 - 9.7°C (Table 3).

Pipistrellus subflavus used the most caves, 4 of 4 caves in autumn and 11 of 12 caves in winter (Table 2). Coon Cave contained over half the total in both autumn and winter, but Buddy Penley held 22% of autumn and 11% of winter populations. Temperatures were warmer in both caves in autumn than in winter (Table 3). In winter, *P. subflavus* concentrated in Main Passage (31% of the winter total) at 7.4 – 8.2°C and Big Room (33%); at 8.6 – 9.7°C of Coon Cave, and in Buddy Penley Cave at 6.5 – 7.4°C (Table 3). During winter, small concentrations of *P. subflavus* in Munsey #1, Paul Penley, and Bane Spring caves were generally in areas >8.0°C (Table 3).

Spring staging and autumn swarming.—Trapping at the entrance to Buddy Penley Cave for 4 nights in April 2000 produced 101 bats of four species: 63 *M. lucifugus*, 31 *M. septentrionalis*, 6 *P. subflavus*, and 1 *E. fuscus*. Female *M. lucifugus* were six times more common than males, but there were nearly equal numbers of male and female *M. septentrionalis*.

During autumn 2001, trapping on 4 nights at Newberry-Bane Cave, 885 bats of six species were processed: 27 *M. sodalis*, 603 *M. lucifugus*, 185 *M. septentrionalis*, 6 *M. leibii*, 60 *P. subflavus*, and 4 *E. fuscus*. Proportions of *M. sodalis*, *M. lucifugus*, and *P. subflavus* in the catch in autumn 2001 were different than proportions observed in Newberry-Bane Cave during winter 2000 (X^2 = 123.9; at P<0.001; df = 2). *Myotis lucifugus* was over represented in the winter survey and *P. subflavus* in the autumn survey. *Myotis sodalis* was similarly represented in samples from both seasons. In addition, *M. septentrionalis* was nearly absent from the winter survey (0.2%), excluding it from the analysis, but it was common in autumn (20.9%).

Catch of female *M. sodalis*, although small, was greater in mid-September than early September and early October, whereas captures of males, relative to females, increased through the samples (Figure 1a). Captures of female *M. lucifugus* remained relatively constant, but captures of males, relative to females, dropped dramatically over the autumn season (Figure 1b). More male than female *M. septentrionalis* were caught early and late in the sample season and the absolute catch appeared to increase late in the season (Figure 1c). The pattern for *P. subflavus* was similar to that of *M. lucifugus* (Figure 1d). *Myotis leibii* were caught on 8 September (2 male and 2 female), 26 September (1 male), and 11 October (1 male). On 26 September, one male *E. fuscus* was caught and on 11 October two males and one female were caught.

Summer maternity colonies.—No large accumulation of guano that would indicate summer use was found during autumn and winter intra-cave surveys. There was a

TABLE 3. Temperatures at which concentrations of three species of bats were found during autumn 1999 and winter 2000 surveys in caves of the Skydusky Hollow Cave System, Bland County, Virginia. Because not all bats were in areas of concentration, totals in this table do not necessarily match totals in Table 2.

Species / Survey	Date	Cave	Location	Bats	Temp (°C)
M. sodalis					
Autumn	22 Nov	Newberry-Bane	Lower Jct.	44	8.5
			Upper Jct.	126	8.9
Winter	5 Feb	Newberry-Bane	Lower Jct	0	7.2
			Upper Jct	29	8.7
			Bane Ent. Passage	206	7.0
M. lucifugus					
Autumn	22 Nov	Newberry-Bane	N. Subway	3,778	9.0 - 9.5
	23 Nov	Buddy Penley	Pit 1	2,068	7.9
	23 Nov	Paul Penley	Big Room	245	11.0
			Whisper Hall	67	10.0
	24 Nov	Coon	Main Passage	67	11.0
			Big Room	245	11.0
Winter	17 Jan	Coon	Main Passage	28	9.1
			Big Room	1,268	8.6 - 9.7
	19 Jan	Bane Spring	Front	383	7.4-8.3
			Pit	59	9.8
	3 Feb	Newberry-Bane	N. Subway	2,891	8.2-8.9
	5 Feb		Junction area	1,802	7.4
			Junction area	255	8.7
	4 Mar	Buddy Penley	Pit 1	4,280	6.3-6.5
			Pit	375	7.4
			Guano Climb	1,400	6.9
			Attic	210	8.4
	5 Mar	Paul Penley	Big Room	76	9.8
			Whisper Hall	755	9.4 - 9.8
P. subflavus					
Autumn	22 Nov	Newberry-Bane	all	31	9.0 - 11.0
	23 Nov	Buddy Penley	Entrance Passage	101	9.0
		Paul Penley	Whisper Hall	32	10.0
	24 Nov	Coon	Main Passage	175	11.0
			Big Room	90	11.0
Winter	17 Jan	Coon	Main Passage	451	7.4-8.2
			Big Room	469	8.6 - 9.7
	19 Jan	Bane Spring	Front	41	7.4 - 8.3
	28 Jan	Munsey #1	all	78	7.7 - 8.4
	3 - 4 Feb	Newberry-Bane	various	105	8.1 - 9.3
	5 Feb		Junction area	29	7.4
	4 Mar	Buddy Penley	all	160	6.5 - 7.4
	5 Mar	Paul Penley	Whisper Hall	47	9.4 - 10.2

