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QUANTIFYING WILDLIFE USE OF CAVE ENTRANCES USING REMOTE CAMERA TRAPS

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Abstract: Digital infrared remote camera traps were placed at the entrance of twelve caves in Great Basin National Park, Nevada during the summer of 2013 to assess the wildlife use of cave entrances. The use of caves by surface wildlife is a major nutrient source for cave organisms that spend their entire lives underground. Cave entrances varied in size (0.9 to 50 m^2), cave length (10 to 1000 m), surface habitat (riparian versus pinyon/juniper), and management approach (gated versus no gate). Data from eight cave entrances are presented, with four other entrances removed from the analysis due to equipment failure. The cameras were deployed for a total of 372 trap days, with an average of 46.5 days per cave (range 28 to 62). The cameras captured 632 trap events, with separate events defined as more than an hour apart for the same species. Of the seventeen taxa documented, the most abundant species photographed were mice, chipmunks, humans, woodrats, and squirrels. Other species observed in cave entrances were cottontail rabbits, bats, skunks, foxes, insects, birds, and domestic dogs. Wildlife entered and exited caves most frequently between 1800 and 0600. Very little information has been previously documented about fauna using cave entrances, and this non-invasive, repeatable technique can help managers learn more about the dominant species using the entrance and twilight areas of the caves they manage, as well as peak use times.

Introduction

Cave entrances provide important habitat to wildlife. Cave entrances can offer a thermal and moisture refuge from above-ground conditions, particularly in desert areas where summer daytime and winter nighttime temperatures can vary more than 30 °C from the relatively steady temperature found underground (Cigna, 2004). Cave entrances provide shelter for a wide variety of vertebrate and invertebrate species that may not use deeper cave environments. They serve as food caching locations for many animals, including mice. In the American West, they frequently provide suitable habitat for nesting cave swallows (*Petrochelidon fulva*) as well as woodrats (*Neotoma* spp.). Over 44,000 caves are known within the United States (Culver et al., 1999). Many caves have an interesting and varied fauna, including many species that are cave obligates. Despite knowledge of what lives in caves, few studies have focused on wildlife use of the transition zone between above and below ground, especially in desert environments (Winkler and Adams, 1972; Strong, 2006; Strong, 2010).

Two main types of wildlife, cave accidentals and trogloxenes, use cave entrances. The facultative use of cave entrances by cave accidentals like beetles and lizards, and the regular use by trogloxenes, such as bats and cave crickets, are critical to cave ecosystems. These wildlife species introduce energy into the nutrient-poor environments in the form of scat, nesting materials, and occasionally carcasses. These deposits provide a nutrient source for troglophiles, species that can complete their entire life cycle in the cave or in a similar habitat aboveground, and troglobites, cave-adapted organisms that never leave caves (Barr and Holsinger, 1985). Therefore, to better understand the nutrient flow into the cave, it is logical to study the use of the cave by cave accidentals and trogloxenes at their point of entrance.

Remote camera trapping, or using remote cameras to take photographs of animals, is a non-invasive technique to study wildlife use. This technique can capture rare and elusive species, monitor animal behavior, and document predation (Kucera and Barrett, 2011). Camera traps can also sample locations where it would be uncomfortable for a person to stay for long. Cameras work both day and night, so diurnal, nocturnal, and crepuscular animals are sampled. In addition, multiple species can be studied at the same time. Studies using remote cameras in various habitats such as forests, shrublands, and riparian areas have been conducted for decades (Kucera and Barrett, 2011), but they have not been reported for cave entrances.

The primary objective of this study is to fill an information gap about which wildlife species use cave entrances, when they use them, and to what extent other variables may influence usage. In particular, I focused on entrance usage by time of day, vegetative habitat above ground, entrance size, and cave gate presence or absence. This information can help managers better understand the role cave entrances play for surface wildlife, as well as better comprehend the role surface wildlife has on nutrient input into caves.

Methods

The study area is located in Great Basin National Park in east-central Nevada (Fig. 1), part of the Basin and Range

