

Final Report
South Dakota Department of Game, Fish and Parks
Wildlife Diversity Small Grants Program

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Project Title: Natural history of Whip-poor-wills (*Caprimulgus vociferus*) and the importance of riparian habitat for insectivorous bats in southeast South Dakota.

The objectives of this project were to:

Whip-poor-wills

- 1) Determine whether free-ranging Whip-poor-wills use torpor.
- 2) Estimate population size during 2001 and, by comparison to 2000, identify any changes in population size.
- 3) Determine habitat fidelity through recapture of birds banded in 2000.
- 4) Assess general habitat use and reproductive success through an expansion of the spatial scale of the study site.

Insectivorous Bats

- 1) Assess the impacts of a recent disturbance to the riparian woodlands on bat foraging behaviour.
- 2) Determine the effect of the riparian woodland removal on different groups of bats (i.e. small maneuverable species versus large less maneuverable species).

Introduction

Whip-poor-wills— During 2000 we conducted a preliminary study on Whip-poor-wills in southeast South Dakota. Due to the secretive nature of nightjars, a function of their cryptic plumage and crepuscular/nocturnal behaviour, little is known of their basic biology. Thus we sought to evaluate some general aspects of the biology of this nightjar representative. The purpose of the 2001 study was to continue this work to develop a more broad understanding of the biology of this species over space and time. Specifically we assessed population sizes, habitat

use and fidelity, and breeding success. In both summers these measurements were achieved via radio-telemetry. Because the transmitters used are temperature sensitive we were able to determine if, when, and to what extent Whip-poor-wills are capable of using torpor in the wild.

During periods of inclement weather, and the often accompanying shortages of food, many small mammals and some birds undergo daily heterothermy (hereafter torpor). Torpor is a behavioural and physiological condition characterized by a short-term reduction in metabolic rate and body temperature (Wang 1989; Geiser and Ruf 1995). Torpor has been recorded in eight orders of birds and is most common in the Caprimulgiformes (nightjars) and Apodiformes (hummingbirds; Reinertsen 1983). These two orders are especially vulnerable to energetic stress during cold weather, because the elevated costs of thermoregulation, are concurrent with severe decreases in food resources (insects for nightjars, and nectar for hummingbirds), thus exacerbating the energetic difficulties of these periods (Dawson and Hudson 1970). Although not yet conclusively demonstrated, there is good reason to believe that Whip-poor-wills should be able to employ this strategy. Morphologically and ecologically similar Common Poorwills (*Phalaenoptilus nuttalli*) are able to use both daily torpor and seasonal hibernation under natural conditions (Jaeger 1948; Brigham 1992), and under laboratory settings congeneric European Nightjars (*Caprimulgus europaeus*) are able to enter daily torpor (Peiponen 1966). Moreover, limited evidence from the preliminary study conducted during 2000 suggested that Whip-poor-wills have the ability to enter torpor during periods of low ambient temperatures (Buck *et al.* 2000).

Estimates of population sizes of Whip-poor-wills, and nightjars in general, are typically conducted with call-count censuses (e.g. Cooper 1981; Cadbury 1981). Although nightjars are rarely seen, their use of calls to advertise territory ownership allows for the use of acoustic surveys to estimate of population sizes. However, the limited time frame of most nightjar census studies, does not allow for an assessment of year-to-year changes in population densities (e.g. Cooper 1981; Cadbury 1981). The temporal scope of this study represented a rare opportunity to measure the population status of this species in southeast South Dakota over two consecutive summers.

Quantifying over-winter survivorship of migrant species is difficult. A potential proxy for this measure in territorial species may be the recapture of individuals over two or more seasons from the same territory. Furthermore, information of territory fidelity may be gained by netting in new areas adjacent to areas netted in the previous year. This technique will allow us to evaluate both site fidelity and survivorship issues in Whip-poor-wills.

To date the only comprehensive study on Whip-poor-will reproduction was conducted in southern Ontario, Canada (Mills 1986). In this area Whip-poor-wills synchronize breeding with the lunar cycle, so that the period of highest energetic demands of the offspring corresponds to the brightest phase of the lunar cycle, important for a visual forager (Mills 1986). Also, in this study, potentially due to the constraints of lunar synchrony, birds only laid one clutch of two eggs each season (Mills 1986). However, Common Poorwills in the Okanogan Valley, British Columbia, Canada typically lay two clutches which are not synchronized to the lunar cycle (Brigham and Barclay 1992). Additionally, the only nest recorded for Whip-poor-wills in southeast South Dakota was not synchronized to the lunar cycle (Dean *et al.* 1995). The importance of the reproductive strategy employed by Whip-poor-wills in southeast South Dakota, in terms of population recruitment, could be profound. As such we sought to determine the degree of lunar synchrony in Whip-poor-wills over two summers, with the corollary of the

number of clutches laid in the breeding season, and to ascertain the reproductive success (measured as number of eggs laid that survive to fledging) of the population.

Tree Roosting Bats— Before the first year of this study the bat fauna of southeast South Dakota remained relatively unstudied. As such there was a paucity of even basic information such as species composition and sex ratios (Stukel and Backlund, 1997). In 2000 we captured six species of bats (*Myotis lucifugus*, *Eptesicus fuscus*, *Lasiurus cinereus*, *Lasiurus borealis*, *Lasionycteris noctivagans*, and *Nycticeius humeralis*). Importantly this includes the first record for an evening bat (*N. humeralis*) in South Dakota. This species typically inhabits more southern latitudes and has not been recorded north of Nebraska (Jones *et al.* 1983). In 2001 we set out to continue the survey that was initiated in 2000, and to more rigorously assess the habitat requirements of tree roosting bats.

Work conducted in anthropogenic environments suggests that roost site availability, rather than prey density, is likely the limiting variable to bat populations (Humphrey 1975). In prairie ecosystems with little or no relief, such as southeast South Dakota, large cottonwoods (*Populus deltoides*) likely represent the principle roosting sites for both cavity roosting species (e.g. big brown bats (*E. fuscus*)) and foliage roosting species (e.g. hoary bats (*L. cinereus*)). Furthermore, as the life cycles of most insects are tied to water, the riparian habitats along the Missouri River should provide a reliable source of flying insects (Borror *et al.* 1989). Trees then serve as a windbreak concentrating the flying insect prey in the riparian zones (Holloway and Barclay 2000). As such, the riparian cottonwood stands of the Missouri River likely represent the best remaining habitat for bats in southeast South Dakota.