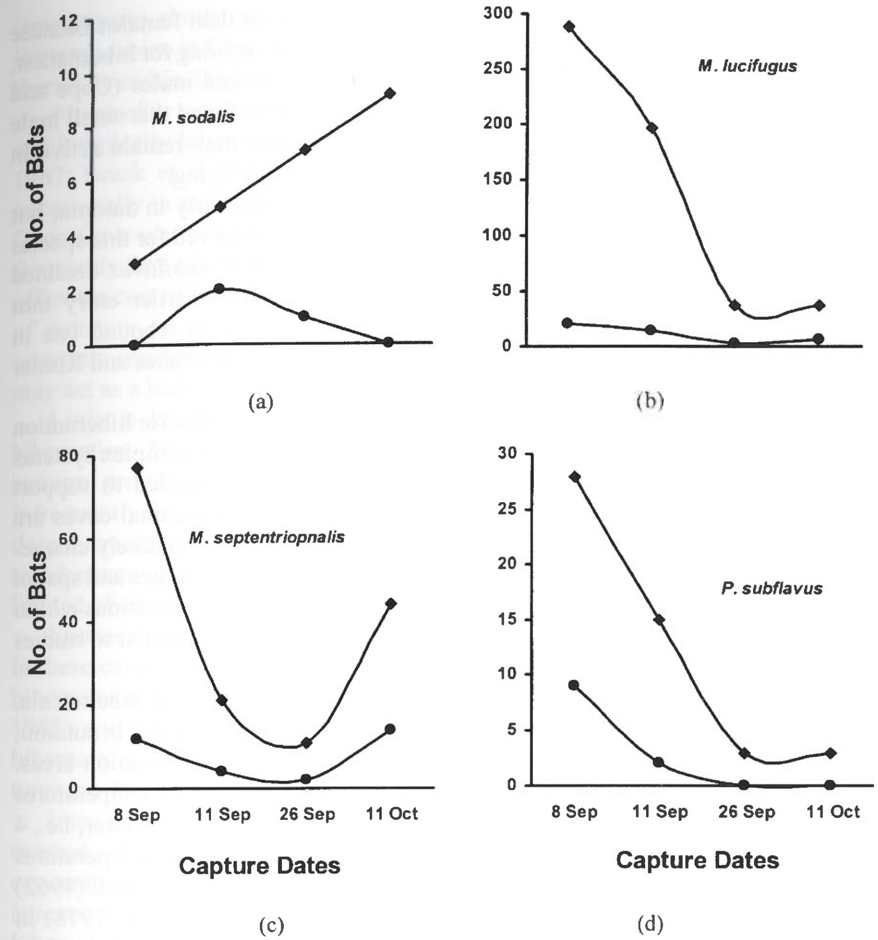

FIGURE 1. Captures of male (diamond) and female (closed circle) *M. sodalis* (a), *M. lucifugus* (b), *M. septentrionalis* (c), and *P. subflavus* (d) during autumn 2001 swarming. Note that numbers of bats are not to the same scale.

moderate accumulation of guano in the Attic of Buddy Penley Cave. When visited on 31 May 2000, no bats were present and there was no new accumulation of guano. The temperature was about 10°C.

DISCUSSION

Spring staging and autumn swarming.—Proportions of species of bats captured in spring and autumn varied among populations hibernating in the same caves. The greatest disparity was seen with *M. septentrionalis*, a species often caught at entrances to hibernacula in spring and autumn (Whitaker and Rissler 1992) but infrequently found during winter (Brack et al. 2003b, 2004).

The change in capture of bats as autumn progressed indicated a social component in use of the cave. Although there were disproportionately large numbers of males of all species, *M. sodalis* had the most dramatic shift in relative abundance of sexes during autumn. Male *M. sodalis* are more common during swarming than females because they congregate near hibernacula to mate with females that are arriving for hibernation; females terminate autumn activities and enter hibernation before males (Cope and Humphrey 1977; LaVal and LaVal 1980). Richter et al. (1993) found that small male *M. sodalis* with insufficient fat reserves to survive the winter may remain active in hibernacula, possibly seeking an opportunity to copulate before dying.

