Appendix 4: Keys to the bats of the Greater Yellowstone Network

Dichotomous Key to the Bats of the Greater Yellowstone Network

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#	If this is true …	… then go to …
1a	Tail extends 1/3 or more beyond rear edge of uropatagium.	2
1b	Tail does not extend more than barely beyond rear edge of uropatagium	3
2a	Forearm > 50mm. [Large bat. Ears join at forehead. Pale-brown to black fur.]	Nyctinomops macrotus
2b	Forearm < 50mm. [Smallish bat. Ears almost joined at forehead. Gray-brown fur.]	Tadarida brasiliensis
3a	Conspicuous pair of white spots on shoulders and one on rump contrast with black dorsal fur. Pink ears.	Euderma maculatum
3b	Lacks white dorsal spots.	4
4a	At least anterior half of dorsal surface of uropatagium heavily furred.	5
4b	Dorsal surface of uropatagium mostly naked or scantily furred.	7
5a	Distinct white patches of fur at dorsal bases of thumbs and often on shoulders. Dorsal surface of uropatagium fully furred.	6
5b	No white patches of fur at dorsal bases of thumbs or on shoulders. Dorsal surface of uropatagium ranging from half to fully furred. Black dorsal fur with silver tips. Black face and uropatagium.	Lasionycteris noctivagans
6a	Light colored ear distinctively edged in black. Dorsal hairs dark gray and tipped with a broad band of white giving a hoary colored appearance. Forearm 46-58mm.	Lasiurus cinereus
6b	Light colored ear never edged in black. Fur bright reddish-orange to yellow in males and tending toward light brownish – grayish in females. Dorsal hairs never dark gray and tipped with white, though possibly frosted. Forearm 35-45mm.	Lasiurus borealis
7a	Dorsal fur lighter at base (pale yellow-blond) than tips (brown). Pale translucent ears 25-33mm long. Forearm 50-55mm. Blunt snout.	Antrozous pallidus
7b	Dorsal fur darker at base than tips. Fur color, ear and forearm lengths highly variable.	8
8a	Prominent pair of lumps above nose on each side of muzzle (see picture). Ear length 30-39mm. Slate-gray fur.	Corynorhinus townsendii
8b	No lumps on nose.	9
9a	Tragus short, blunt, and club-shaped. Small-bodied. Body fur medium to pale brown in contrast to jet black face and ears. Forearm 27-33mm.	Pipistrellus hesperus
9b	Tragus longer and pointed	10
10a	Large, medium to dark brown bat with keeled calcar. First upper premolar at least ½ as long as canine (see diagram below). Forearm 42-51mm (wingspan 325-350mm). Tragus rounded.	Eptesicus fuscus
10b	Smallish bat. First upper premolar less than ¼ as tall as canine (see diagram below).	11

Fig. 10a. First upper premolar ½ as tall as canine (*Eptesicus fuscus*)

Fig. 10b. First upper premolar < ¼ as tall as canine (Myotis spp.)

Myotis species

#	If this is true …	… then go to …
11a	Calcar keeled. (Fig. 11a)	12
11b	Calcar not keeled. (Fig. 11b)	14

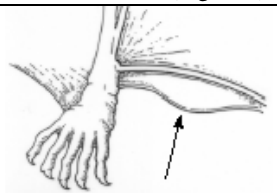


Fig. 11a. Keeled calcar (go to 12)

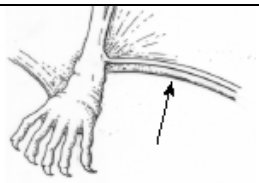


Fig. 11b. Keel absent (go to 14)

12a	Body fur uniformly dark brown or grayish brown with no distinctively darker face mask. Forearm 38-42mm (wingspan 250-270mm). [Underside of wing furred from side to elbow.]	Myotis volans
12b	Body fur medium to very light tan or reddish brown with clearly darker face mask. Forearm 29-36mm. [Underside of wing not furred from side to elbow.]	13