The importance of riparian zones has been indicated previously by bat activity (recorded as echolocation calls) being typically several times higher here than in the nearby forest or agricultural fields and the relatively high capture rates of bats in riparian zones as compared to the other two (Grindal 1996; Holloway and Barclay 2000). This result was indicated in southeast South Dakota as well by the relatively high capture rate and acoustic activity in the riparian habitats sampled during 2000. The Myron Grove River access had the highest capture rate (0.24 bats/net hour) followed by Cotton Park south of Vermillion (0.06 bats/net hour), and the one site that was not a riparian woodland (Union County State Park) did not yield any captures (Buck *et al.* 2000).

Despite the importance of riparian habitat to bats, little work has been done to assess the impact of removal of this habitat. One of the few studies investigated the effect of clear-cut logging riparian areas on foraging bats in western Oregon (Hayes and Adam 1996). Although the disturbances were relatively small (90m and 180m of streamside habitat) bat activity was between 4 and 7 times higher in the undisturbed areas as compared to the disturbed areas (Hayes and Adam 1996). This study, though of limited scope (all work was conducted on third-order streams with alder dominated riparian zones in the Oregon Coast Range; Hayes and Adam 1996), draws attention to the potential deleterious effects of disturbing riparian areas on insectivorous bats.

In addition to the general finding that logging riparian areas reduces numbers of foraging bats, it was also found that logging affected different groups of bats in different ways (Hayes and Adam 1996). Small maneuverable bats (e.g. *Myotis* spp.) made up the vast majority of the species assemblage (>99.9% of all calls) in the wooded areas, while larger, less maneuverable bats (e.g. *E. fuscus*) were much more common (between 6 and 30% of all calls) in logged areas.

The stretch of the Missouri river system between Gavins Point Dam, SD and Sioux City, IA represents the largest remaining unaltered section of this system. However the competing demands on this habitat for agriculture, recreation, and road development, has meant that riparian habitat, important for wildlife, is rapidly being lost. As such mature-old cottonwood stands may soon be lost from the landscape, and the long term effects of this habitat change on wildlife needs to be elucidated.

Materials and Methods

Whip-poor-wills— In order to determine whether or not Whip-poor-wills use torpor and to provide location data, birds were captured and outfitted with external temperature sensitive radio-transmitters. In 2000 Birds were captured in mist nets in Clay County State Park, Union County State Park and the remnant riparian woodlands adjacent to the Vermillion Airport (henceforth the Airport Site). In 2001 these sites were used again (with the exception of Union County State Park as acoustic monitoring revealed that Whip-poor-wills did not occupy this site in 2001). The road development for the bridge to connect Vermillion, SD with Newcastle, NE allowed a more in depth sampling of the Airport Site. We also conducted acoustic surveys at the Burbank River Access, and the Myron Grove River Access and both acoustic surveys and mist netting at the Adam's Homestead. All of these sites, except Union County State Park, are riparian woodlands of the Missouri River. Union County State Park is non-riparian remnant woodland.

The project began on 21-April-2001, when Whip-poor-wills returned from spring migration. Territories identified 2000 were still marked with surveyors tape. We initially returned to these sites and listened for the calls of the territorial males. Once it was determined that the territory was reoccupied, mist-nets were erected on the edge of the forest stand. During 2000 it was found that the most effective mist-net arrangement for capturing the Whip-poor-wills was a "box" style arrangement with 4 or 5 2.5m-5m high/10-12m long mist nets (Buck *et al.* 2000). In total we netted for Whip-poor-wills on 88 nights (Clay County State Park: 25, Airport Site: 60, Adam's Homestead: 3). To lure birds into nets we used playbacks of territorial males placed in the center of the mist net arrangement. The responsiveness of the birds to the playback remained relatively high from April through to the end of August. Birds were also captured opportunistically when they hit one of the nets on their usual flight paths.

Once captured, birds were removed from the net and held in cloth bags in order to reduce the potential for self-injury. We measured body mass, wingspan, age (adult or juvenile), and sex. Finally, a 2.3g temperature sensitive radio-transmitter was affixed to the bird. The transmitters were attached backpack-style, and fit between the scapulae. As these transmitters are external, they provide a measure of skin temperature (T_{sk}), which has been found to reliably vary with body temperature (T_b ; Brigham 1992; Brigham *et al.* 2000). The transmitters emit a signal with a pulse rate proportional to the animal's T_{sk} (pulse rates are faster with higher T_{sk} and slower with lower T_{sk}). The signal could be received from a distance of approximately 1-2 km, depending on the terrain. In general, based on subsequent observations of birds in the field, the transmitters had no apparent negative effect on the bird's ability to fly. As in 2000, T_{sk} readings were taken manually from 9 p.m. to 6 a.m., at half-hour intervals, from the date of capture to either signal loss, thrown transmitter, death, or migration. During 2001, we also employed a remote telemetry receiver (Model SRX_400, Lotek Engineering, Aurora, Ontario, running version 3.61 W21 software). The receiver was attached to 1-3, 5-element Yagi antennas and powered by a 12V volt battery. The receivers were deployed in the territory, within 500m-1km of the focal bird. The

receivers were programmed to record an "event" after the reception of 5 noise-free pulses, and then calculate the average interpulse interval. This interval was then converted to a temperature with previously input calibration curves. Temperature measurements, using this method, were taken every 15 min for 24hr.

In addition to field measurements of body temperature, six males (5 adults and 1 juvenile) captured throughout the season were transported to the laboratory at the University of South Dakota, where we measured metabolic rates (MR) of the animals. The birds were held at room temperature and provided with water ad libitum. Metabolic measurements were conducted on the following day. Birds were transferred to a respirometry chamber where metabolic trials were conducted following the procedure of Cooper and Swanson (1994). MR was measured at 10 designated chamber temperatures (5, 10, 20, 22.5, 25, 27.5, 32.5, 35, 37.5, 40 °C). Basal metabolic rates (at 28-35°C) were recorded during the daylight hours (the normal rest phase for Whip-poor-wills). The temperature was then dropped by 15°C and the MR was recorded at this temperature during the night. This procedure was then repeated once more for all but one bird, so the MR of each bird was measured at three temperatures. The one exception was a male who was recorded at 5 temperatures. The T_a was then held at the lowest temperature for each bird for the duration of the night to determine if Whip-poor-wills could be induced to enter torpor under laboratory conditions. Birds were released at their site of capture directly following the metabolic measurements.

Nest searches were carried out weekly for birds that had been outfitted with radio-transmitters. When a nest was found, local vegetative characteristics were recorded, as was the number of young, and the incubation behaviour of the parents. The sampling interval was increased to once every 2-3 days while eggs or dependent young were in the nest. In this manner we were able to achieve an accurate assessment of incubation period, time to fledging, and fledging success.

The ages of the stands in which Whip-poor-will territories were located were determined through coring the canopy cottonwood trees. The density of live and dead trees (>30cm DBH) was also recorded to determine general habitat variables selected for by the Whip-poor-wills.

