BAT INVENTORIES AT GRANT-KOHRS RANCH NATIONAL HISTORIC SITE AND LITTLE BIGHORN BATTLEFIELD NATIONAL MONUMENT

Final Report

Submitted By
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Executive Summary: We conducted inventories of the chiropteran fauna at two small NPS units, namely the Grant Kohrs National Historic Site (GRKO) and Little Bighorn Battlefield National Monument (LIBI) during July and August of 2005 and 2006. The techniques employed included mist netting (~9 hrs), active and passive acoustic monitoring (~64 hrs) and building surveys. A total of 1,778 echolocation sequences obtained from acoustic monitoring were analyzed. Cumulatively, these efforts documented the occurrence of six species (four and five for GRKO and LIBI, respectively). The species recorded in order of approximate numerical importance were little brown myotis (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), long-legged myotis (*M. volans*), and hoary bat (*Lasiurus cinereus*).
These species complements may be conservative and are dominated by generalist species that often use buildings for colonial roosting sites. However, greater species richness for these units may be limited by their relatively small size and monotypic habitat.

Introduction

Information on the distribution of the chiropteran fauna of Montana is limited, and has been but has been compiled in works by Foresman (2001) and Adams (2004a) A recent study by Keinath (2004) inventoried the bats of NPS units the Greater Yellowstone network. However, specific inventories of several of the smaller NPS units have not been conducted previously. This study was conducted to determine the bat species complement of the Grant-Kohrs Ranch National Historic Site (GRKO) and the Little Bighorn Battlefield National Monument (LIBI).

METHODS

We employed several methods to obtain information on the bat species composition of the two NPS units. These included (1) capture with mist nets; (2) acoustic monitoring of echolocation sequences; (3) direct observation of flying bats with spotlights; and (4) surveys of buildings to determine their actual or potential suitability as any one of several kinds of roosts. The generally open habitat of both units, including riparian areas, did not lend itself well to mist netting. In fact we were able to locate only two suitable sites at GRKO; none were found at LIBI. Accordingly, acoustic monitoring was the principal technique employed. Because this was an effort to inventory species richness, the sampling sites were not selected randomly, but rather chosen for maximum potential bat activity. Dates, locations and other details relating to survey activities are given in Table 1and Figures 2 and 3.

Capture and handling of bats was conducted under the auspices of Protocol #1223 from the Utah State University Institutional Animal Care and Use Committee and appropriate collection permits from the NPS (GRKO-05-11; LIBI-2005-SCI-0001) and the Montana Game Fish and Parks Department (Certificate No. 1579). Bats captured in mist nets were processed to identify species and obtain other pertinent biological information, sex and age, morphological measurements, weight and reproductive condition as well as photographs. We used various aids to facilitate identification, principally a key developed by the Utah Bat Conservation Cooperative (see Appendix I).

We used ANABAT detectors manufactured by Titley Electronics (Balina, Australia) for acoustic surveys. An older detector was used in 2005, but malfunctioned on various occasions. In 2006 we used the older [subsequently repaired] detector as well as a newer device (ANABAT CF). The detectors were employed in both active (observer present) and passive (observer absent) monitoring modes. We obtained a total of 2,529 echolocation sequences, 1,099 and 1,330 from GRKO and LIBI, respectively (Table 2)

Echolocation sequences were analyzed with the aid of program ANALOOKW (Windows version 3.3f, Corben 2006) and various keys, including that recently developed by Keinath (2004b). Only sequences of = 5 sec duration and separated from the previous vocalization by =10 sec were used in order to obtain a reliable signature of the sonograms involved. As noted by O'Farrell et al. (1999) not all calls are equally useful and many fragmentary calls must be discarded before making a determination. These investigators found 20-40% non-usable calls within usable vocal sequences in vespertilionids. The parameters compared were minimum and maximum frequencies (F_{min} and F_{max}), slope characteristics (? slope), and time between calls (TBC). The latter constraint may have had the effect of increasing the likelihood that successive calls derived from different individuals.

RESULTS AND DISCUSSION

A total of 64.6 hrs were spent in actual survey activities, specifically netting and acoustic monitoring (Table 1). Of this total effort, passive acoustic monitoring accounted for 34.5 hrs. An additional 16 hours were spent in conducting inventories of buildings on the NPS sites and [in the case of GRKO] potential roosting sites in Deer Lodge.

We captured a total of 34 bats on two nights at Cottonwood Creek on GRKO (Table 2). Of these we identified 29 (85.3%) individuals as little brown Myotis (*Myotis lucifigus*; MYLU). Long-legged myotis (*M. volans*; MYVO) and big brown bats (*Eptesicus fuscus*; EPFU) accounted for an additional 3 and 2 individuals, respectively. Females comprised nearly 90% of the MYLU.

Using the criteria described above and after the extraction of 164 known sequences that derived from the White Swan Library at LIBI we analyzed a total of 1,778 echolocation sequences from the two sites. These materials indicated the probable occurrence of five species at both units (Table 4). At GRKO at least three of the species had been documented by captures. At LIBI only one species had been verified by visual observations. The results of acoustic monitoring only record the number of passes – possibly multiple passes by only a few individuals or single passes by many. Accordingly, these results preclude inferences about density.

Generalist species that may use buildings for colonial roosting sites dominated the species complement at both sites, with MYLU comprising 88.9% and 30.0% of the passes analyzed at GRKO and LIBI, respectively. EPFU was the other dominant species, comprising 6.6% and 55.7% of the calls analyzed for the two locations respectively. Silver-haired bats

(*Lasionycterus noctivagans*, LANO) accounted for 10.6% of the calls analyzed for LIBI, but did not appear in the species complement for GRKO. Long-legged myotis (*M. volans*, MYVO), hoary bats (*Lasiurus cinereus*, LACI) and unknown myotis (MYUNK) comprised minor proportions of the calls from both locations.

The fact that we were compelled to rely heavily on analysis of echolocation sequences for species determination poses some question as to whether the nominal species composition is truly indicative of the actual species complement. As has been noted by various investigators (e.g., Lance et al. 1996), similarities between the characteristics of echolocation calls of various species may preclude absolute species determination. Effectively, the pool of vocalizations consisted principally of sequences with minimum frequencies (F_{min}) of ~25 kHz and ~40 kHz. Conservatively, this allows reliable differentiation of only EPFU and Myotis sp. In the case of the 25K calls, both EPFU and LANO have nearly identical F_{min} and only subtle differences in shape and other call parameters (Keinath 2004a). Consequently, some of the calls we identified as LANO may have been those of EPFU. Typically, the former species inhabits higher elevation habitats with coniferous trees, whereas EPFU is more ubiquitous in occurrence (Table 5). Distinguishing among *Myotis* species that share a characteristic F_{min} of ~ 40K is equally problematical. Nonetheless, these uncertainties underscore the difficulties of species determination by analysis of echolocation sequences alone.

The “unknown myotis” category (Table 3) included a few sequences with characteristics suggestive of two additional species, namely fringed myotis (*M. thysanoides*, MYTH) and California myotis (*M. californicus*, MYCA) for GRKO and LIBI, respectively. The former species is listed as a Species of Concern by the Montana Department of Fish, Wildlife and Parks. We are reluctant to base documentation of these relatively rare species (Foresman 2001) solely on 1-2 echolocation sequences.

In the case of MYTH the species has not previously been recorded in Powell County, but has been collected in Jefferson, Lewis and Clark and Missoula Counties (DuBois 1999). The species is known to frequent a broad spectrum of habitats ranging from low-and mid-elevation grasslands up to and including spruce-fir forests (O’Farrell and Studier (1980). One problem with assigning the ANABAT sequence to this species is that it was collected at 0030 h, whereas the peak foraging activity fringed myotis, at least in the southern United States, occurs within 1-2 hrs after sunset.

In the case of MYCA, the evidence for documentation is equally questionable. According to Foresman (2001) the known and probable occurrence of the species is limited to the extreme western portion of Montana. Keinath (2003) reported the capture of a single specimen in Bighorn Canyon, but noted that conclusive identification awaited corroboration by museum experts.