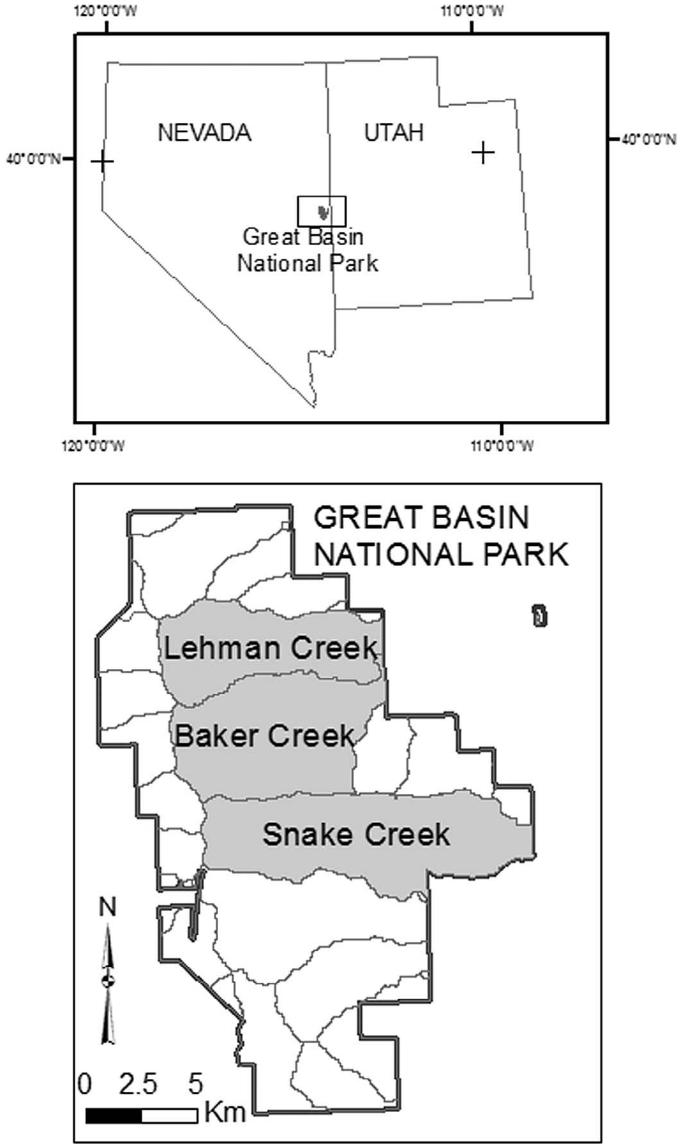

Figure 1. General location of Great Basin National Park, White Pine County, Nevada, and location of study watersheds (Lehman, Baker, and Snake) within the park.

Province. The park encompasses much of the southern Snake Range, which is considered a metamorphic core complex of Proterozoic to Middle Cambrian age. About 40% of the surface rock at the park consists of karst, primarily Middle Cambrian to Ordovician limestones (Hose and Blake, 1976; Miller et al., 1987; Graham, 2014). Elevations in the park range from 1,600 to over 3,900 m. The climate is typical of the high desert, with summer highs exceeding 30 °C and winter lows below –20 °C at the park headquarters, located at 2,070 m. Annual precipitation at this elevation averages 33 cm, with precipitation increasing and temperatures decreasing as one rises in elevation (Elliott et al., 2006; Reinemann et al., 2011).

Twelve caves were selected in the Lehman, Baker, and Snake Creek watersheds based on their accessibility, within a ten-minute walk, and size, at least 12 m in length. The caves were located at elevations from 2,020 to 2,235 m in Middle Cambrian Pole Canyon limestone in the Baker and Lehman watersheds and in the Notch Peak limestone in the Snake watershed. Nearby habitat consisted of pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) woodlands or riparian habitat dominated by water birch (*Betula occidentalis*). Half the caves were gated, and half were not gated. Entrance areas ranged from 0.9 m^2 to 50 m^2. Lengths of the caves ranged from 10 m to 1000 m, with a mean length of 250 m. Data were successfully obtained from eight of the caves (Table 1).

Four models of infrared-triggered wildlife cameras were installed at the caves: Cuddeback Expert (n = 1), Cuddeback NoFlash (n = 2), Reconyx PC 90 HO (n = 2), and Reconyx PC 85 (n = 2). The Cuddeback cameras took one photo per trigger, whereas the Reconyx cameras took one to three photos per trigger. Cameras were mounted with bungee cords or bailing wire to rocks and signs or were propped up with rocks where appropriate flat surfaces were present. Cameras were aimed at or across the cave entrance, but not pointed directly into the rising or setting sun. No lures or bait were used for this study.

The total number of photographs taken, events, and trap days of effort were summarized after subtracting the days

Table 1. Caves selected for remote camera study in Great Basin National Park, White Pine County, Nevada.

Cave Name	Entrance size (in m; width × height)	Gated?	Length, m	Elevation, m	Habitat type	Watershed
Fox Skull Cave	3 × 2	No	60	2020	Pinyon/Juniper	Snake
Ice Cave	2 × 3; 2 × 4[a]	No[b]	900	2150	Riparian	Baker
Lower Pictograph Cave	10 × 5	No	12	2140	Riparian	Baker
Model Cave	2 × 1	Yes	590	2080	Riparian	Baker
Root Cave	1 × 1.5	Yes	120	2090	Pinyon/Juniper	Lehman
System's Key Cave	0.5 × 0.5	Yes[c]	300	2120	Riparian	Baker
Three Hole Cave	1 × 1, 1 × 1.2[a]	No	10	2120	Pinyon/Juniper	Baker
Wheeler's Deep	2 × 3	Yes	1000	2150	Pinyon/Juniper	Baker

[a]Ice Cave and Three Hole Cave both have two entrances, and cameras were alternated between the entrances.
[b]Ice Cave is gated, but the cameras were placed at the ungated section of the cave.
[c]System's Key is gated, and the camera was placed at the gate and later above the gate, which showed a wider variety of animal life.