Call counts were conducted on a sample of nights, at all study sites. This form of census is commonly employed to determine the population size of nightjars (e.g. Cadbury 1981; Cooper 1981). As territories remained constant throughout the season we are confident that our censuses reflect the actual numbers of a relatively stable population.

Tree Roosting Bats— Three ultrasonic detectors (Anabat II, Titley Electronics, Ballina, N.S.W. Australia) were set up nightly (one in cleared riparian habitat, one in undisturbed, and one on the edge between the two habitat types) for 5 nights. The detectors were programmed to turn on at dusk and turn off at dawn. Echolocation calls of bats were stored to an audiocassette with a time signature. These tapes were analyzed at a later date to separate commuting passes from feeding buzzes. Feeding buzzes are characterized by a rapid series of calls, indicating that a bat is attempting to catch an insect (Griffin *et al.* 1960). Thus we were able to determine, not only the relative abundance of bats within the three habitat types, but also the specific activities (commuting or foraging) in each of these habitats. We also classified each call to one of two groups (small maneuverable bats versus large less maneuverable bats) to assess the effects of the disturbance on the two groups. Although this type of analysis does not allow for an exact identification of species (Barclay *et al.* 1999) it does allow separation of *M. lucifugus* and *N. humeralis* from *L. borealis*, *L. cinereus*, *L. noctivigans*, and *E. fuscus*. All analyses were

conducted with an interface module (Anabat V ZCA Interface Module and Anabat 6.3f Analysis Software, Titley Electronics, Ballina, N.S.W. Australia) connected to a personal computer.

During 2000, bats were opportunistically captured at Clay County State Park, and the Airport site. Additionally bats were netted for bats at the Myron Grove River Access, Cotton Park (near Vermillion, SD), Union County State Park, and the Airport Site. In 2001 we also netted bats at the Burbank River Access. Opportunistically bats were captured by netting for Whip-poor-wills. At sites where bats were targeted we distributed three to five mist nets along anticipated flight paths such as foliage tunnels created by overhanging tree branches and along river edges, where there is a high abundance of flying insects.

Captured bats were extracted in a similar fashion to that of Whip-poor-wills. Bats were removed from the nets and held in cloth bags until measurement. The following data were collected: location of capture, time, sex, reproductive status, species, mass, and forearm length. All bats were released at the site of capture immediately following data collection.

Results and Discussion

Whip-poor-wills—A total of 26 birds were captured, 23 of which were outfitted with radio-transmitters. Twenty of the twenty-six birds captured were male (15 adult, 5 juvenile) and six were female (5 adult, 1 juvenile). Although males are assumed to be more aggressive in their territories than are females (Mills 1986), an assumption which was borne out by the higher proportion of males caught in our study, females were observed to call and defend territories during the breeding season. Adult males and females did not significantly differ in mass (males = 53.02 ± 3.93 g; females = 53.39 ± 5.76 g; Two-sample t-test, $P > 0.05$) or wingspan (males = 40.64 ± 4.07 cm; females = 41.05 ± 2.45 cm; Two-sample t-test, $P > 0.05$). While adult birds had a significantly larger body mass than juvenile birds (adults = 53.11 ± 4.29 g; juveniles = 48.42 ± 3.64 g; Two-sample t-test, $P < 0.05$), there was not a significant difference in the wingspan between the two age classes (adults = 40.73 ± 3.71 cm; juveniles = 42.70 ± 0.14 cm; Two-sample t-test $P > 0.05$)

Based on the call counts, birds were most abundant in Adam's Homestead state park (30 males), followed by the Airport Site (24 males) and Clay County State Park (13 males). Although these values mostly represent calling territorial males, the capture of females implies that both sexes were present. Birds were not observed calling at Union County State Park, the Burbank River Access, or Myron Grove River Access. However Whip-poor-wills were heard calling from across the river in Nebraska at both the Burbank and Myron Grove River Accesses. During 2000, birds were heard calling at Union County State Park early in the season, and two males were captured on 29-May and 30-May. However, by 11-June both birds had left the site and could not be relocated and birds were not heard calling at this site for the remainder of the season. Similarly acoustic activity was not observed during our census in 2001. The cause(s) of this evacuation and lack of recolonization are unknown.

We did not recapture any of the individuals banded in 2000, in 2001. However we believe that this result was due to the reluctance of previously captured individuals to approach the playback tape. That Whip-poor-wills are capable of long-term song memory is evidenced by the responsiveness of birds at the Clay County State Park. The majority of birds were captured here in 2000 (9 of 12) while in 2001 only 4 of the 26 birds were captured at this site, and all were individuals who had not been handled the previous year. Although territories identified last year were occupied, as indicated from acoustic surveys, these territories did not yield any captures.

This phenomenon prohibited an evaluation of habitat fidelity and overwintering success of Whip-poor-wills in this study, and has important relevance to future studies.

As predicted, all of the birds were captured and detected in remnant riparian woodlands of the Missouri River. This habitat is dominated by a cottonwood (*Populus deltoides*) overstory and an understory of rough leaved dogwood (*Cornus drummondii*) and prickly ash (*Zanthoxylum americanum*). Poison ivy (*Toxicodendron radicans*) and Virginia creeper (*Parthenocissus quinquefolia*) compose the herbaceous layer (Dean *et al.* 1995). The age classification of both Clay County State Park and Adam's Homestead were similar (55.4-65.6 years), as were the density of live and dead canopy trees (Figure 1). The road development at the Airport site allowed us to more extensively survey this area for Whip-poor-wills. The age classification differed from the other two sites and was more variable within the site (22.8-91 years), as was the density of live and dead canopy trees (Figure 1). During 2000, we observed 4 birds calling at this site, while in 2001 we observed six times this number. Two potential reasons could account for this dramatic increase. First the numbers of birds present during the two years were similar but the limited accessibility of this site may have prevented us from detecting the birds that were present during 2000. Second, the few anecdotal reports of Whip-poor-will habitat selection have suggested that mixed woods forests with large amounts of edge are preferred (Hamel *et al.* 1978; Bjorklund and Bjorklund 1983). Therefore, the increased edge habitat created by the road development may have rendered this habitat more suitable to Whip-poor-wills in 2001.