Our results suggest the occurrence of at least four and five chiropteran species for GRKO and LIBI, respectively. According to Foresman (2001) all five of the species we documented for LIBI have been verified as in Bighorn County. None of the species documented for GRKO have been verified as occurring in Powell County, but this may merely reflect a dearth of studies in this portion of the state. Foresman rated as probable the occurrence of all but MYTH.

Computation of formal species diversity and equitability indices (Magurran 1988, Rosenzweig 1995) for these units is likely a spurious exercise due to the limited spatial sampling and the constraints of using data obtained from acoustic monitoring. What can be said from casual inspection of the data in Table 3 is that LIBI shows a higher species richness and evenness.

Our inventory produced approximately half the species richness recorded by Keinath (2004b) for NPS units in the Greater Yellowstone Network. This discrepancy is likely a function of two factors. Of principal importance is the larger size and greater diversity of habitat types and features available to bats in the GYA as opposed to small size and open and relatively simple nature of the habitat for bats at GRKO and LIBI. Specifically, caves, rock outcrops and crevices and higher elevation aspen woodlands and coniferous forests did not occur in the immediate proximity of the two units that we were working with. The lack of these features may account in part for the absence of some of the rarer *Myotis* species. The second contributing factor is the greater sampling intensity employed by Keinath (e.g., 63 nights of mist netting and 450 hours of passive acoustic monitoring). Conceivably, a greater amount of netting effort in this inventory could have yielded a higher species richness, but as noted earlier, sites with a high probability of success were rare at GRKO and non-existent at LIBI.

Placement of a passive bat detector in the grassland portion of LIBI revealed only seven passes, 3 by EPFU and 2 each by LACI and MYLU, during the course of one night from dusk to dawn. This indicated at least some degree of foraging over open areas.

Building Surveys. - The results of our building surveys at the GRKO site (Appendix I) revealed no bats or sign. Except for the Kohr and Warren Residences, bat use of the majority of buildings seemed suited only as night roosts - if even at that level in some cases. Those buildings/shelters with large openings - missing doors/windows/walls - appeared especially well suited as night roosts. However, we did document use of two buildings in Deer Lodge by big brown bats, namely the Episcopal Church and historical Montana Institute's Trask Hall. Both of these buildings apparently serve as maternity roosts, the latter for a colony of big brown bats. The partially decomposed carcasses of ~100 juvenile EPFU found in the bottom of a cistern in the attic of the school building indicate that it has been used perennially as a maternity roost. Some of the animals probably forage on Park property. Generally, at GRKO the buildings were too well constructed ("tight") to afford access for maternity roosts. The only building at LIBI that showed utilization was the White Swan Library, where we observed 10-15 animals visually foraging in the vicinity of the building and emerging from under the eaves at the west end of the building.

Management Implications and Future Work

As indicated previously, both sites provide ample foraging habitat for bats, but roosting habitat is limited to those species which are known to utilize trees in riparian areas or buildings either on the sites in adjacent areas of human habitation. For this reason the installation of bat boxes at locations near the riparian areas at each site could conceivably increase the numbers and species richness of bats at both locations. However, there exists some question as to whether the species using theses structures would be the more ubiquitous species such as MYLU and EPFU or the less common [and possibly as yet undocumented] *Myotis* species.

K. Dubois, Native Species Biologist with the Montana Department of Fish, Wildlife and Parks (personal communication) maintains that differentiation between little brown myotis and Yuma myotis (*M, yumanensis*, MYYU) is not possible by means of morphological characteristics alone. Moreover, the vocalizations of the two species are extremely similar. For this reason we collected tissue samples (wing punches from approximately 20 of the animals we captured and identified as MYLU at GRKO, and these samples are currently stored frozen at Utah State University. Pending availability of additional funding we recommend that these samples be processed to determine their species of origin by means of DNA analyses.

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Table 1. Dates and locations of mist netting and acoustic monitoring activities at GRKO and LIBI sites.

			UTM Coordinates				Environmental Conditions[a]			Type of Activity		
NPS Unit	Date	Location	Easting	Northing	Zone	Habitat	Weather	Moon Phase	Wind	Net Area (m^2)	Acoustic Monitoring	Ho
GRKO	2-Aug-05	Clark's Fork Bridge	365885	5140742	12T	Riparian	2	6	1	0	Active	3
GRKO	3-Aug-05	Ranch House	366391	5140676	12T	Riparian	1	3	1	0	Failed	0
GRKO	4-Aug-05	Cottonwood Creek	366407	5140051	12T	Riparian	1	1	1	75		3
GRKO	5-Aug-05	Kohrs-Manning Diversion Ditch	366051	5140176	12T	Riparian	1	0	1	82.5		2
GRKO	18-Jul-06	Clark's Fork Bridge	365882	5140750	12T	Riparian	1	42	2	0	Active	3
GRKO	19-Jul-06	Cottonwood Creek	366401	5140022	12T	Riparian	1	32	1/2	75	Active	3
GRKO	20-Jul-06	Slough behind stables	366236	5140698	12T	Riparian	1	22			Passive	1
LIBI	17-Aug-05	Little Bighorn River gauging station	309485	5048559	13T	Riparian	3/4	92	2	0	Active	2
LIBI	18-Aug-05	SW corner of park	309460	5048617	13T	Sagebrush	3	97	1	0	Active	3
LIBI	21-Jul-06	White Swan Library	310194	5049019	13T	Building	1	14	1	0	Active	4
LIBI	21-Jul-06	Little Bighorn River	309702	5048478	13T	Riparian	1	14	1	0	Passive	1
LIBI	22-Jul-06	Little Bighorn River (Chlorine House)	309498	5048429	13T	Riparian	1	8	2	0	Active	3
LIBI	22-Jul-06	Calhoon Hill	311467	5048315	13T	Grassland	1	8	2	0	Passive	1

[a]Weather conditions and wind categories (Beaufort Scale) are explained on the reverse side of the data form (Appendix I). Entries for moon phase refer to percent of full illumination and were obtained from a standard astronomical ephemeris.

Table 2. Numbers of echolocation sequences obtained by year and location.

Unit / mode	2005	2006	Totals
GRKO			
Active	67	120	187
Passive	0	912	912
Subtotals	67	1032	1099
LIBI			
Active	245	383[a]	628
Passive	0	702	702
Subtotals	312	1085	1330
Totals	312	2117	2429

[a]Of these 164 call were of EPFU obtained at the White Swan Library

Table 3. Data from bats netted at Cottonwood Creek, Grant Kohrs Historic Site, Montana.