13a	Tail does NOT extend beyond uropatagium. Thumb length < 4.2mm. Braincase has an abruptly rising profile (convex forehead). Length of bare snout ≈ width across nostrils. Dorsal fur dull, pale colored, with dark-brown face mask distinctive but less contrasting with fir. (Fig. 13a)	Myotis californicus
13b	Tail often extends slightly beyond uropatagium. Thumb length > 4.2mm. No distinct rise in braincase profile (sloping forehead). Length across snout ≈ 1.5 times width across nostrils. Dorsal fur slightly shiny, pale colored, and sharply contrasting with black face mask. (Fig. 13b)	Myotis ciliolabrum

Fig. 13a. *M. californicus:* Rising braincase. Length of bare snout ≈ width across nostrils.

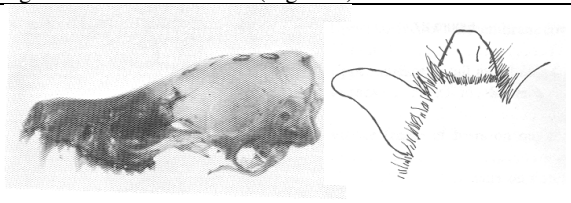


Fig 13b. *M.ciliolabrum*: Shallow braincase. Length across snout ≈ 1.5 times width across nostrils

14a	Distinct fringe of hair extending 1.0-1.5mm be[illegible]nd edge of uropatagium (picture). Ears darkly pigmented and 16-20mm long. Belly fur light. Forearm 39-46mm.	Myotis thysanodes
14b	Fringe absent (no more than scattered hairs on edge of uropatagium).	15

15a	Ear length ≥17mm.	16
15b	Ear length ≤ 16mm.	17

16a	Ears, wings, and uropatagium are blackish and opaque. Ear length 19-24mm. [May have an inconspicuous fringe of hairs on the posterior uropatagium.]	Myotis evotis
16b	Ears, wings, and uropatagium are brownish and translucent. Ear length 17-19mm.	Myotis septentrionalis

17a	Dorsal body fur brown to reddish-brown, long and glossy. Forearm usually 36.5-40.5mm (BC Range: 33.0-40.3mm). Ears dark, 14-16mm long, with short tragus. Forehead with a gradual slope (Fig. 17a), skull usually greater than 14mm. Ventral fur light-tipped but never white. Foot hairs extend beyond toes.	Myotis lucifugus
17b	Dorsal body fur brown to reddish-brown, short and dull. Forearm usually 32-36mm BC Range: 30.0-38.0mm). Ears paler, 12-14mm long. Forehead with steep slope (Fig. 17b), skull usually less than 14mm. Ventral fur with whitish tips.	Myotis yumanensis

Fig. 17a. *M. lucifugus*: Forehead with gradual slope

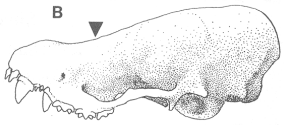
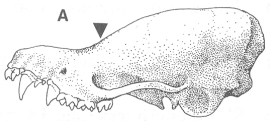


Fig. 17b. *M. yumanensis*: Forehead with steep slope



Draft Key to ANABAT® Echolocation Call Recordings for Bats of the Greater Yellowstone Network

Developed by

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DISCLAIMER

This is not a definitive classification key.

Anabat™ is a system designed to help users find and identify echolocating bats by digitally recording those calls and plotting them on a computer screen (please see the following web site for more information: http://users.lmi.net/corben/anabat.htm#Anabat%20Contents). With the appropriate software, the resulting calls can be visually analyzed to determine what type of bat made each call. However, these echolocation calls are notoriously hard to distinguish at the species level, due to the wide variation in recording quality, intra-species call morphology, and environmentally induced frequency shifts. Correct analysis depends heavily on the accumulated experience of the analyst.