Nest searches during 2001 resulted in the discovery of nine Whip-poor-will nests produced by seven different females. We know the laying date for three (the others were found at varying stages post-laying). The incubation period for Whip-poor-wills has been recorded as 14-19 days (Bent 1940). The duration of the incubation period for the two nests that we have complete information for was 19 and 22 days. In contrast to Mills (1986) finding that Whip-poor-will reproduction is synchronized to the lunar cycle we found that nest initiation occurred evenly throughout the summer (Table 1). During 2000 a male was observed incubating a nest with one chick (on 10-June) while the female performed a distraction display 10m away. The behaviour of males incubating nests was not observed at all in 2001. Whether this indicates that male incubation is a rare occurrence in Whip-poor-wills or conditions were somehow different between the two years is unknown. Of all of the nests for which we know the fate (eight of nine), only two hatched both young. Three nests were completely depredated (including one in which the incubating female was depredated as well). Interestingly at three of the nine nests only one of the two eggs hatched, two of which fledged the young. Upon hatching of one of the eggs for one nest, the abandonment of the other egg was observed with the female moving the chick to a new nest site. Juveniles were volant on days 13 and 18 after hatching and the first capture of a juvenile occurred on 22-June at the Airport site. Similar to 2000, the "nest" consisted of a small clearing in the herbaceous layer, with the immediate area predominated by ground/detritus and some alive herbs and grasses (Figure 2).

In 2000 we collected some data indicating that Whip-poor-wills are capable of using torpor during periods of low ambient temperatures. Although temperature recording during the autumn (beginning in September and extending to migration in early October) was discontinuous, a positive linear correlation between T_a and T_{sk} was observed. This correlation was mainly due to the depressed skin temperatures at T_a 's below 10°C. While these temperatures were indicative of torpor use, they were not conclusive. During 2001 we recorded irrefutable evidence that Whip-poor-will use torpor. During May of this year two males used a total of five torpor bouts (Figure 3). During a week of cool weather the skin temperatures of the males

dropped to an average minimum temperature of $20.06 \pm 2.63^\circ\text{C}$ for an average duration of 360.00 ± 93.67 min. The use of torpor was restricted to males. Two incubating females concurrently being followed remained euthermic during this period (Figure 3). Entry into torpor occurred prior to sunset (between 5:16 and 5:46 a.m.), and arousal corresponded to the rise in ambient temperature in mid-morning (Figure 3).

The combination of ambient temperatures used during 2000 and 2001 in the laboratory provided an accurate representation of the metabolic response of Whip-poor-wills over all ambient temperatures that they are likely to experience under natural environments (Figure 4). The basal metabolic rate (recorded over all temperatures within the thermal neutral zone: $28\text{--}35^\circ\text{C}$) was 88% of that predicted for nonpasserines with a mass of 45g (Aschoff and Pohl 1970). A lower than average basal MR is consistent with published data for other caprimulgids (Bartholomew *et al.* 1957). However, MR at 0°C was 3.1 times greater than basal MR suggesting this species is poorly insulated, and thus supporting the necessity for the use of torpor when exposed to low environmental temperatures. Use of torpor was recorded under laboratory conditions on 3-July-2001 (Figure 5). The parameters of its use did not differ from bouts recorded under natural conditions. The Tsk of the bird decreased concurrent with MR to 19.3°C and 0.13 ml O_2/hr respectively. Due to the low MR, it was assumed that the bird had died in the chamber, and it was removed while still torpid. The bird was then aroused with external heat and returned to the site from which it was captured.

In conclusion, our field measurements of skin temperature recorded during 2000 and 2001 and our laboratory metabolic data recorded during 2001 demonstrate that Whip-poor-wills are capable of using torpor during periods of low ambient temperatures. Stemming from the similarities in ecology, and morphology and the taxonomic relatedness to Common Poorwills, it is not surprising that both species use torpor as an energy saving strategy

Tree Roosting Bats—Bats were visually observed foraging in and around Vermillion, SD on 9-April indicating that spring migration and emergence from hibernation occurred around this time. During 2000, bat captures were concentrated within Myron Grove River Access. During 2001 sites were expanded to include the Burbank River Access, and a more in depth survey of the Airport Site. Additional captures occurred in Clay County State Park during both years, Union County State Park during 2001, and Cotton Park during 2000

A total of 56 bats of five different species, were captured during 2001. In total, over the two summers, 116 bats from six different species were captured. The remainder of the analyses use the entire, two-summer, data set. Overall the most dominant species in the assemblage was *E. fuscus*, followed by, in decreasing order of abundance, *M. lucifugus*, *L. borealis*, *L. cinereus*, *N. humeralis*, and *L. noctivigans* (Table 2). Importantly *N. humeralis* was recorded for the first time in southeast South Dakota. This species was captured both summers indicating that a population is present in southeast South Dakota. In addition, the female captured during 2001 was post-lactating signifying that it is a reproductively active population. Although we reported the capture of northern long-eared bats (*Myotis septentrionalis*) from 2000, these were later reclassified as little brown bats (*M. lucifugus*).

A nearly equal sex ratio was recorded for all species for which we had a reasonable sample size (ratio of males to females: *E. fuscus*: 50%/50%; *M. lucifugus*: 46%/54%; *L. borealis*: 44%/56%; *L. cinereus*: 40%/60%). The two *L. noctivigans* caught during 2000 were both males, while the three *N. humeralis* caught were all females. The dates that palpably pregnant females,

volant young, lactating females, and post-lactating females of each species were captured are shown in Table 2.

The importance of riparian habitat for insectivorous bats in southeast South Dakota was suggested by the relatively high capture rate, and acoustic activity in this habitat during 2000. During 2001 we quantitatively determined the importance of intact riparian habitat. As predicted there were differences detected in commuting and foraging behaviour between the three habitat types (Figure 6). Surprisingly, the difference was the exact opposite of what we expected. The open habitat consistently had a higher proportion of both feeding buzzes and commuting passes than either of the other habitat types, with the edge habitat being mid-way between the intact and cleared patches. The commuting passes by big bats did not differ significantly between the open and edge habitat or the edge and forest habitat, but the open habitat had significantly more passes than the forest (ANOVA with Tukey's Post Hoc Test $F_{2,11} = 11.42$, $P < 0.05$). The open habitat similarly yielded significantly more feeding buzzes by big bats than the other two, which weren't significantly different (ANOVA with Tukey's Post Hoc Test, $F_{2,11} = 8.35$, $P < 0.05$). The number of commuting passes by little bats did not differ significantly between the open and edge habitat, but both were significantly higher than the forest (ANOVA with Tukey's Post Hoc Test, $F_{2,11} = 5.24$, $P < 0.05$). A significant difference was not detected between the feeding buzzes of little bats in the three habitat types (ANOVA with Tukey's Post Hoc Test, $F_{2,11} = 1.28$, $P > 0.05$).