Date	Species	Forearm Length	Ear Length	Tragus Shape	Keel	Sex	Age	Reproductive Status	Weight (g)
4-Aug-05	MYLU	37	11	Pointed	N	F	Ad	Post lactating	6.3
4-Aug-05	MYLU	38	10	Pointed	N	F	Ad	Post lactating	7.7
4-Aug-05	MYLU	39	13	Pointed	N	F	Ad	Lactating	7.9
4-Aug-05	MYLU	38	13	Pointed	N	F	Ad	Lactating	6.5
4-Aug-05	MYLU	40	13	Pointed	N	F	Ad	Lactating	7.6
4-Aug-05	MYLU	37.5	13	Pointed	N	F	Ad	Lactating	7.2
4-Aug-05	MYLU	37	12	Pointed	N	F	Ad	Lactating	7.1
4-Aug-05	MYLU	38	12	Pointed	N	F	Ad	Lactating	7.2
4-Aug-05	MYLU	37	13	Pointed	N	F	Ad	Lactating	6.8
4-Aug-05	MYLU	37.5	11	Pointed	N	F	Ad	Lactating	6.9
4-Aug-05	MYLU	37	12	Pointed	N	F	Ad	Lactating	7.6
4-Aug-05	MYLU	40	12.5	Pointed	N	M	Juv	Not descended	5.8
4-Aug-05	MYLU	37	13	Pointed	N	F	Ad	Lactating	7.7
4-Aug-05	MYLU	39	13.5	Pointed	N	F	Ad	Post lactating	7.5
4-Aug-05	MYLU	38	12.5	Pointed	N	F	Ad	Non-reproductive	7.5
5-Aug-05	MYLU	40	13	Pointed	N	F	Ad	Lactating	6.7
5-Aug-05	MYLU	39	12.5	Pointed	N	F	Ad	Non-reproductive	6.3
5-Aug-05	MYLU	38.5	13	Pointed	N	F	Juv	Non-reproductive	5.8
5-Aug-05	MYLU	38	14	Pointed	N	F	Ad	Non-reproductive	7.6
5-Aug-05	MYLU	37	13	Pointed	N	F	Ad	Non-reproductive	6.9
5-Aug-05	MYLU	35.5	12	Pointed	N	F	Juv	Non-reproductive	5.7
5-Aug-05	EPFU	49	16	Pointed	Y	F	Juv	Non-reproductive	17.4
5-Aug-05	MYLU	34	12.5	Pointed	N	F	Ad	Non-reproductive	6.2
19-Jul-06	MYLU	37	12	Pointed	N	M	Juv	Descended	7
19-Jul-06	MYLU	39	10	Pointed	N	M	Ad	Descended	7.5
19-Jul-06	MYLU	37	11	Pointed	N	F	Ad	Post-Lactating	6.5
19-Jul-06	MYLU	41	11	Pointed	N	F	Juv	Non-reproductive	6
19-Jul-06	MYLU	40	13	Pointed	N	F	Ad	Non-reproductive	7.25
19-Jul-06	MYLU	38	11	Pointed	N	F	Ad	Post-Lactating	6.5
19-Jul-06	MYLU	38	12	Pointed	N	F	Ad	Lactating	6.8
19-Jul-06	EPFU	46	16	Blunt	Y	F	Ad	Post-Lactating	19.8
19-Jul-06	MYVO	36	13	Pointed	N	F	Ad	Non-reproductive	8.3
19-Jul-06	MYVO	39	13	Pointed	N	F	Ad	Non-reproductive	9.1
19-Jul-06	MYVO	37	10	Pointed	N	F	Ad	Non-reproductive	7.5

Table 4. Probable species composition of 1,778 chiropteran echolocation sequences recorded at GRKO and LIBI units (NPS) in July and August of 2005 and 2006.

Unit	EPFU	LACI	LANO	MYLU	MYVO	MYUNK
GRKO	66[a]	10[a]	0	884	27	8
LIBI	436[b]	13[b]	83	235[b]	11[b]	3

[a]Species for which the occurrence in Powell County has not been documented by considered probable (Foresman 2001)
[b]Species for which the occurrence has been verified for Big Horn County (Foresman 2001)

Species acronym codes:

EPFU = *Eptesicus fuscus* (Big Brown Bat)
LACI = *Lasiurus cinereus* (Hoary Bat)
LANO = *Lasionycteris noctivagans* (Silver-haired Bat)
MYLU = *M. lucifugus* (Little Brown Myotis)
MYVO = *M. volans* (Long-legged Myotis)
MYUNK = *M.* sp. (Unknown Myotis)

Table 5. Pertinent ecological characteristics of bats putatively documented in this study (compiled from various sources).

Species	Foraging Habitat	Peak of Foraging Activity	Roost Sites	Colony Size	Wintering Habits (in Montana)
EPFU	Meadows, grasslands	1-2 hrs after sunset	Mostly buildings, rock crevices	Colonial – size highly variable	Resident / hibernating
LACI	Ponderosa pine habitats	Later in the evening	Mostly in coniferous trees; also abandoned cavities and buildings	Solitary	Migratory
LANO	Woodlands, ponds and streams	Bimodal: 2-4 hrs after sunset 6-8 hrs after sunset	Tree foliage	Solitary to semi-colonial	Resident / hibernating
MYLU	Generalist	Shortly after dusk	Generalist	Large colonies	Resident / hibernating
MYTH	Low- to mid-elevation grasslands up to spruce-fir forests	1-2 hrs after sunset	Rock crevices, caves, abandoned mines, buidlings	Medium sized colonies	Unknown
MYVO	Mostly montane coniferous forests; secondarily riparian areas	First several hours after sunset	Trees, rock crevices, caves, buildings	Large colonies	Resident / hibernating

Species acronym codes:

EPFU = *Eptesicus fuscus* (Big Brown Bat)
LACI = *Lasiurus cinereus* (Hoary Bat)
LANO = *Lasionycteris noctivagans* (Silver-haired Bat)
MYLU = *M. lucifugus* (Little Brown Myotis)
MYTH = *M. thysanoides* (Fringed Myotis)
MYVO = *M. volans* (Long-legged Myotis)

Figure 1: Grant-Kohrs Ranch National Historic Site mist netting and acoustic monitoring locations.

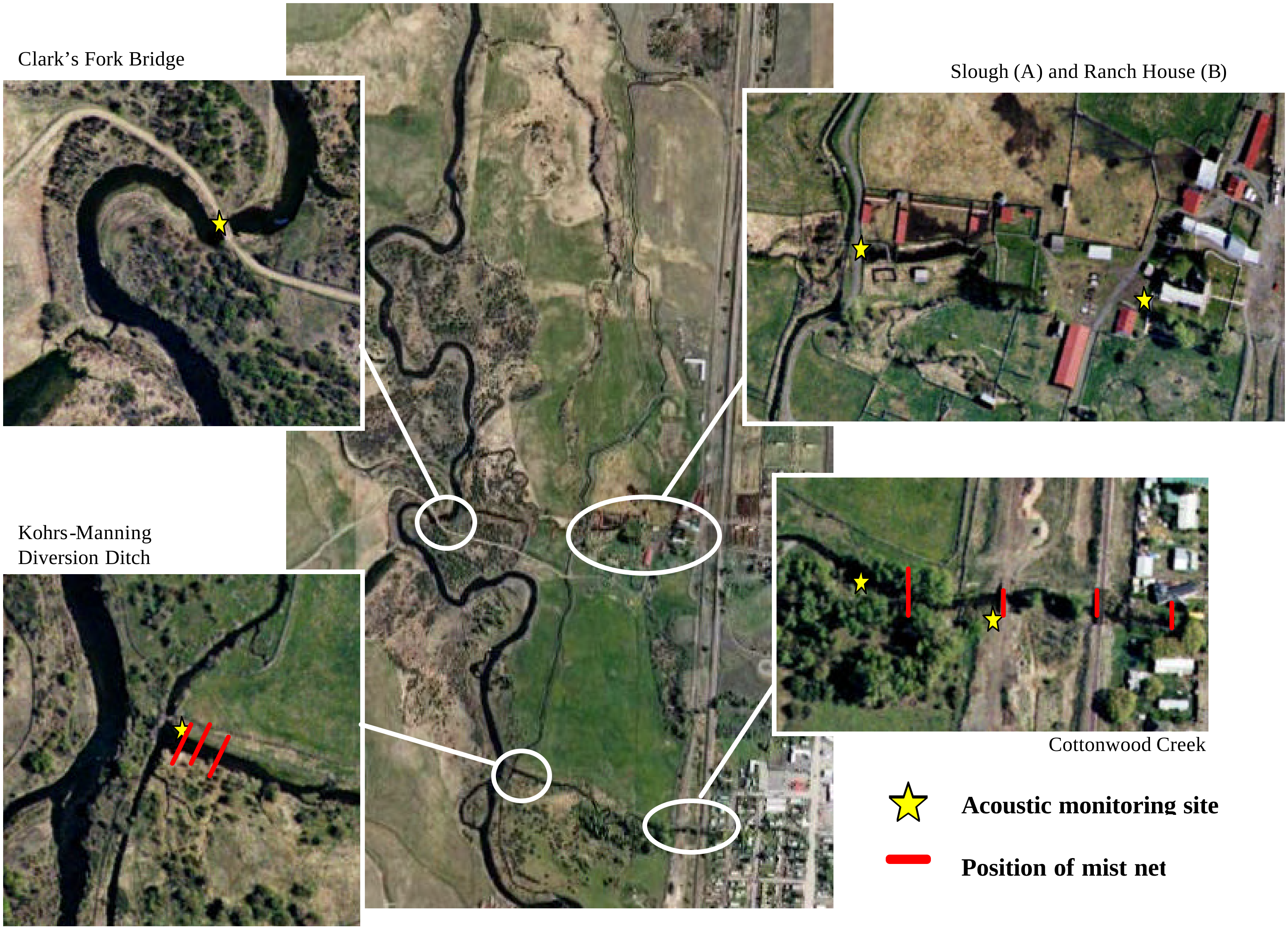


Figure 2: Little Bighorn Battlefield National Monument mist netting and acoustic monitoring locations.