Male *M. lucifugus* were much more abundant than females early in autumn, but numbers dropped precipitously over time, similar to patterns observed for this species at caves in Indiana (Humphrey and Cope 1976). Activity of *P. subflavus* declined earlier in autumn than for other species, perhaps signaling an earlier entry into hibernation. By contrast, activity of *M. septentrionalis* seemed to rebound late in autumn, and perhaps is related to greater activity during winter (Whitaker and Rissler 1992).

Winter hibernation.—Cave morphology strongly affects suitability for hibernation (Humphrey 1978) by affecting airflow and thus temperatures. Large complex systems offer more opportunities for the combination of characteristics needed to support hibernating bats. The Skydusky Hollow Cave System and its individual caves are complex and extensive (Zokaites 1995). Most species of bats make relatively characteristic and recognizable use of hibernacula, including temperature regimes and spatial associations (Brack et al. 2003b). In the caves of Skydusky Hollow, the locations within caves used by concentrations of bats often changed between seasons, similar to studies in Missouri (Myers 1964; Clawson et al. 1980)

Hibernating *M. sodalis* often form dense clusters in cool areas of hibernacula. *Myotis sodalis* did not use the traditional roost in the Bane Entrance Passage in autumn, but by winter had moved there, at 7°C, from the Upper and Lower Junction areas. About 12% of the population remained in Upper Junction at 8.7°C. These temperatures are not as cold as is often considered optimal for the species during mid-winter, i.e., 4 - 8°C, or perhaps more narrowly 3 - 6°C (USFWS 1999). Further, cooler temperatures (6.3 – 6.5°C) were available at the bottom of Pit 1 in Buddy Penley Cave. Hall (1962) in the Midwest, Henshaw and Folk (1966) in Kentucky, and Humphrey (1978) in midwestern and eastern states, considered mid-winter temperatures used by *M. sodalis* to be 4 - 5°C, 2 - 3°C, and 4 - 8°C, respectively, but they did not provided supporting documentation. In contrast, Brack et al. (2003b) completed 25 years of studies in many of the caves addressed by Hall (1962) and Humphrey (1978) in Indiana, and they documented increasing populations of *M. sodalis* in these caves, hibernating in areas with mean mid-winter temperatures of 6 - 8°C. In Missouri, Myers (1964) found *M. sodalis* hibernating at 4.4 - 16.7°C, but considered 7.8°C representative; mid-winter temperatures at clusters in three caves were 5.0 - 9.2°C ($n = 6$; $\bar{X} = 7.1$; $SD = 1.4$). Also in Missouri, Clawson et al. (1980) found *M. sodalis* hibernating at 6 - 8°C in late January. Thus, temperatures used by *M. sodalis* in Skydusky caves were similar to those reported in other studies.

Myotis lucifugus uses many caves (Dalton 1987; Brack et al. 2003b) and small numbers often hibernate in warm areas, sometimes giving the impression that this species prefers the warmer temperatures that are available in caves for hibernation (Brack et al. 2003b, 2004). In Skydusky caves, the largest concentration of *M. lucifugus* ($n = 4{,}380$) hibernated at 6.5°C at the bottom of Pit 1 in Buddy Penley in an area cooler than areas used by *M. sodalis*. The remaining 6,300 *M. lucifugus* hibernated at

temperatures similar to, or slightly less than, temperatures used by *M. sodalis*. In a limestone mine in Ohio, *M. lucifugus* similarly used cooler areas, which were also less thermally stable, than did *M. sodalis* (Brack unpublished data).

Pipistrellus subflavus is found hibernating in more caves than other species of bats, and it typically hibernates singly and dispersed at warm, stable temperatures (Hassell 1967; Brack et al. 2003b, 2004). As in other caves, *P. subflavus* hung singly or occasionally in pairs and used a stable, warm area, but the number of *P. subflavus* in Coon Cave was much greater than observed in most caves. The species arouses less frequently than other species (Brack and Twenty 1985; Twenty et al. 1985), which may offset the cost of hibernating at warmer temperatures. This species often collects beads of moisture on guard hairs, which increases the mass of individuals and it is an interesting question whether this water, suspended between the bat and its environment, may act as a heat sink, dampening fluctuations in air temperature.