The two summers of field data yielded a number of noteworthy results. The riparian habitat of the Missouri River houses a diverse insectivorous bat fauna (at least six species) dominated by *E. fuscus*. This species represented over 52% of all of the bats captured. This species is common and widespread throughout much of North America (van Zyll de Jong 1985) and is known to be able to acclimate well to anthropogenic sites (Nagorsen and Brigham 1993). Thus the combination of roosting opportunities in the town of Vermillion, and the riparian woodlands likely represents an ideal combination of habitats for this species. While in 2000 it appeared that males were more common than females, using the combined results from both summers it is apparent that there is an almost equal sex ratio for most species. Previous studies have suggested that the increased energy demands of females, with young, cause them to be more prevalent in lowland foraging habitats, while males are relegated to less optimum habitats and potentially spend the majority of the summer torpid (Grindal *et al.* 1999). Potentially the higher temperatures and greater insect abundance in the riparian woodlands of the Missouri River (Grindal *et al.*'s 1999 work was conducted in the southern interior of British Columbia) allow both males and females to exploit this habitat. That the more favorable climate allows individuals to remain euthermic is supported by the finding that Whip-poor-wills did not use torpor during the majority of the study (from late May to mid September).

Three *N. humeralis* were captured over two summers. This species typically inhabits more southern latitudes and has never before been recorded in South Dakota. The capture of three individuals over two summers suggests that this species is indeed present in southeast South Dakota, and that the captured bats weren't accidental vagrants. Further, the capture of a post-lactating female indicates that the population in southeast South Dakota is reproductive.

The finding that open habitats are beneficial to foraging bats was contrary to our predictions, and findings from previous work (e.g. Hayes and Adam 1996; Holloway and Barclay 2001). Two potential reasons could account for this result. First the thick mid-level growth of Virginia creeper and other sub canopy trees characterizing the riparian woodlands of the Missouri River may create sufficient clutter to impede foraging by bats. As such, the openings provided a beneficial foraging environment for bats. Second the openings in the forest

may have created "windows" to the Missouri River for bats commuting from more upland areas. Regardless of the cause of the observed increase in bat activity in the disturbed sites we are hesitant to suggest that this disturbance is beneficial to the bat community. Although an increase in activity was observed in the cleared sites, it is important to realize that the clearing resulted in the removal of both live and dead cottonwood trees which represent current and potential roost sites for insectivorous bats.

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Table 1. Nesting Data for Nine Whip-poor-will (*Caprimulgus vociferus*) nests monitored during the 2001 breeding season in southeast South Dakota.

| Variable | Nest 1 | Nest 2 | Nest 3 | Nest 4 | Nest 5 | Nest 6 | Nest 7 | Nest 8 | Nest 9 |
|--|--|----------------------|------------|------------|---------------------|----------------------------------|----------------------|--|--|
| Female | 567 | 567 | 732 | 732 | 792 | 762 | 523 | Unmarked | Unmarked |
| Date of initiation | May 13 | June 23 | May 15 | June 8 | June 12 with 2 eggs | June 26 with 2 volant juveniles) | July 9 with 2 eggs) | July 16 with 2 eggs) | Unknown (found on July 24 with 2 eggs) |
| Outcome | Hatched one juvenile | Hatched one juvenile | Depredated | Depredated | Depredated | Found with two volant juveniles | Hatched one juvenile | Hatched two juveniles | Depredated |
| Date of failure or hatching | June 5 | July 11 | May 21 | June 26 | June 16 | Unknown | July 19 | July 31 | July 28 |
| If hatching, number of juveniles fledged | Unknown (Female found roosting without chick on June 16) | 1 | N/A | N/A | N/A | 2 | 1 | Unknown (Female moved nest after hatching and was not relocated) | N/A |

Table 2. Summary of number captured, morphological, and reproductive data for insectivorous bats in southeast South Dakota during the summers of 2000 and 2001.

| Species | Number Captured | Average (± 1 SD) Mass (g) | Average (± 1 SD) Forearm Length (mm) | Period When Pregnant Females Captured | Period When Lactating Females Captured | Period when juveniles captured | Period When Post-lactating Females Captured |
|-----------------------|-----------------|--------------------------------|---|---------------------------------------|--|--------------------------------|---|
| <i>E. fuscus</i> | 60 | 18.60 \pm 4.22 | 45.49 \pm 2.04 | June 10-June 28 | June 15-July 23 | July 17-Aug 22 | Sept 7-9 |
| <i>M. lucifugus</i> | 35 | 6.74 \pm 1.02 | 35.22 \pm 1.34 | None captured | June 27-June 30 | Aug 1 - Aug 17 | None captured |
| <i>L. borealis</i> | 9 | 10.60 \pm 2.27 | 40.10 \pm 1.82 | None captured | None captured | July 9-Aug 17 | None captured |
| <i>L. cinereus</i> | 5 | 23.76 \pm 2.38 | 53.70 \pm 1.52 | None captured | None captured | July 9-Aug 22 | None captured |
| <i>N. humeralis</i> | 3 | 12.37 \pm 4.56 | 37.08 \pm 1.47 | None captured | None captured | Aug 22 | Sept 7 |
| <i>L. noctivigans</i> | 2 | 10.90 \pm 0.00 | 40.9 \pm 0.14 | None captured | None captured | July 17-July 27 | None captured |