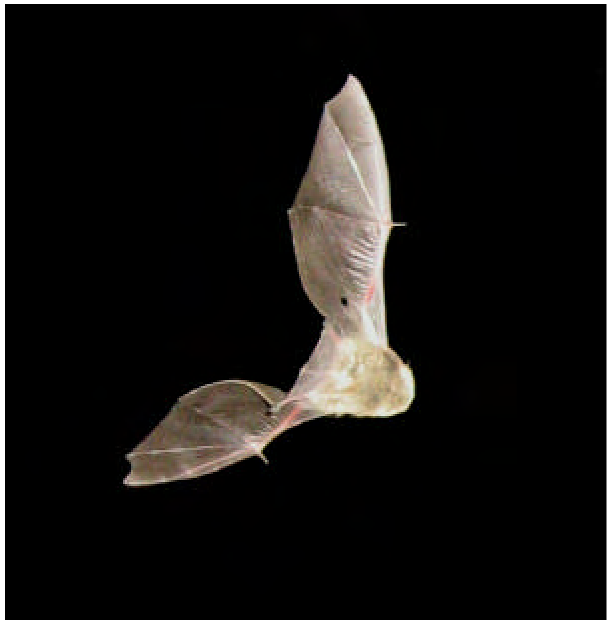


Fig. 3. Post-release photo of little brown bat netted at Cottonwood Creek, GRKO, showing biopsy punch marks in wings.

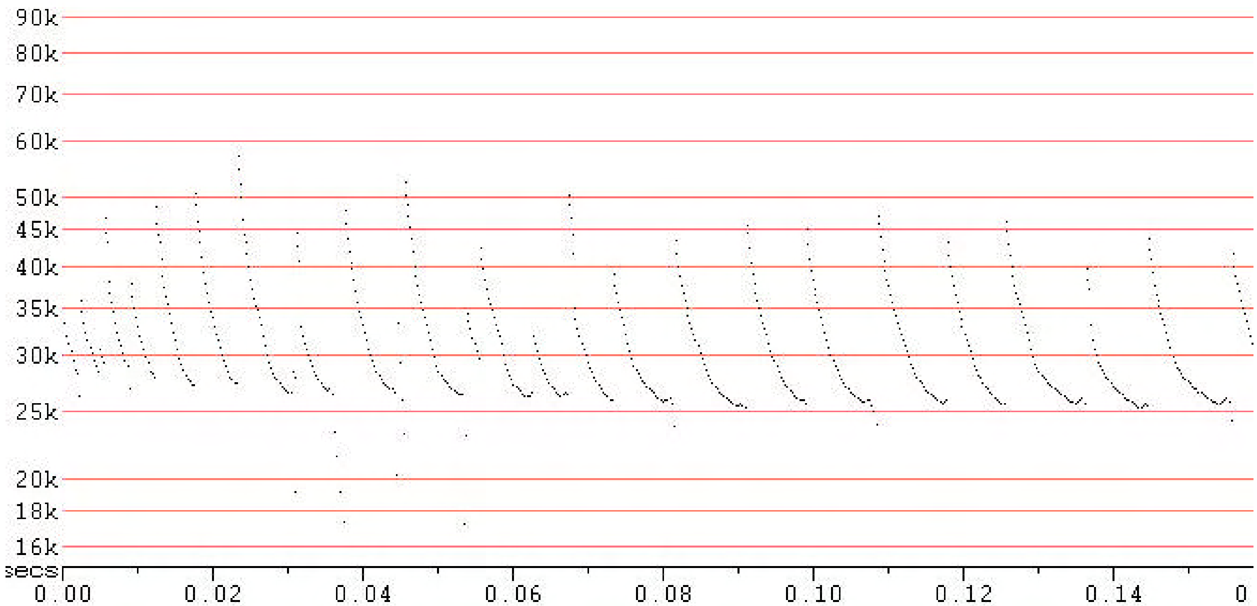
Fig. 4. Long-legged myotis showing furred portion of underside of wing.

Fig. 5. Big brown bat under facia board of Episcopal Church in Deer Lodge, Montana (left) and maternity colony of big brown bats in attic of Trask Hall in Deer Lodge.

Fig. 6. Eaves of White Swan Library, showing bat guano and entry points used by roosting big brown bats.

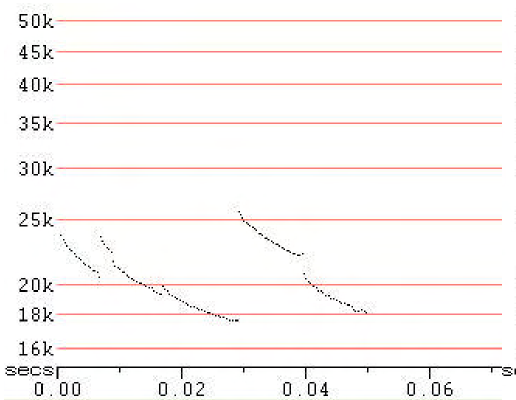
Fig. 5. Sample echolocation sequences from various species documented in this study.

EPFU G7192104.34

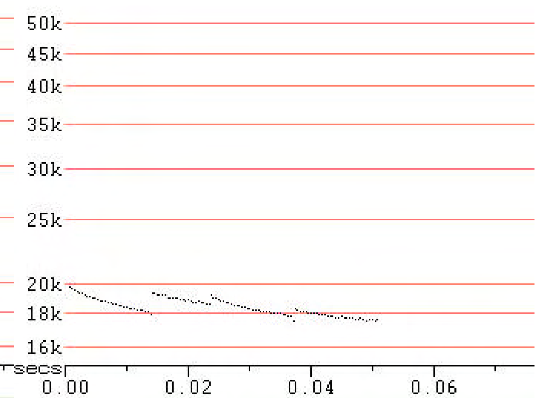


a. Big brown bat. Sequence obtained by passive monitoring at Cottonwood Creek, GRKO, 21 July 2006.