Table 2. Number of trap events for different wildlife taxa at each selected cave in Great Basin National Park, White Pine County, Nevada.

Common Name	Scientific Name	Fox Skull Cave	Ice Cave	Lower Pictograph Cave	Model Cave	Root Cave	System's Key Cave	Three Hole Cave	Wheeler's Deep Cave	Total Events	Number of Caves
Mouse	*Peromyscus* cf. *maniculatus*	8				19	61	69	6	163	5
Cliff chipmunk	*Tamias dorsalis*	5	12	2	1	11	3	2	33	69	8
Desert woodrat	*Neotoma lepidus*	9	43		7				6	65	4
Human	*Homo sapiens*		1	63				1		65	3
Rock squirrel	*Otospermophilus variegatus*	12		25				5	2	44	4
Bat	unknown				4		15	1	1	21	4
Rock wren	*Salpinctes obsoletus*		1				6	6		13	3
Western spotted skunk	*Spilogale gracilis*	1	1	1			1	8		12	5
Mountain cottontail	*Sylvilagus nuttallii*	7						3		10	2
Gray fox	*Urocyon cinereoargenteus*					6				6	1
Beetle	unknown	3								3	1
Fly	unknown			1	1				1	3	3
Western fence lizard	*Sceloporus occidentalis*							3		3	1
Dog	*Canis lupis familiaris*			2						2	1
Ringtail	*Bassaricus astutus*						1	1		2	2
Black-chinned hummingbird	*Archilochus alexandri*							1		1	1
Cliff Swallow	*Hirundo pyrrhonota*			1						1	1
Unknown		39	9	24	14	10	20	15	18	149	8
Total Events		84	67	119	27	46	107	115	67	632	
Number of species		7	5	7	4	3	6	10	6		
Number of Trap Days		62	53	56	39	24	59	51	28		

Figure 2. A ringtail (*Bassaricus astutus*) outside of System's Key Cave at Great Basin National Park, White Pine County, Nevada.

that the camera malfunctioned, most commonly due to battery failure. Animals that could not be distinguished as individuals and that were captured within one hour of each other were considered to be the same event. After one hour, they were arbitrarily considered to be a new photographic event. All photos were examined at least two times, with wildlife-biologist consultation as needed to reach the lowest taxonomic level feasible, usually species. Microsoft Excel (v. 2007) and Minitab Statistical Software version 14 (www.minitab.com) were used to perform data analyses. Values are presented as means $\pm$ standard deviation.

Results

Cameras were deployed at various caves from May 30 to September 20, 2013 (Table 2). During the 113-day study period, the cameras recorded 372 trap days, with 46.5 $\pm$ 14.4 days of effort per cave (range of 28 to 62) for eight caves. Cameras at four caves (Lehman Annex, Upper Pictograph, Snake, and Squirrel Springs) malfunctioned, and their data were not included in the analysis. Seventy-six percent of the trap events had identifiable taxa, to species level except for some mice, bats, and invertebrates.

Camera traps documented a minimum of seventeen taxa at the cave entrances. The most common animals captured by the cameras were mice, with 163 trap events (Table 2; includes scientific names). These were followed by cliff chipmunks, humans, desert woodrats, rock squirrels, and bats. Several species were only captured ten to fifteen times, including western spotted skunks, mountain cottontails, and rock wrens. Gray foxes were only captured six times, all at one cave. Ringtails (Fig. 2) were even more elusive, being recorded only twice.

Some taxa were more widespread across cave entrances than others. Chipmunks were found at all eight cave entrances, and mice were found at five of the eight cave entrances. Squirrels, desert woodrats, birds, and bats were recorded at four cave entrances. However, four taxa were found at only one or two cave entrances. The number of taxa per cave entrance varied from three at Root Cave to ten at Three Hole Cave, with a mean of 6.0 $\pm$ 2.1 per cave. Species accumulation curves are shown in Figure 3.

The number of trap events per cave ranged from 27 at Model Cave to 119 at Lower Pictograph Cave, an average of 79 $\pm$ 33 trap events per cave. To compensate for the varying efforts at the caves, the trap events per camera day were calculated, with a resulting catch of 1.7 $\pm$ 0.6 trap events per camera day, with a range of 0.7 trap events per camera day at Model Cave to 2.4 trap events per camera day at Wheeler's Deep Cave.

At the three caves equipped with Reconxy 85 cameras that took three photos for each trigger, the first photo identified the species 73% of the time, while the second photo accounted for 5% and the third photo for 2% of the identifications. The second and third photos did not add to species richness. In 20% of the trap events, the species was not identifiable or was absent from the photos.

Sixty-four percent of trap events occurred during the twelve-hour period between 1800 and 0600 (Fig. 4). Some wildlife species showed distinct preference for particular time periods (Fig. 5). Animals most active at night were bats, mice, skunks, and ringtails. Animals most active during the day were chipmunks, humans, birds, and squirrels. Although woodrats were primarily nocturnal, at Three Hole Cave they showed a surprising tendency to be active during daylight hours as well. Cottontails (Fig. 6) were captured at all hours of the day and night except from 0900 to 1300.