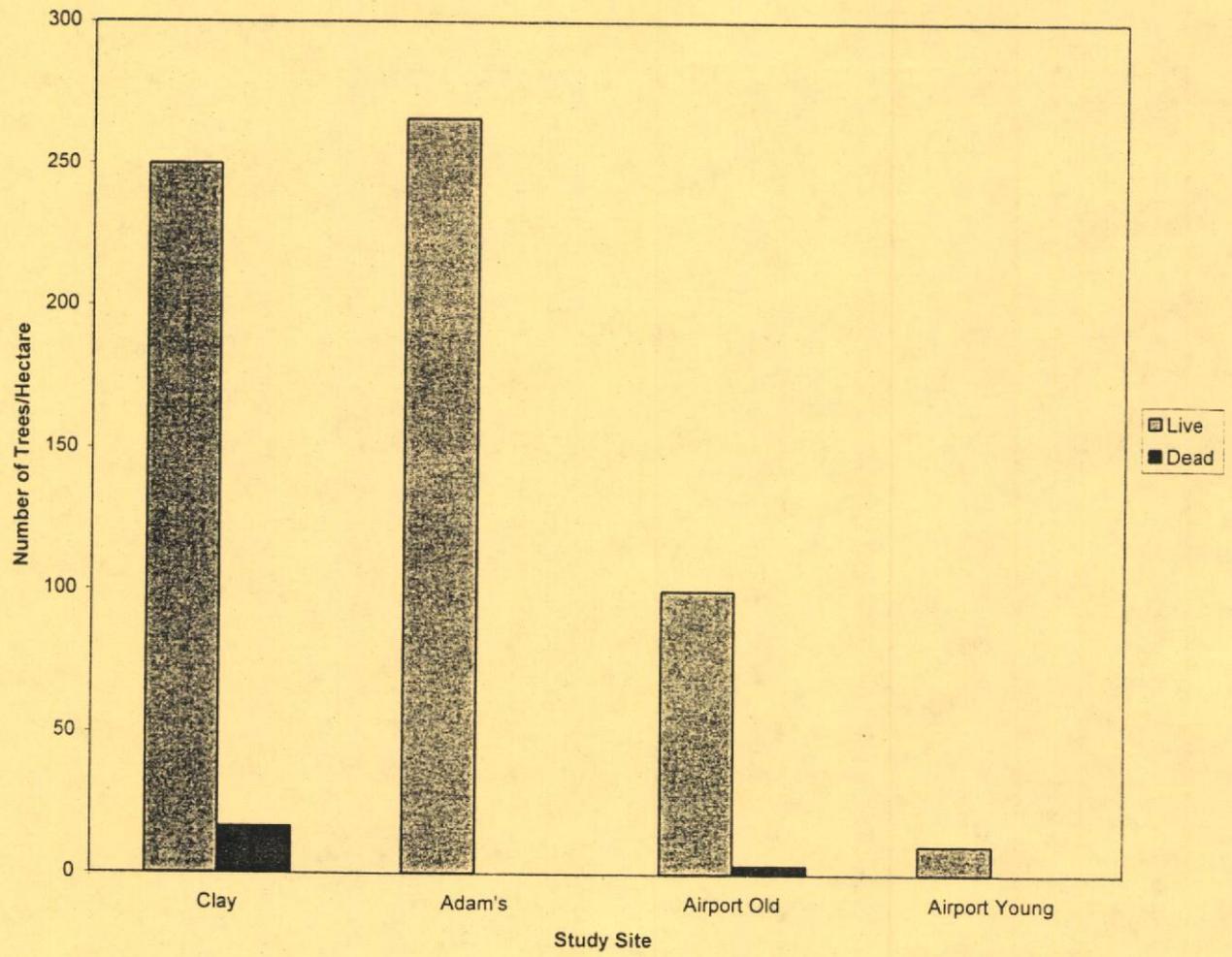


Figure 1. Density of live and dead trees in each of the study sites in southeast South Dakota. Only trees >30cm DBH were enumerated.

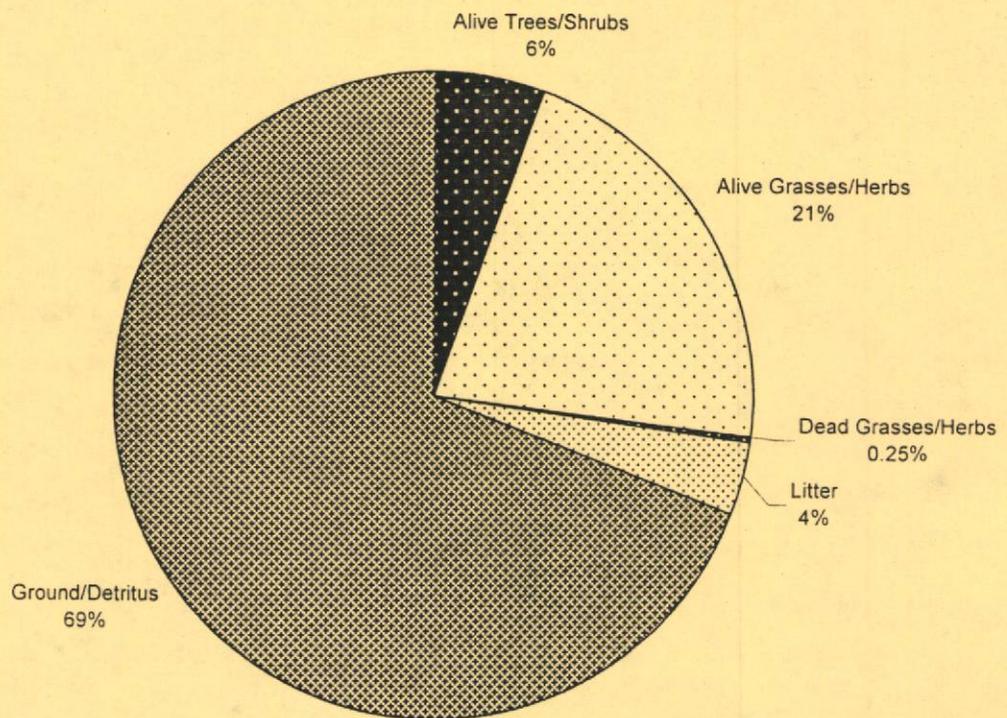


Figure 2. Vegetative composition of the immediate surroundings (1mX1m) of Whip-poor-will nests in southeast South Dakota.