LACI F8030021.51

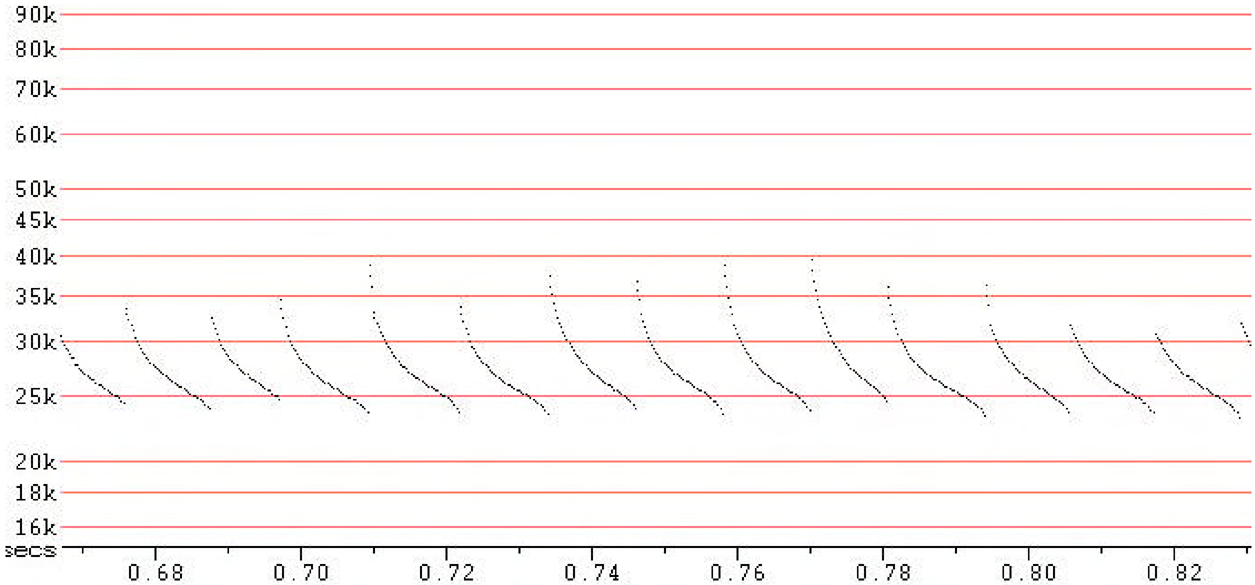


LACI F8182241.23



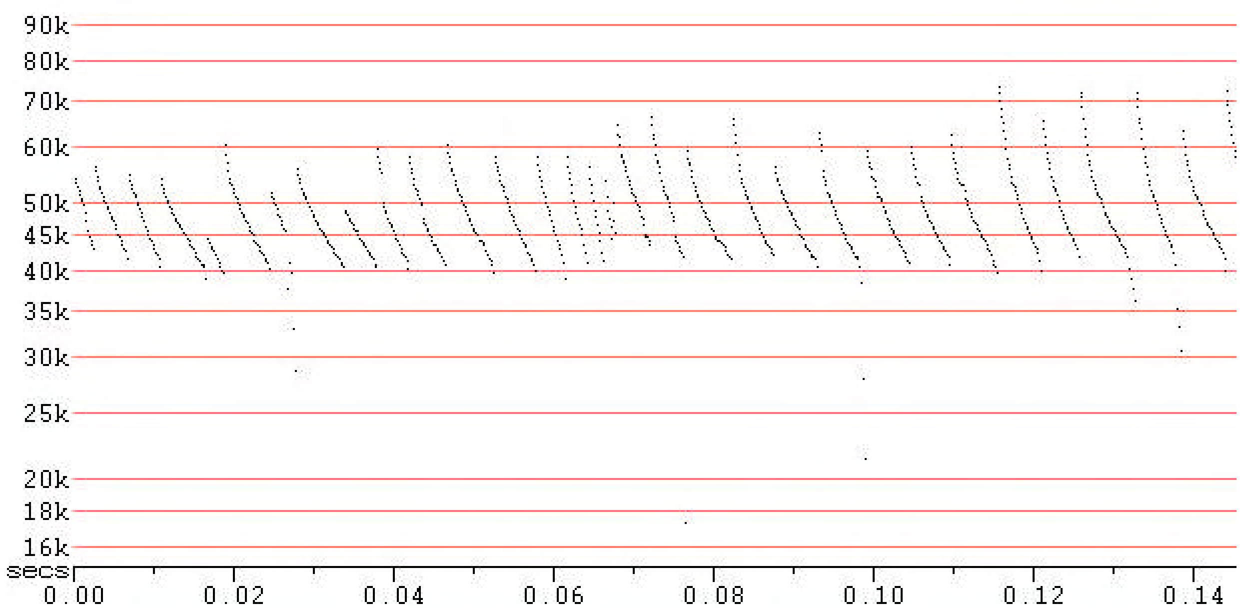
b. Hoary bat. Sequences obtained by active monitoring at the Clark's Fork Bridge, GRKO, 03 August 2005 (left) and Gauging Station, LIBI, 18 August 2005 (right).

LANO G7212026.35



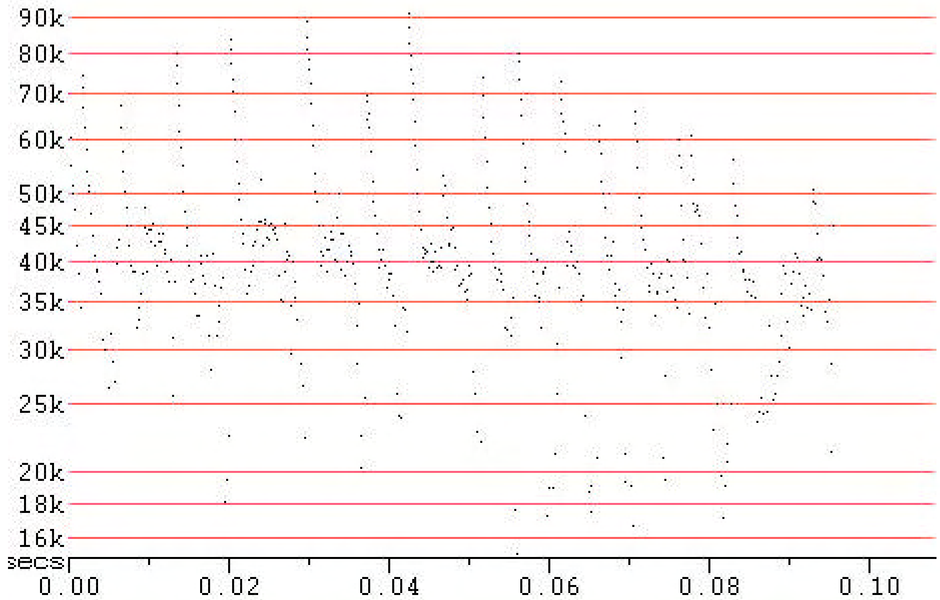
c. Silver-haired bat. Sequence obtained by passive monitoring at Little Bighorn River, LIBI, 21 July 2006.

MYLU G7212153.50



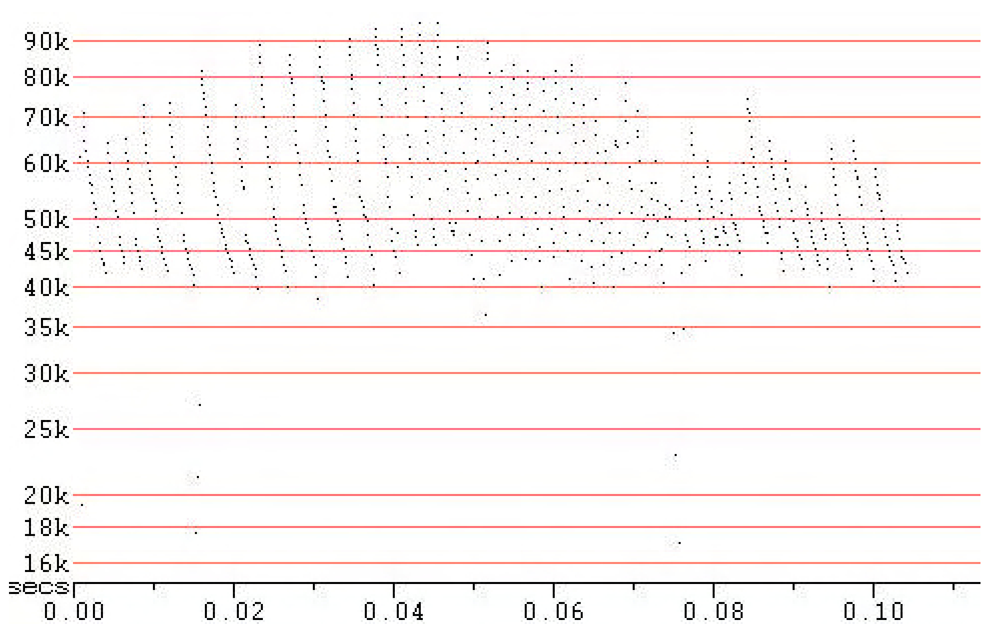
d. Little brown bat. Sequence obtained by passive monitoring at Little Bighorn River, LIBI, 21 July 2006

MYTH G7210030.05



e. Echolocation sequence, possibly of fringed myotis obtained by passive monitoring at slough behind stables, GRKO, 21 July 2006.

MYVO G7230058.55



f. Long-legged myotis. Sequence obtained by active monitoring at Chlorine House, LIBI, 23 July 2006.