Although ungated caves had a higher number of trap events (n = 413) than gated caves (n = 248), the difference between the medians was not significant (p = 0.113), using a Mann-Whitney U test. Likewise, the difference between pinyon/juniper and riparian habitats was not significant using a Mann-Whitney U test. A regression did not show the length of cave (p = 0.197) or cave entrance size p = 0.260) to significantly predict different numbers of wildlife. However, some taxa were more common with certain conditions (Fig. 7). Ungated caves accounted for all human visits, as well as 95% of squirrel and 80% of woodrat trap events. Ninety-five percent of bats and 70% of chipmunks were seen at gated caves. No taxa showed a preference for cave entrances in pinyon/juniper areas, but 99% of human, 95% of bat, 86% of woodrat, and 74% of chipmunk trap events were found at caves with entrances in riparian areas. The four longer caves (>250 m) accounted for 95% of bat and 70% of chipmunk trap events, while 100% of human, 91% of squirrel, and 80% of woodrat trap events were at shorter caves.

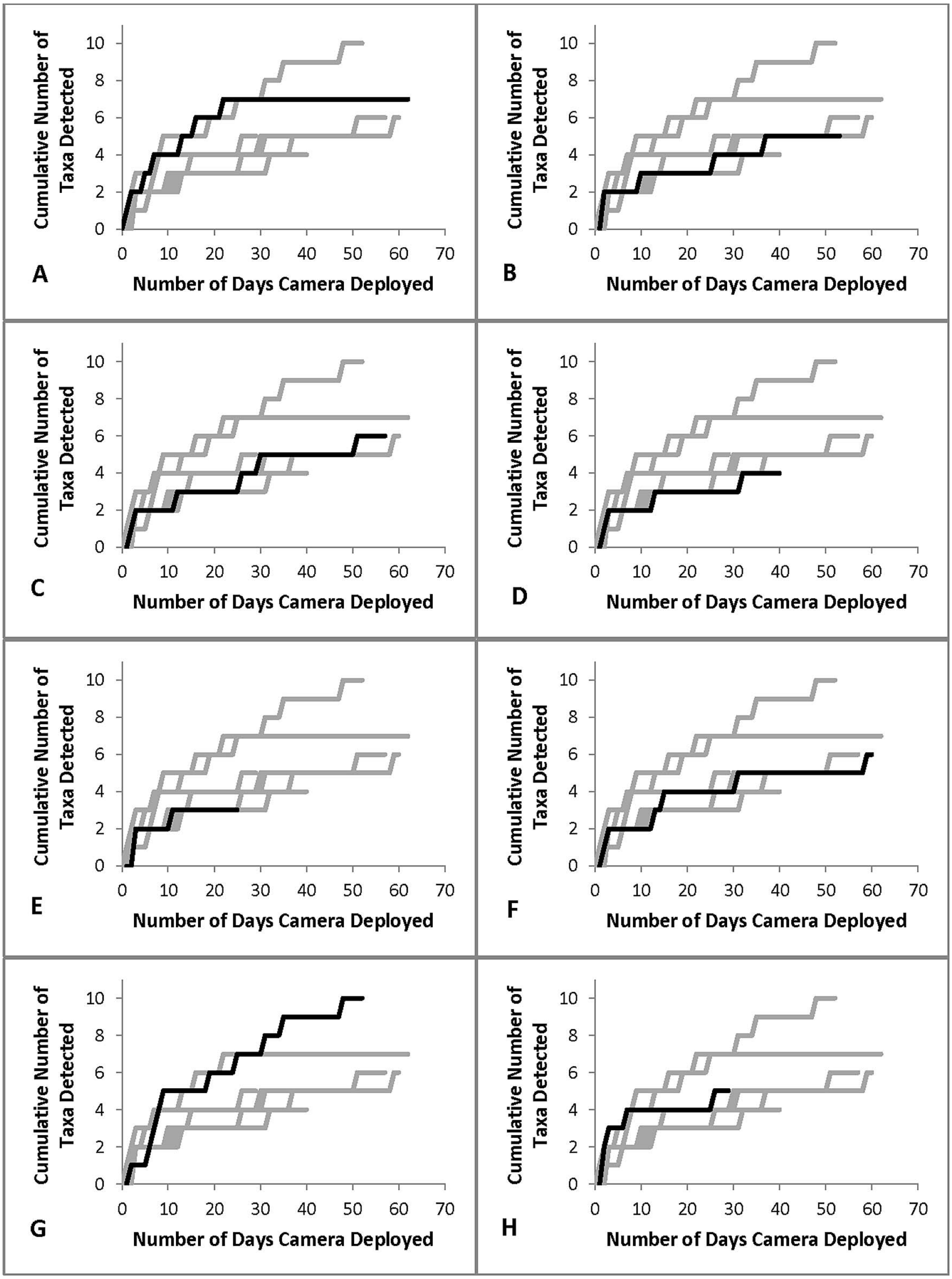

Figure 3. Species accumulation curves from wildlife camera events for each of the eight caves studied at Great Basin National Park, White Pine County, Nevada. A-Fox Skull Cave, B-Ice Cave, C-Lower Pictograph Cave, D-Model Cave, E-Root Cave, F-System's Key Cave, G-Three Hole Cave, H-Wheeler's Deep Cave. Each cave is shown in black, with the other seven caves in gray for context.