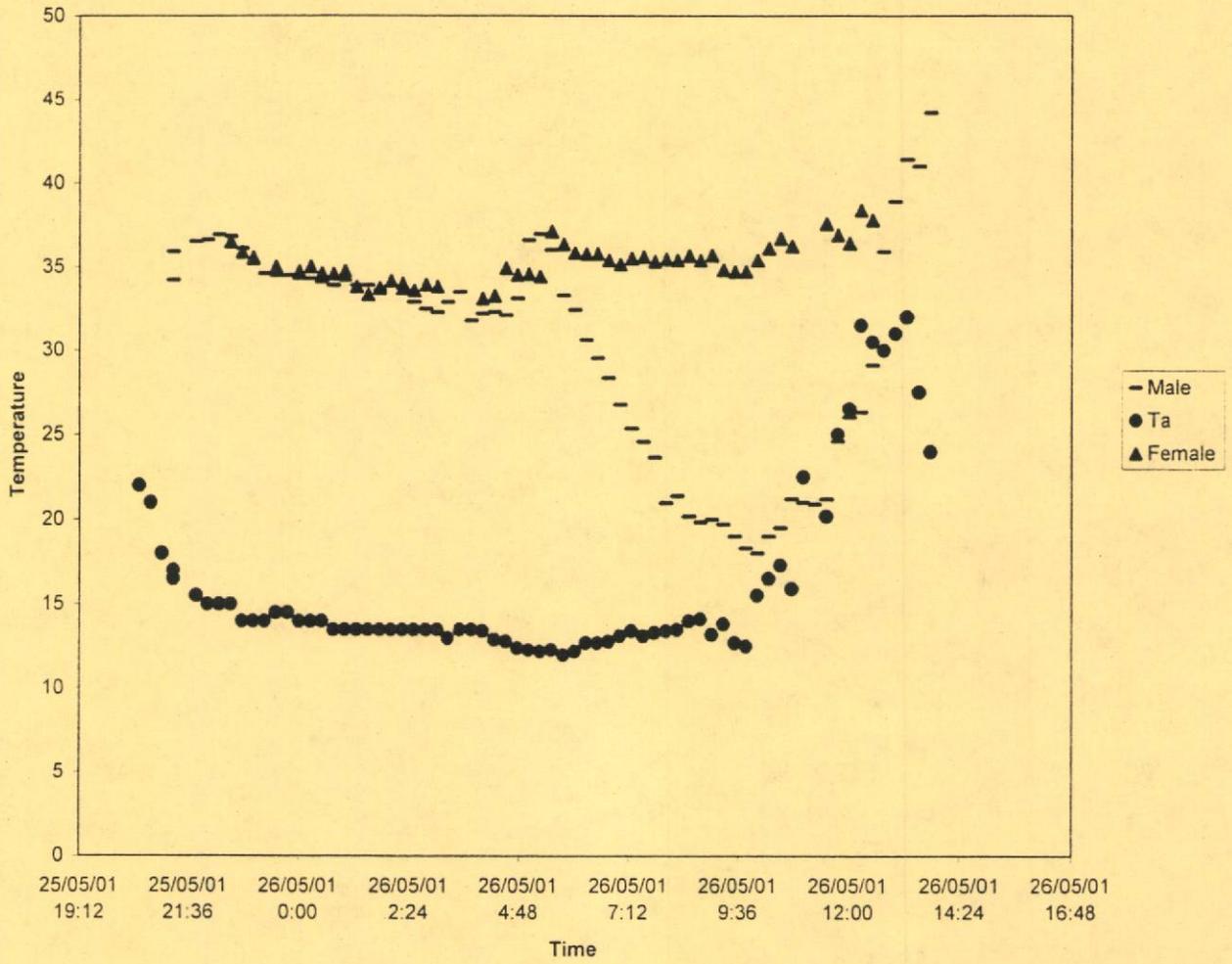


Figure 3. Ambient temperature and skin temperature measurements for a reproductive female and a male on 23-24-May, 2001. The depression in Tsk of the male indicates the use of torpor.

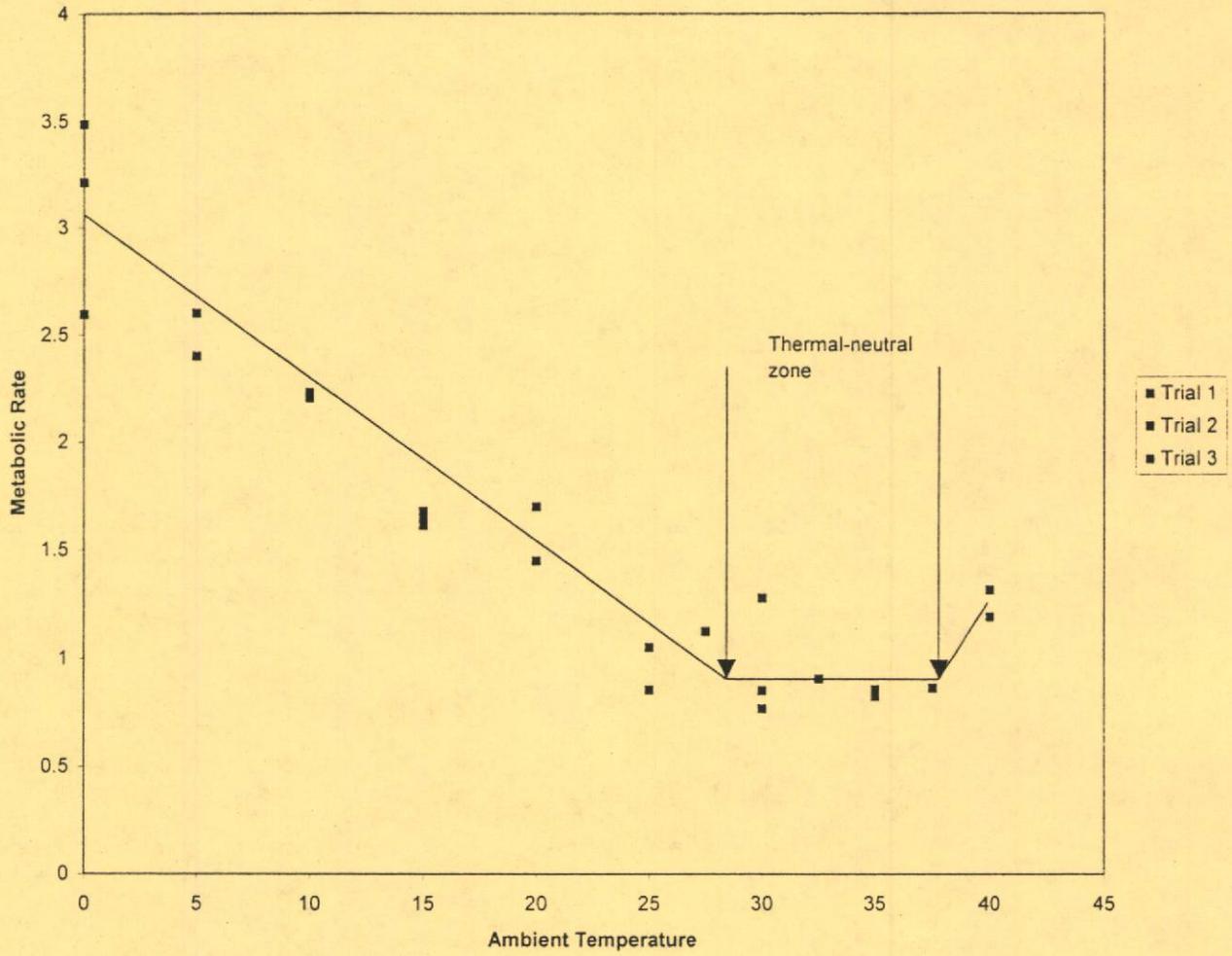


Figure 4. Metabolic response to temperature in Whip-poor-wills.