Bat Survey Data Form

1. Page ____ of ____

2. Date: ______________________ 3. Capture Location:__________________________________ 4. County/State: ____________

5. Habitat/Site Description: ____ 6. Photographs: N ____ S_____ E ____ W _____

7. UTM Coordinates (Datum: NAD27): [ ][ ][ ][ ][ ][ ] E [ ][ ][ ][ ][ ][ ][ ] N, Zone (ex. 12T): [ ][ ][ ] 8. Elevation (m): ____________

9. Team Members: ____ 10. Recorder: ____________________

11. Methods Used (Mark all that apply): a) Mist Nets (Y/N)____ (surface area in m^2)___________ b) Harp Net (Y/N)____ c) Anabat (Y/N)____ d) Other

e) Data logger (data type) __________________________ (interval in minutes) ______________________

12.	Start	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Total
13. Time (24 hr):												
14. Net Status:												
15. Detector Status:												
16. Logger Status:												
17. Temp (°C):												
18. Wind:												
19. Weather:												
20. Moon:												

21. Bat No.	22. Time (24 hr)	23. Temp (°C)	24. Species	25. FA (mm)	26. Ear (mm)	27. Tragus Shape	28. Keel (Y/N)	29. Sex (M/F)	30. Reproductive Status	31. Age (Ad/Juv)	32. Photo? (Y/N/#)	33. Mark? (Y/N)	34. Weight (g) *Tared*	35. Notes

ARE ALL THE FIELDS FILLED OUT COMPLETELY? PLEASE INITIAL:_____

Field Descriptions for Bat Survey Data Form

1. **Page__ of __:** Fill in the first blank with the current page number and the second blank with the total number of pages used during the survey period (ex. Page 2 of 3).
2. **Date:** The Day, Month, and 4 digit Year the survey was conducted (23 June 2005).
3. **Capture Location:** The 'common' name of the site being surveyed (ex. Nirvana Pond or Selman's Ranch House).
4. **County/State:** The County and State in which the survey is being conducted (ex. Box Elder County, UT).
5. **Habitat/Site Description:** Short, simple description of surroundings and dominant vegetation within one mile of survey site. Description should also include the characteristics that caused the site to be selected (ex. presence of a stock pond, mine shaft, roost, etc.)
6. **Photographs:** Take one photograph in each cardinal direction (N,S,E,W) from the location the Coordinates were recorded (see #7). Note number of photograph if digital and applicable. Future photographs should always be taken from the same location to simplify historical comparisons.
7. **UTM Coordinates:** Record easterly (6 digit) and northerly (7 digit) UTM coordinates of the survey site using a GPS unit set to collect data in the North American Datum 1927 (NAD27).
8. **Elevation (m):** Use a GPS unit to record the Elevation at the same location the site's Coordinates were taken (see #7). Record elevation in meters.
9. **Team Members:** Record the first and last names of the individuals conducting the survey. Record professional affiliations if applicable (ex. USFWS, USFS, TNC, etc.)
10. **Recorder:** Record the full name of the individual most often recording the data; insuring that questions about what was written can be directed to the right person.
11. **Methods Used:** Mark Yes (Y) for all the methods that were used during the current survey and No (N) for those not used. If mist nets are being used, calculate and record their surface area in square meters [surface area = height (m) x sum length of all nets open (m)]. If a data logger is being used, note the type of data it is collecting (ex. temperature, humidity, barometric pressure) and the intervals to which it is set to collect data (ex. 5 min.). Use the Other category to record other methods employed during the survey period.
12. **Start; Hour 1…:** The status of Fields 13-20 should be recorded at the Start of the survey period and each consecutive 60 minutes after until the end of the survey. Uneven starting or ending times of either the nets, data loggers, or ultrasonic detectors should be recorded in the Hour column closest to the event. The actual time for each event will be recorded in Field 13.
13. **Time:** Actual time that the status of Fields 14 thru 20 are recorded.
14. **Net Status:** Record whether nets are 'Open' or 'Closed' at time in Field 13.
15. **Detector Status:** Recorded whether an ultrasonic detector is 'Active' or 'Not Active' at time in Field 13.
16. **Logger Status:** Recorded whether a data logger is 'Active' or 'Not Active' at time in Field 13.
17. **Temp (°C):** Record the temperature in degrees Celsius at time in Field 13.
18. **Wind:** Use MPH categories as determined from the Beaufort Wind Scale. 1) *0-1 MPH*: Calm; smoke rises vertically. 2) *1-3* MPH: Direction of wind shown by smoke drift, but not by wind vanes. 3) *4-7* MPH: Wind felt on face, leaves rustle, ordinary vane moved by wind. 4) *8-12* MPH: Leaves and small twigs in constant, gentle motion; wind extends light flag. 5) *13-18* MPH: Raises dust and loose paper; small branches are moved. In most situations winds in categories 3, 4,and 5 will not be conducive to operating mist nets.
19. **Weather:** Record the dominant weather over the last hour: 1*) Clear*: 0-10% cloud cover. 2) *Partly*: 10%-50% cloud cover. 3) Cloudy: 50%-100% cloud cover. 4) *Precip:* some amount of precipitation fell during this hour.
20. **Moon:** Record phase of moon as: 1) *None*: Either a new moon, or it hasn't risen yet. 2) *Crescent*: 0-25% lit. 3) *Half:* 25-75% lit. 4) *Full*: 75-100% lit. 5) *Obscured*: Obscured by cloud cover.
21. **Bat No.:** Number the bats as they are caught (ex. 1, 2,3 …).
22. **Time (24 hr):** The time the bat *was caught*, not the time it was processed (ex. 2234).
23. **Temp (°C):** The temperature in degrees Celsius when the bat *was caught*, not when it was being processed.
24. **Species:** Use a dichotomous bat key for the area the survey is being conducted to help identify bats to species. It is likely that characters in addition to the Fields below will be needed for proper identification.
25. **FA (mm):** The length of the forearm in millimeters. The forearm is defined as the length between the elbow and the distal side of the wrist (Figure 1).
26. **Ear (mm):** The length of the ear in millimeters. The ear length is measured from the notch on the base of the ear to the ear's tip (Figure 2).
27. **Tragus Shape:** Note the shape of the tragus as either 1) Long and Pointed (Figure 3a) or 2) Short and Rounded (Figure 3b). Especially useful to determine identification of Pipestrelles.
28. **Keel:** Note the 1) Presence or 2) Absence of a flap of skin hanging loose off the posterior edge of the calcar (Figure 4a & b).
29. **Sex:** Record the sex of the bat as 1) Male or 2) Female. Evidence of sex is best obtained from the genitalia, with the males possessing a well developed penis.
30. **Reproductive Status:** Record the reproductive status of the Males as either 1) Reproductive – one or both testes have descended or 2) Non-reproductive – neither testes are descended. For the Female note evidence of 1) Lactating – nipples are pink and enlarged, hair surrounding the nipple is worn. 2) Post-lactating – nipples wrinkly and dark hair has often grown back. 3) Pregnant – presence of unborn fetus evident. 4) Non-reproductive – nipples very small and well haired.
31. **Age:** Record the age of the bat as either 1) Juvenile or 2) Adult based on the calcification of the phalangeal joints. Best observed by shining the joints from behind with a head lamp (Figure 5).
32. **Photo?:** Record whether a photograph was taken of the bat with a Yes (Y) or (N). Note number of photograph if digital and applicable.
33. **Mark?:** Record whether the animal was marked before release with a Yes (Y) or No (N). Note method of marking in the Notes (ex. Marker, band, tattoo, freeze brand, etc.)
34. **Weight:** The total weight of the bat minus the weight of the bag in grams.
35. **Notes:** To be used to record observations or actions of this particular bat not accounted for by the data sheet (ex. parasite load, marking method, injuries, capture method, etc.)