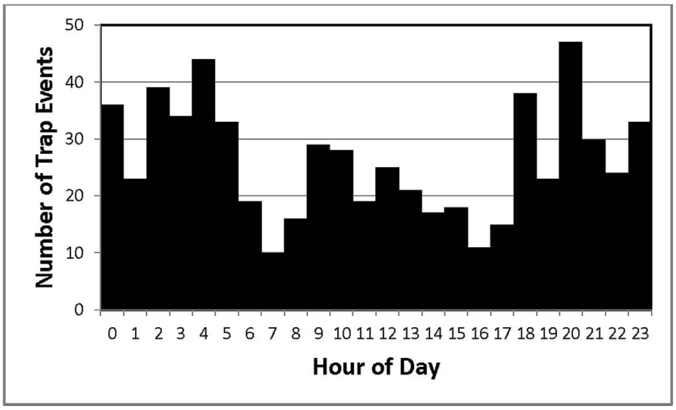

Figure 4. Total number of wildlife camera trap events pooled by hour of day for all eight caves sampled in Great Basin National Park, White Pine County, Nevada.

Discussion

Previous information about overall wildlife use of cave entrances is extremely limited (Winkler and Adams, 1972; Strong, 2006; Strong, 2010), but this low-cost, low-personnel-effort provided a baseline of summer use for multiple cave entrances. In addition to informing managers as to what animals use the cave entrances, the camera traps also allowed a glimpse into the peak times of use and showed habitat preferences for some taxa.

No species were captured that had not been previously documented in the park in other habitats. However, this study was the first to document the use of park cave entrances by several species, including western fence lizard, gray fox, domesticated dog, ringtail, western spotted skunk, rock squirrel, rock wren, black-chinned hummingbird, and cliff swallow. Previous studies (Desert Research Institute, 1968; Stark, 1969; Krejca and Taylor, 2003; Taylor et al., 2008) noted use of park caves by taxa also found in this study: bats, humans, cliff chipmunks, mountain cottontails, woodrats, mice, beetles, and flies. This study expanded the number of caves and the seasons of use by these taxa. The previous studies also found kit fox, black-tailed jackrabbit, broad-tailed hummingbird, and canyon wren use of caves. Taylor et al. (2008) noted that in their biological inventories of 15 caves in Great Basin National Park, evidence of woodrats was found in nearly every cave, but no live specimens were ever seen. This study photographed desert woodrats at half of the caves studied. With regards to small mice, previous studies (Desert Research Institute, 1968; Stark, 1969; Krejca and Taylor, 2003; Taylor et al., 2008) documented them in three caves in the Lehman Creek watershed (Fig. 1): Lehman, Lehman Annex, and Root Caves. Taylor et al. (2008) stated that they were likely facultative trogloxenes but not easily observed. This study had 163 total events showing mice, but most of those were at night, which may account for the difficulty of finding them during standard biological inventories conducted during the day.

I was unable to detect a significant effect of entrance size, length of cave, habitat, and presence or absence of a gate on cave entrance utilization by overall wildlife. However, certain taxa appeared to have preferences. Due to the low sample size of eight caves, it may be easy to oversimplify. For example, 95% of bats were photographed at gated, long caves in riparian areas, but looking more closely at the data, 71% of all bats seen were at just one cave (System's Key Cave). Although it is not surprising that bats were found in the longer caves, it is unknown why chipmunks would prefer entrances of long caves. While several abundant taxa showed an inclination to certain cave entrance characteristics, mice had no preferences for gated/ungated, habitat, or length of cave.

The percentage of unknown events per cave varied from just over one tenth of the events (13.0 and 13.5% for Three Hole Cave and Ice Cave, respectively) to around half of the events (46.4 and 51.9% for Fox Skull Cave and Model Cave, respectively). These differences may reflect different sensitivities of the kinds of cameras, the presence of wildlife that vary in detectability, changes in lighting, triggers due to movement of vegetation due to wind, or differences in appropriateness of positioning of the cameras. In any case, the use of different types of cameras at different cave entrances was a constraint on interpreting the results (Kelly and Holub, 2008). However, Hughson et al. (2010) found that even using the same model of camera, detection probability can vary greatly. Although some cameras can be programmed to take multiple photos per trigger, only an additional 5% of wildlife species were captured in this study by the second photo and 2% by the third photo. The value of this additional identification should be weighed against the amount of time needed to sort through a much larger data set. The second and third photos did not add additional taxa for any of the caves.