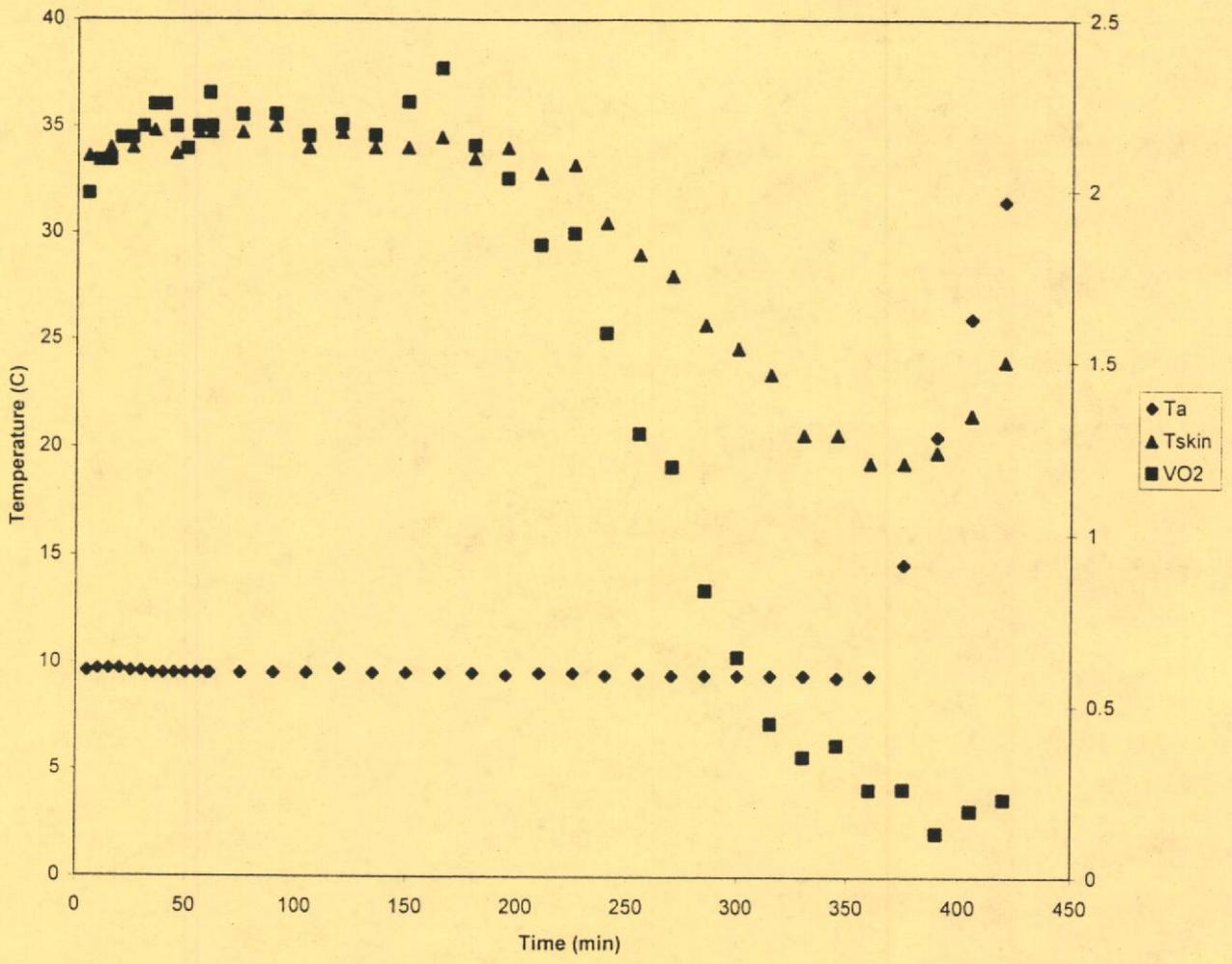


Figure 5. Metabolic rate and skin temperature during a torpor bout recorded on 3-July-2001 under artificial laboratory conditions.

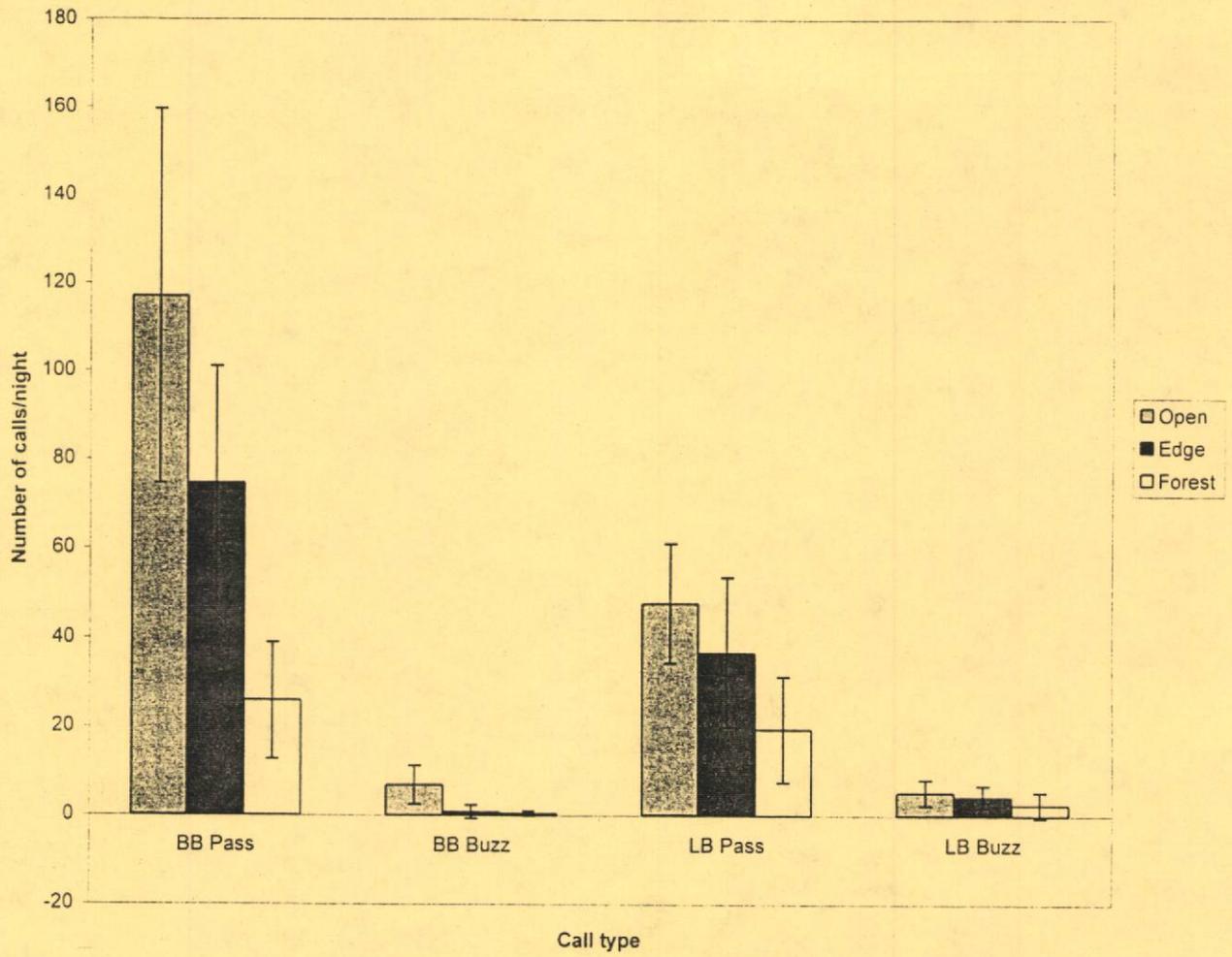


Figure 6. Bat activity (separated into big bat commuting passes, big bat feeding buzzes, little bat commuting passes and little bat feeding buzzes) in the three habitats.