Some bats (e.g., hoary bats, spotted bats) can readily be identified by new users, but other species (e.g., myotis volans and myotis ciliolabrum) are very difficult to distinguish, even by experts. This key is meant to provide a starting point for biologists wishing to analyze bat calls recorded in Wyoming, particularly in the northwestern corner of the state, in the vicinity of Yellowstone National Park, Grand Teton National Park and Bighorn Canyon National Recreation Area. Even with this information, many calls cannot be identified at the species level.

Before employing this key, users should be familiar with the general principals of call analysis (e.g., see http://users.lmi.net/corben/glossary.htm#Glossary). With such background information, this key can be used to roughly classify calls and perhaps (given well-recorded calls) identify the particular species making those calls. Questionable calls, calls of difficult to distinguish species, or those that represent new occurrences in an area should always be viewed by local Anabat™ experts. In Wyoming, people should contact the Wyoming Natural Diversity Database (Doug Keinath: 307-766-3013, dkeinath@uwyo.edu) or the Wyoming Game and Fish Department (Martin Grenier: *****).

Analyzing bat calls can be very challenging and frustrating, but with patience and experience it provides a fascinating look at our bat communities. Please let me if you found this document useful or if you have suggestions for improving it.

Good luck!

Sincerely,

Doug Keinath

GRYN ANABAT® Call Key

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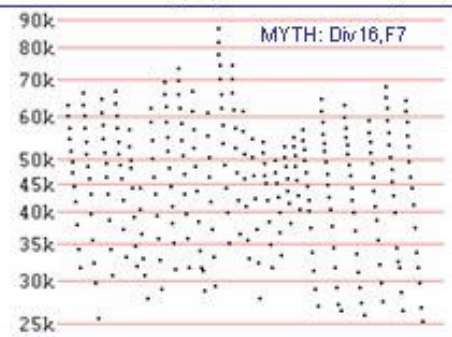
F_{min} (kHz)

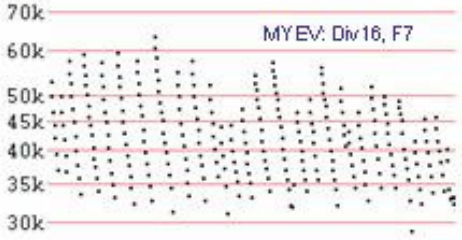
- <10 — Yes → **EUMA** Calls steep and sparse. Usually beginning above 10 and ending below 8.
- No → 16 - 20 — Yes → **LACI** Calls usually low slope and can be hook-shaped. Calls tend to jump around in Fmin, but typically 17-18k. Often give several calls at a higher freq, but with same shape.
- No → ~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 "aE30k".
- No → ~40 — Yes → **40k Myotis** (MYLU, MYVO, MACI) … Next Page
- No → 45 - 50 — Yes → **50k Bats** (PIHE, MYYU, MYCA) …. Next Page

30k Bats (steep calls)

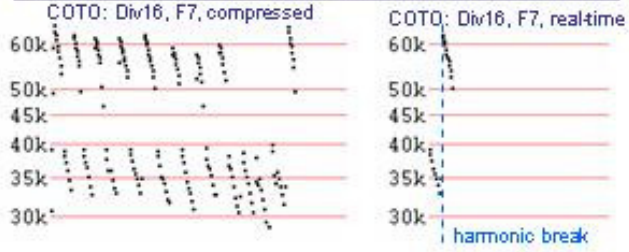
MYTH Calls very steep (Δslope ≥ 100) with huge freq. range (up to 20-100 in same call) and no tail. Variable F_{ess} with some calls usu. dropping to or below 25. Freq range usu ≥50.