Many camera trap studies focus on one size of target, such as medium- or large-sized mammals (e.g., Swann and Perkins, 2013). This study analyzed all sizes, and the cameras performed well in this regard. Nevertheless, it should be noted that due to camera limitations, particularly in the passive infrared detection capabilities, some classes of wildlife such as cold-blooded vertebrates are likely underrepresented in this survey. Invertebrates like beetles, flies, and cave crickets, which may be an important nutrient source to the cave (Taylor et al., 2005), are only rarely captured by remote cameras. One way to compensate for this could be to use both time- and motion-triggered settings. With an average of just 1.7 trap events per day per cave, setting time-triggered settings could greatly augment the number of photos to analyze.

Wildlife were observed using cave entrances for a variety of reasons. At Root Cave, photos of a mouse at the cave entrance were closely followed by that of a gray fox (Fig. 8), suggesting the fox may have been hunting. At

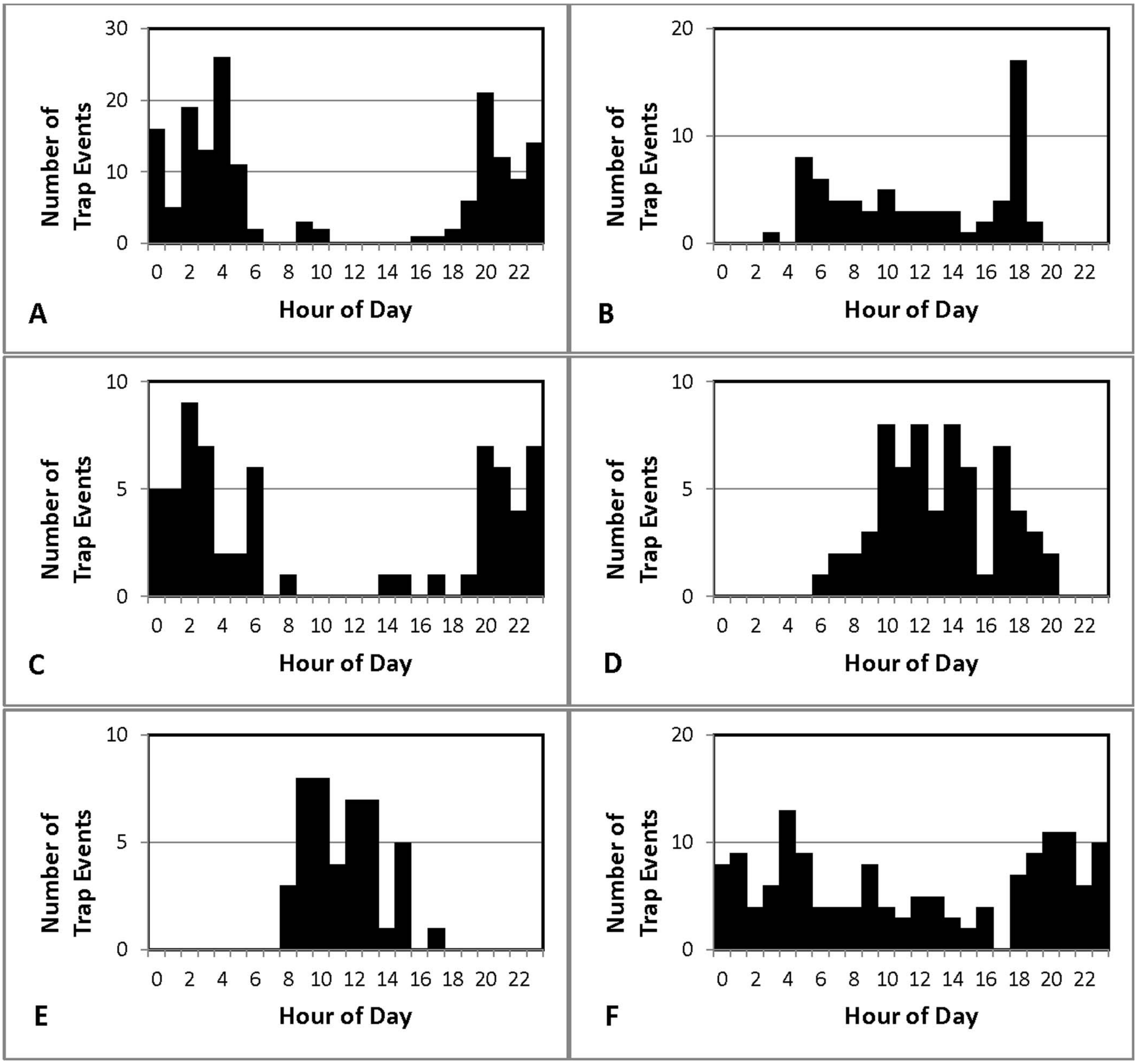

Figure 5. Total number of wildlife camera trap events by taxa pooled by hour of day for all eight caves sampled in Great Basin National Park, White Pine County, Nevada. Shown in order of abundance, except for unknown: A-mouse (*Peromyscus* cf. *maniculatus*), B-cliff chipmunk (*Tamias dorsalis*), C-desert woodrat (*Neotoma lepidus*), D-human (*Homo sapiens*), E-rock squirrel (*Otospermophilus variegatus*), F-unknown trigger.