Figure 1:
Forearm =elbow to wrist

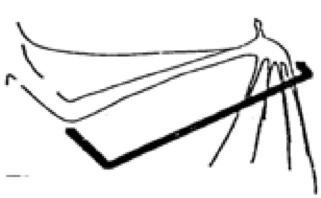


Figure 2:
Ear = notch bottom to tip

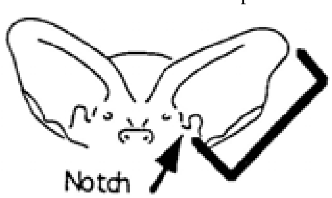


Figure 3: Tragus shape
a) long, pointed b) short, rounded

Figure 4: Keeled calcar
a) Present b) Absent

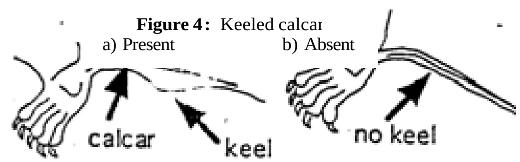
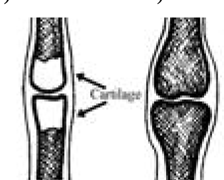


Figure 5: Age
a) Juvenile b) Adult



Cartilage in juveniles transmits light; appears whitish when backlit.

DICHOTOMOUS KEY FOR THE BATS OF UTAH

Authored by: Chris Witt, Adam Kozlowski, and George Oliver
Figures by: Adam Kozlowski
Last edited: 23 August 2006

GBBC GREAT BASIN BAT COOPERATIVE

FIGURE

Figure 1: Tail extends >5 mm beyond uropatagium.

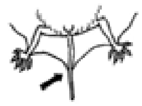


Figure 2: Tail does not extend more than 5 mm beyond uropatageum.

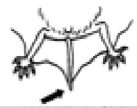


Figure 3: Small bumps present along leading edge of ears.

Figure 4: Ear length is measured from notch to tip.

Figure 5: Spotted bat's dorsal markings.

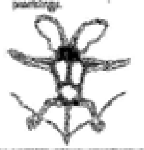


Figure 6: Lappets, flaps of skin, extending from base of each ear toward snout.

Figure 7: Muzzle with well defined dorsal glands.

Figure 8: Tragus is short, blunt, rounded, and curved.

Figure 9: Tragus is long, pointed, and straight.

STEP — DIAGNOSTIC

1 a. Tail extends beyond rear edge of uropatagium (interfemoral membrane) by more than 5 mm [Figure 1].
GO TO: 2 FAMILY: Molossidae

b. Tail does not extend beyond rear edge of uropatagium or only slightly (≤5 mm) [Figure 2].
GO TO: 3 FAMILY: Vespertilionidae

2 a. Ears do not join at the base, small bumps are present along the ear's front edge.
Ears barely extend past the shout when laid forward.
Tail generally does not extend >25 mm past interfemoral membrane; usually extends ~19 mm.
Fur is generally uni-colored, darkish gray/brown, species often exudes strong, musty odor.
BRAZILIAN FREE-TAILED BAT *(Tadarida brasiliensis)*

b. Ears join at the base, small bumps along the front edges of the ear are not present [Figure 3].
Ears extend well beyond the snout when laid forward.
Tail generally extends at least 25 mm past interfemoral membrane.
Fur is bi-colored, almost white at its base, distal color ranges from reddish-brown to black.
BIG FREE-TAILED BAT *(Nyctinomops macrotis)*

3 a. Ears longer than 25 mm [Figure 4].
GO TO: 4

b. Ears shorter than 25 mm.
GO TO: 7

[redacted]

5 a. Ears clearly separated at base; dorsal pelage is light brown to yellow, hairs lighter at base.
PALLID BAT *(Antrozous pallidus)*

b. Ears joined at base.
GO TO: 6

[redacted]

7 a. Uropatagium (interfemoral membrane) heavily furred dorsally.
GO TO: 8

b. Uropatagium (interfemoral membrane) not heavily furred dorsally.
GO TO: 10

[redacted]

9 a. Fur color is dark brown to black with silver/white tips, giving a frosted appearance.
SILVERED-HAIRED BAT *(Lasionycteris noctivagans)*

b. Fur color is not dark brown to black with silver/white tips, rather it is brick red to rust on upperparts with pale undersides.
WESTERN RED BAT *(Lasiurus blossevillii)*

[redacted]

Figure 10: Uropatagium has conspicuous fringe of hairs on its posterior edge.

11 a. Forearm >40 mm (42 – 52); ears extend outward; mass greater than 11 g.
BIG BROWN BAT *(Eptesicus fuscus)*

b. Forearm <40 mm (28 – 33); mass less than 11 g.
WESTERN PIPISTRELLE *(Pipistrellus hesperus)*

12 a. Ears blackish and extend 4mm or more past end of snout when pressed forward.
LONG-EARED MYOTIS *(Myotis evotis)*

b. Ears extend less than 4 mm past end of snout when pressed forward.
GO TO: 13

Figure 11: Underside of wing has long, dense fur extending outward from body.

13 a. Uropatagium (interfemoral membrane) has conspicuous fringe of hairs on its posterior edge; [Figure 10]. Fringe often accompanied by lighter skin pigmentation on uropatagium's trailing edge.
FRINGED MYOTIS ***(Myotis thysanodes)***

b. Uropatagium (interfemoral membrane) does not have conspicuous fringe of hairs (but may be very sparsely haired).
GO TO: 14

14 a. Underside of wing has long, dense fur extending outward from body to a line between elbow and knee [Figure 11].
LONG-LEGGED MYOTIS *(Myotis volans)*

b. Underside of wing does not have long, dense fur between elbow and knee.

Figure 12: Calcar keel not present or poorly developed.

15 a. Calcar keel is not well developed or is absent [Figure 12].
GO TO: 16

b. Calcar keel is present and well developed [Figure 13].
GO TO: 17

Figure 13: Calcar keel is present and well developed.

[illegible]

Figure 14: Naked part of snout top is as wide (w) as it is long (square).

17 a. Naked part of snout top is as wide as it is long (square) [Figure 14].
Tail does not extend beyond uropatagium.
Forehead rises steeply and abruptly from rostrum.
Face, ears, and wings are not black and do not contrast sharply with pelage color.
CALIFORNIA MYOTIS *(Myotis californicus)*

b. Naked part of snout top is 1.5X the nostril width (rectangular) [Figure 15].
Tail often extends 1.5-2.5 mm beyond uropatagium.
Forehead rises gradually from rostrum.
Face, ears, and wings are black, often contrasting sharply with pale pelage.
WESTERN SMALL-FOOTED MYOTIS *(Myotis ciliolabrum)*

Figure 15: Naked part of snout top is 1.5X the nostril width (rectangular).

Species	Body Mass (g)	Forearm (mm)	Ear (mm)	Keel on Calcar	Special Characteristics
californicus	3 – 6	29 – 36	9 – 15	Well developed	See step 17 to differentiate.
ciliolabrum	4 – 6	30 – 36	13 – 21	Well developed	See step 17 to differentiate.
yumanensis	4 – 7	32 – 36	12 – 15	None	See step 16 to differentiate.
lucifugus	5 – 9	34 – 41	11 – 15	None	See step 16 to differentiate.
evotis	5 – 8	37 – 40	20 – 24	Poor	Ear length is distinctive among *Myotis*.
thysanodes	5 – 7	39 – 46	16 – 20	Poor to None	Short, dense hairs on trailing edge of tail.
volans	6 – 10	37 – 42	10 – 15	Well developed	Fur on wing between elbow and knee. Tibia is ≥2.5X the length of the hind foot.