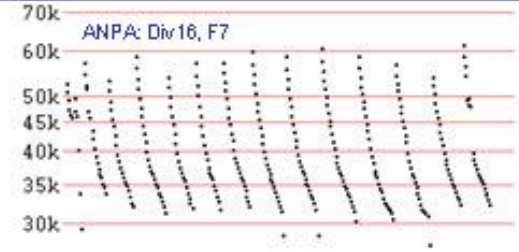
MYEV Calls very steep (Δ_{slope} usu > 150; often 300) and very sparse, with no tail. F_{ess} usu ~35, but varies within sequence, seldom dropping below 30. Freq range usu ~30.



COTO Calls steep, weak, have two harmonics. F_{ess} 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.



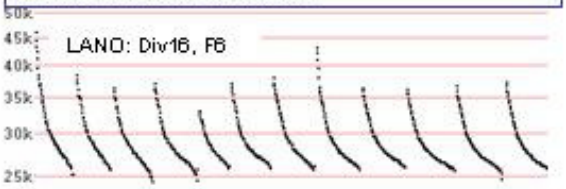
ANPA Calls steep, but often slightly more curved than MYTH or MYEV and somewhat "thicker". Very little tail, but sometime "dribbling off" in a "lazy S" shape. Fmin ~30k and Fmax ≥50. Can also be difficult to tell from EPFU in clutter, which will usu. have time between calls of <100ms.



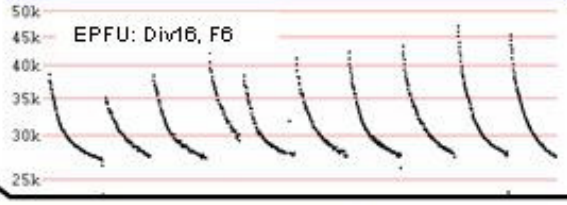
25k Bats (tailed calls)

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").



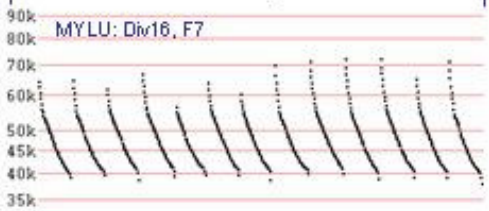
EPFU Calls are more curvilinear than LANO, but can be more bilinear when they are short in sweep (i.e., ~25-40). Slope of tail is very consistent. On flat calls, Δslope plots may show many calls with "fish-hook" ends. Fmin often not uniform, with some calls falling below 25k. Calls sometimes irregularly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



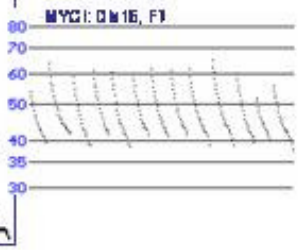
40k Myotis

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

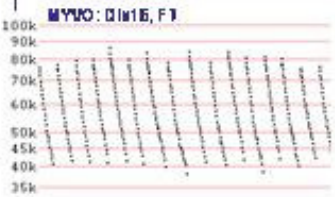
MYLU Gently curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end). Clean calls often sweep from ~100 to just over 40. On clean calls, $\Delta slope_{ave}$ can be as low as 40, but usually higher. Sometimes alternate curved call with a more linear one.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



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 $\Delta slope_{ave}$ 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.



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.



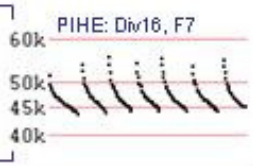
50k Bats

Steep Calls

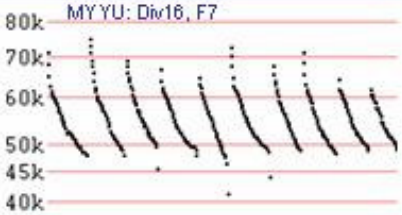
Steeper than PIHE and usu. Fmin at or just below 50k. Single calls can drop to 40k, but not whole series (consistently above 43k). Difficult to distinguish from each other, especially in clutter, and many must be reported simply as "**aM50k**".

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.



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.



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.