System's Key Cave, a mouse was photographed eating a fly. The Three Hole Cave entrances may be a resting location for skunks, given their coming and going at intervals. Desert woodrats and small mice are clearly using cave entrances as a home and may enter and leave the caves multiple times per day. For this reason, using camera traps to estimate abundance is not advisable, as the same individuals are likely photographed more than once, and in some cases many more times than once. Nevertheless, the camera traps can be valuable for documenting wildlife interactions with each other and their environment that help augment the understanding of cave ecology (Baker et al., 2014).

With the exception of Upper Pictograph Cave, this study did not target any caves with known bat maternity colonies. This study found bat use of four caves with previous documented bat use, did not find bats in three caves with previous documented bat use, and did not find bat use in one cave with no previous bat use documented (unpublished

Figure 6. A mountain cottontail (*Sylvilagus nuttallii*) photographed with a wildlife camera at the entrance of Fox Skull Cave, Great Basin National Park, White Pine County, Nevada.

bat data for Great Basin National Park). This study augmented previous bat data by adding to the months of observed bat use for two caves. The times of bat outflight and inflight varied. The bats were captured primarily in gated caves. It is possible that bats may be flying fast enough that they escaped capture by the camera traps except in caves that have gates, where the bats may be flying more slowly to navigate the bars of the gate. Hirakawa (2005) used a pencil eraser connected to a line to attract bats searching for prey and to slow them sufficiently for camera traps, However, a non-photographic approach such as an infrared beam counter or acoustic loggers may be more appropriate (Wilson, 2000; MacSwiney et al., 2008; Blumstein et al., 2011).

The photographs indicate that temporal-niche partitioning is occurring at some cave entrances. Mice and woodrats were most abundant from 1900 to 0700, with only 6% of either species seen from 0700 to 1900. Meanwhile, chipmunks and humans were predominant from 0600 to 2000, with only 13% and 3% respectively from 2000 to 0600. Squirrels showed an even narrower range of use, with all captured from 0800 to 1500. Trap events classified as unknown occurred fairly consistently across the 24 hours, further adding credence that camera positioning may be a large reason for those unknowns. Other remote camera studies have documented temporal-niche partitioning, but have focused on medium-sized mammals (Fedriani et al., 2000, Almeida Jácomo et al., 2004). Lower Pictograph Cave, the only cave with high human visitation in this study, is readily visible to human visitors to the park, as it has a large entrance and is located right next to a publicly accessible road. All other caves in this study are less accessible and less visible to casual park visitors. Human visitation to

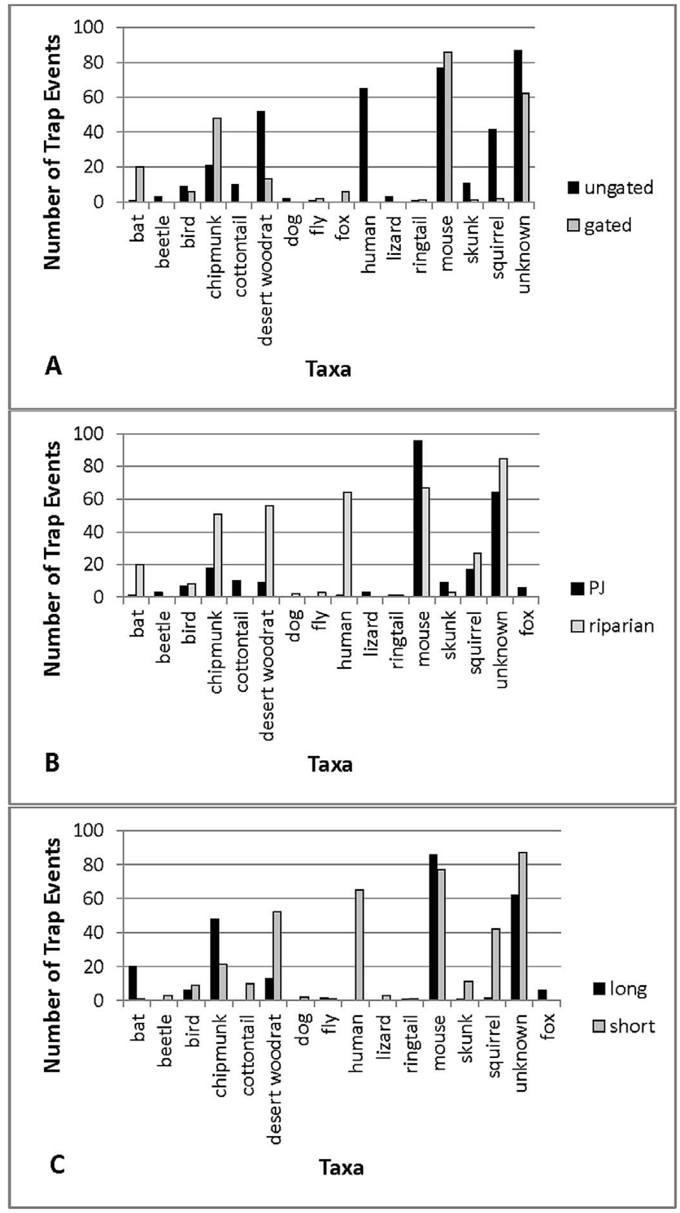

Figure 7. Number of wildlife camera trap events pooled for all caves by species in Great Basin National Park, White Pine County, Nevada. A—gated vs. ungated caves, B—pinyon/juniper vs. riparian habitat, C—long (>100 m) vs. short (<100 m) caves.