Little is known about *M. septentrionalis* and *M. leibii* during the season of hibernation. *Myotis septentrionalis* is readily caught at cave entrances in spring and autumn, providing indirect evidence of winter use (Whitaker and Rissler 1992), but is infrequently found in hibernation (Brack et al. 2003b). When found in winter, it is often deep in cracks or tight crevices in warm stable areas of the cave. *Myotis leibii* is believed to hibernate at cold temperatures (Best and Jennings 1997), an inference based on limited observation.

Eptesicus fuscus, a common summer resident in western Virginia, was uncommon in these caves in winter. In natural hibernacula, it is considered a hearty species that hibernates near entrances where temperatures may get very cold (Brack and Twente 1985), and it moves among hibernacula during winter. However, *E. fuscus* commonly hibernates in walls of old brick houses (Whitaker and Gummer 1992), where temperatures are 3 - 20°C ($\bar{X}$= 10°C).

Intra-cave movements of bats during the season of hibernation are poorly documented. Like Skydusky caves, Clawson et al. (1980) documented an increasing concentration of *M. sodalis* in areas considered traditional hibernacula roosts between autumn and mid-winter. Similar to Skydusky, Hassell (1967) found that *M. sodalis* hibernated in areas that got colder through the first half of the winter and warmer during the latter half of winter.

Because *M. sodalis* is listed as endangered, the occurrence of even a single individual has sometimes been used to identify a cave or mine as a hibernaculum. A single *M. sodalis* was found in Buddy Penley Cave in autumn; none were present in winter. There are several similar occurrences in Indiana: (1) an individual *M. sodalis* was in a cave one winter, and none were present the next (Brack et al. 2004), and (2) an *M. sodalis* was netted at a cave entrance in autumn, but no *M. sodalis* have been found during several winter surveys over a 25-year period (Brack et al. 2003b). In Ohio, a single *M. sodalis* was caught at a mine portal, but four additional nights of sampling during two seasons did not produce additional *M. sodalis* (Brack, unpublished data). These occurrences indicate that *M. sodalis*, and likely other species, visits caves and mines that are not used as hibernacula. Bats undoubtedly explore caves or parts of caves not suitable for hibernation, especially during the spring and autumn migration and transient periods.

Although Hassell (1967) reported that *M. lucifugus* occupied the same locations within caves throughout winter, we found that numbers and proportions of *M. lucifugus* in specific regions of Newberry-Bane, Paul Penley, and Coon caves changed dramatically over the season of hibernation. It is probable there were also inter-cave movements; Whitaker and Rissler (1992) documented bats exiting and entering hibernacula throughout winter. The net result of these population shifts was to concentrate hibernating *M. lucifugus* in cooler areas of the cave. Similarly, there were large changes between autumn and winter in numbers and proportions of *P. subflavus* in parts of Coon Cave. It is probable that in addition to temperature, the social nature of bats affects the locations they used for hibernation. Raesly and Gates (1987) found that the presence of other bats, of all species, strongly influenced use of sites for hibernation.

Summer maternity colonies.—No concentrations of bats were found in Skydusky caves during summer. The most likely candidate for summer use was *C. t. virginianus*, although there are records of bachelor colonies of *M. grisescens* in Lee County Virginia (Webster et al. 1985). There was no large accumulation of guano indicative of past use, and there were no bats in the Attic of Buddy Penley Cave in late May. The Attic was cooler (10°C) than maternity roosts used by *C. t. virginianus* in Kentucky (Lackie et al. 1994) and the closely related subspecies *C. t. ingens* (Ozark big-eared bat) in Oklahoma (Clark et al. 1996) at this time of year (12.8 - 16.3°C).

Summary.—The caves of Skydusky Hollow held >16,000 bats of 6 species in winter 2000, which is an important resource for the Commonwealth of Virginia and the region. Most (89%) were *M. lucifugus*, although 9% were *P. subflavus* and 1% the federally endangered *M. sodalis*. No endangered *C. t. virginianus* were found. Most bats were in two caves, Newberry-Bane (37%) and Buddy Penley (40%), including endangered *M. sodalis*, although there was an unusually large concentration of *P. subflavus* (64% of this species and 6% of the total) in Coon Cave. Of the three most common species, the largest mid-winter concentration of *M. lucifugus* was at the coldest temperature (6.3-6.5°C), *M. sodalis* at a more moderate temperature (7.0°C), and *P. subflavus* at the warmest temperature (8.6-9.7°C). No concentration of bats used the caves during summer. Proportions of species captured in spring and autumn were not consistent with wintering populations, with the greatest disparity shown by *M. septentrionalis*, a species often caught at hibernacula in spring and autumn but infrequently found in winter. Changes in proportions of males and females caught over autumn indicate a social function to autumn swarming.

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