GRYN ANABAT® Call Key

© Doug Keinath
University of Wyoming, WYNDD
307-766-3013

F_{min} (kHz)

- **<10** — Yes → **EUMA** Calls steep and sparse. Usually beginning above 10 and ending below 8.
- No ↓ **16 - 20** — Yes → **LACI** Calls usually low slope and can be hook-shaped. Calls tend to jump around in Fmin, but typically 17-18k. Often give several calls at a higher freq, but with same shape.
- No ↓ **~25** — Yes → **25k Bats** (EPFU or LANO) … Next Page
- No ↓ **25 - 35** — Yes → **~30k Bats** (MYTH, MYEV, COTO, or ANPA) …. See Below
  *Note: If sequences are not long and clean, many of these can be difficult to tell apart and must then be reported simply as "**aB30k**".*
- No ↓ **~40** — Yes → **40k Myotis** (MYLU, MYVO, MACI) … Next Page
- No ↓ **45 - 50** — Yes → **50k Bats** (PIHE, MYYU, MYCA) …. Next Page

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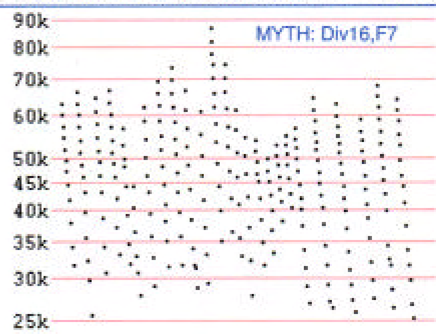
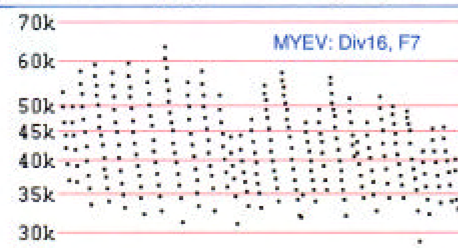
30k Bats (steep calls)

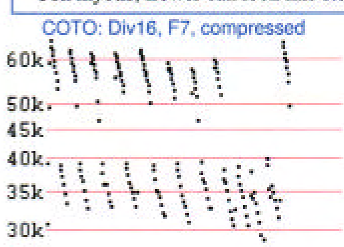
MYTH Calls very steep (Δslope ≥ 100) with huge freq. range (up to 20-100 in same call) and no tail. Variable F_{min} with some calls usu. dropping to or below 25. Freq range usu ≥50.

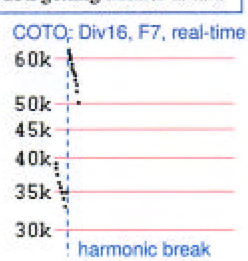


MYEV Calls very steep (Δ_{slope} usu > 150; often 300) and very sparse, with no tail. F_{min} usu ~35, but varies within sequence, seldom dropping below 30. Freq range usu ~30.

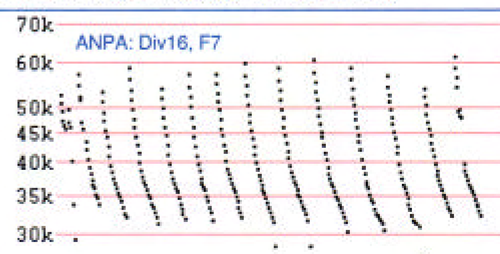


COTO Calls steep, weak, have <u>two harmonics</u>. F_{min} usu ~30, but can be ≤25. Harmonic-break often between 40-50. Sometimes only one harmonic captured: Upper can look like 50k myotis; Lower can look like steep 25k getting thinner at tail.





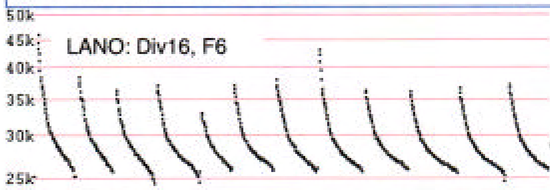
ANPA Calls steep, but often slightly more curved than MYTH or MYEV and somewhat "thicker". Very little tail, but sometime "dribbling off" in a "lazy S" shape. Fmin ~30k and Fmax ≥50. Can also be difficult to tell from EPFU in clutter, which will usu. have time between calls of <100ms.



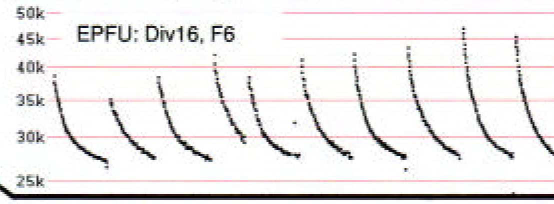
25k Bats (tailed calls)

*Note: LANO and EPFU are difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aB25k**".*

LANO Calls are more bilinear than EPFU. Slope of tail is more variable than EPFU. Min Δslope often ~10 and Δslope plots usually "dribble off" rather than forming "fish-hook" ends. Calls rarely fall below 25k. Calls very regularly spaced ("metronome").



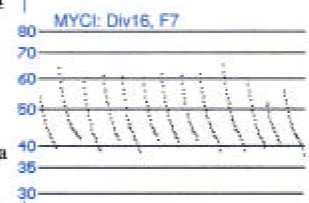
EPFU Calls are more curvilinear than LANO, but can be more bilinear when they are short in sweep (i.e., ~25-40). Slope of tail is very consistent. On flat calls, Δslope plots may show many calls with "fish-hook" ends. Fmin often not uniform, with some calls falling below 25k. Calls sometimes irregularly spaced ("heart beat").



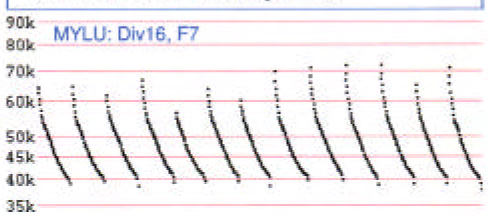
40k Myotis

*Note: 40k myotis are very difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aM40k**".*

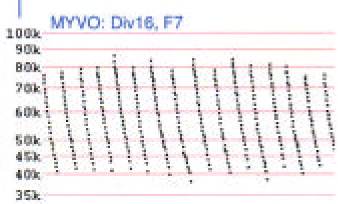
MYCI Calls steep and regularly have a small "toe" at or just before the end, resulting in a "golfclub" or "S" shaped call. Even with a toe, calls usually have $\Delta slope_{min}$ near 80. Clean calls usually straighter than MYLU, but can be more curvilinear than MYVO. Calls can have a wobble in the middle of the call (usually ≤50k). *Behavior*: MYCI feed around vegetation, like MYCA.



MYLU Gentlly curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end). Clean calls often sweep from ~100 to just over 40. On clean calls, $\Delta slope_{min}$ can be as low as 40, but usually higher. Sometimes alternate curved call with a more linear one.
Behavior: MYLU classically feed over water, which can result in "wobbly" calls."



MYVO Calls steep often with "wiggly look"; like MYLU in clutter, but greater call spacing. Calls tend to be more linear (or bilinear) than MYLU and have less "toe" than MYCI. Calls can have a wobble high in the sweep (usually ≥50k). Δslope is usually high (~100) but can drop to ~60. Difficult to distinguish from other 40k myotis.

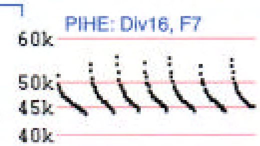


50k Bats

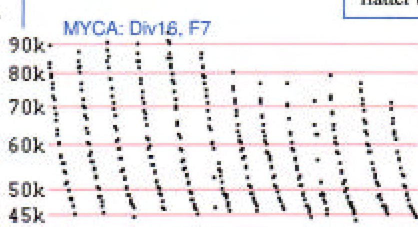
Steep Calls
Steeper than PIHE and usu. Fmin at or just below 50k. Single calls can drop to 40k, but not whole series (consistently above 43k). Difficult to distinguish from each other, especially in clutter, and many must be reported simply as "**aM50k**".

Flat / tailed calls→

PIHE Usually starting around 50 and often ending below (~45). Thick calls with flat tails often with a drooping tail. Duration>5.0ms.



MYCA Calls frequently have a flat "toe" at the end, rather than dribbling off. Toed calls usually have Min. Δslope of 30ish. "Dribbling calls" usually have Min. Δslope greater than MYYU (i.e., above 40).
Behavior: MYCA typically feed by hugging vegetation.



MYYU Often show calls dropping below 50k (~45k). Call shape similar to MYLU, but thicker tail. Calls often "dribble-off", rather than having constant toes. Dribble calls can have Δslope down to 40. In a series, there is often one call that is flatter than the rest. *Behavior*: MYYU often feed over water.