Lower Pictograph Cave clearly showed humans visiting the cave entrance to observe and photograph the pictographs (Fig. 9). This human visitation to Lower Pictograph Cave did not entirely preclude wildlife use, although the cave entrance had fewer species than nearby Three Hole or System's Key caves.

Some taxa expected to appear in this study, such as mountain lions and bobcats (Rickart and Robson, 2008), did not show up at any of the camera traps. Other camera-trap studies have shown that at least one thousand trap

Figure 8. This wildlife camera photo of a gray fox (*Urocyon cinereoargenteus*) was immediately preceded by a photograph of a mouse at the same location, suggesting the fox was hunting at the entrance to Root Cave, Great Basin National Park, White Pine County, Nevada.

Figure 9. A human visitor photographing the pictographs at the cave entrance to Lower Pictograph Cave, Great Basin National Park, White Pine County, Nevada.

days are needed in an area to infer that a species is absent (Carbone et al., 2001). In addition, for some species, remote photography may not be the best tool; for example, Harrison (2006) found a dog trained to find bobcat scats was superior in New Mexico. Park staff have noted mountain lion tracks entering a cave in the winter (M. Horner, pers. comm.). In addition, in the winter some species hibernate (e.g., western fence lizard) or migrate (e.g., hummingbirds), so it is likely that different fauna are using the cave entrances at different seasons, and conducting seasonal inventories would provide a fuller picture of wildlife use of cave entrances.

Determining the ideal length of time to conduct a similar cave-entrance study is important for future study designs and efficient research-resource allocation. An asymptote of species accumulation was only found with Fox Skull Cave, with seven species reached at 22 days and no additional species added through the 62 day monitoring period (Fig. 3). The other seven caves did not reach an asymptote, including the three caves with over 50 days of sampling. System's Key Cave appeared to have an asymptote with five species at day 30, but then at day 58 a spotted skunk appeared. This long period of accumulation is different from that seen by Silveira et al. (2003), who found that species richness increased for about 34 days when they used camera traps in grasslands of central Brazil. However, Tobler et al. (2008) estimated the need of 400 to 500 camera days for a camera-trap array to capture the most common medium- to large-sized mammals in rainforests, and 2,000 days to get nearly all. Rovero et al. (2013) recommend 1,000 to 2,000 trap-days to get 60 to 70% of the species. Clearly longer camera-trap studies at cave entrances are needed to determine the ideal time needed to capture species richness.

Some caves studied in the Baker Creek drainage are located within 65 to 800 m of each other, yet the camera traps did not record the same species. For example, skunks were found only at System's Key Cave, Three Hole Cave, and Ice Cave, but not at Lower Pictograph Cave or Wheeler's Deep Cave. This suggests that some species are more particular about the cave habitat they use. Future studies could incorporate more physical measurements such as air temperature and relative humidity, as well as topography, access, or amount of human use in conjunction with the camera traps. The inclusion of these covariates could assist in conducting occupancy estimation, if desired (O'Connell and Bailey, 2011).

Conclusions

Very little information has been documented about what fauna use cave entrances. This non-invasive technique using camera traps can help managers learn about the dominant species using the entrance and twilight areas of the caves they manage, as well as supplement cave bioinventories. Although the cost of camera trapping may initially be high if new equipment must be purchased, it is preferred over track surveys and direct counts for rapid faunal assessments of mammals (Silveira et al., 2003). Remote cameras can often be borrowed from wildlife or law enforcement programs. Using remote cameras at cave entrances is easily repeatable, which would allow for monitoring to determine changes in a measure such as species richness over time.

The use of camera traps to do this inventory of eight cave entrances in summer at Great Basin National Park worked well, with some caveats that serve as recommendations for others who would like to use this technique for inventorying wildlife at cave entrances in their area:

1. Use the same make and model of camera if possible at all cave entrances;
2. Use cameras with both infrared and motion detection to improve trapping rates;
3. Three photos per trigger result in 7% more identifications, but three times more photos to process, adding little to the understanding of site usage by wildlife;
4. Install cameras for a minimum of 60 days at each cave entrance to capture most of the wildlife species using it; longer is better;
5. Measure covariates, as listed above, if trying to account for why species may or may not be present at a particular cave entrance; and
6. Sample during different seasons and for subsequent years to obtain a stronger dataset.

Camera traps are a useful tool for conducting wildlife inventories of cave entrances. They can be broadly applied to caves throughout the world.

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