Bat Usage of the Weymer Creek Cave Systems on Northern Vancouver Island

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ABSTRACT

Bat use of the Weymer Creek karst area, Vancouver Island, British Columbia, Canada, was studied from 1996 to 1998, following the discovery of a *Myotis* bat hibernaculum. We used a variety of monitoring techniques backed up by careful observations to develop an understanding of how bats use the study area and to determine the climatic characteristics of subsurface bat habitat. We hope to produce recommendations that will lead to sound management of *Myotis* bats and their habitat within the west coast rain forest karst environment. The Weymer caves are used for swarming and hibernation by *Myotis volans, M. lucifugus, M. yumanensis,* and the rare and endangered *M. keenii*. In addition, *M. californicus* and *Eptesicus fuscus* use the surface habitat for feeding. Caves used for swarming and hibernation vary in elevation from 500 to 900 m, with the largest concentrations of hibernating bats being found above 800 m. Most hibernating bats are found in deep passages with stable environments of 3–4°C and 100% relative humidity. Caves underlying clearcuts are also used by bats and have stable winter temperatures. Within the study area, female Keen's long-eared myotis use low elevation sites (<400 m) in summer for feeding and raising young. They join males in cave swarming activity at higher elevations (>650 m) between August and September. Our observations suggest that the entire range of habitats from sea level to high elevation and both cave and surface habitats are vital to the life history and survival of at least 6 species of bats.

Key words: bats, caves, hibernation, karst, *Myotis keenii*, Vancouver Island.

Nine species of *Myotis* bats inhabit British Columbia in summer, yet until 1993, no winter aggregation sites were known for any *Myotis* in British Columbia (Nagorsen and Brigham 1993). Any new information regarding critical hibernaculum sites and characteristics of these sites is vital to bat management and conservation. The Province of British Columbia is initiating legislation and guidelines to regulate forest practices and ensure protection of forest-dependent endangered species at this time; however, due to the lack of information about forest-using bats, recommendations are based on information from other jurisdictions. Thus, in 1993, when cavers discovered hibernating *M. lucifugus*, *M. volans,* and the endangered *M. keenii* in Labyrinth Cave under a Vancouver Island coastal montane forest slated for logging, measures were taken to protect and study the Weymer Creek cave systems.

Because the Labyrinth hibernaculum had its main entrance at 900 m above sea level, we hypothesized that bat hibernation in coastal areas may be related to the constant cool temperature in the higher elevation caves during hibernation. If this proved true, then efforts to locate and conserve bat hibernacula in coastal karst areas could focus on higher elevation sites. Our goal was to determine critical habitat characteristics for bats in this coastal rain forest ecosystem to make recommendations for conserving bats and bat habitat within this environment. Our specific objectives are

1. to document cave usage by bats in the Weymer karst area through discreet visitation, electronic monitoring, guano collection, and skeleton collection;

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2. to determine the physical characteristics of bat hibernacula through year-round monitoring of temperature and humidity patterns in caves of different elevation ranges;
3. to document summer habitat use patterns of bats in caves and the overlying forest; and
4. to determine the impact of clearcut logging on cave physical characteristics and bat use patterns.

STUDY AREA

The Weymer and Green Creek drainages, located about 3 km southeast of Tahsis on northwestern Vancouver Island, range from sea level to 1126 m (49°51'N–49°53'N, 126°37'W–126°39.5'W). The study area contains >150 caves from sea level to 1,000 m, and was partially clearcut over 25 years ago (Davis 1995). The study area is primarily in the Coastal Western Hemlock (CWH) biogeoclimatic zone (subzones vm1 and vm2) and Mountain Hemlock (MH) biogeoclimatic zone (subzone mm1). Lower elevations have small stands of old-growth Douglas-fir (*Pseudotsuga menziesii*), while red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) predominate in areas that were logged before 1950. The cave systems are mostly protected within a 305-ha park, while the remainder are within Tree Farm Licence (TFL) 19.

METHODS

TEMPERATURE AND HUMIDITY DATA LOGGING

To characterize the physical habitats suitable for bat hibernation we deployed "Onset" temperature and humidity data loggers in caves and surface control sites at low elevation (0–400 m), mid-elevation (401–650 m), and high elevation (651–950 m). For low elevation, finding replicate caves of sufficient length was not always possible, so some shorter caves were used. Data were also collected from caves under clearcuts and under forested areas in each elevation category. The pair of temperature and humidity loggers were

Table 1. Summary of mean winter temperatures and coefficients of variation (CV) at data logger sites (sorted by mean temperature). Data from 17 October 1996 to 5 March 1997.

Cave site	Mean temp (°C)	CV	Cave depth (m)	Elev. cat.[a]	Elevation (m)	Treatment[b]	Hibern. bats
Wormhole: entrance	0.05	60	10	H	810	cc	
Labyrinth: snag	0.23	4.64	0	H	922	fo	
Labyrinth: entrance	0.52	3.55	10	H	915	fo	
Marmot Maus: snag	1	3.94	0	H	824	cc	
Slot Canyon: snag	1.43	1.951	0	M	596	fo	
Whistling: clearcut	1.65	2.273	0	M	568	cc	
Whistling: low entrance	1.83	1.361	10	M	510	cc	
Headwall: entrance	2.39	0.842	10	M	483	fo	
Labyrinth-Keens Junct.	2.64	0.114	100	H	843	fo	yes
Wormhole: station 19	2.68	0.198	100	H	751	cc	yes
Slot Canyon: Mcl. ent.	2.77	0.339	10	M	554	fo	
Labyrinth: hibernaculum	3.08	0.026	200	H	838	fo	yes
Slot Canyon-Rckn. Rub.	3.56	0.242	300	M	592	fo	yes
Deerdrop-Ant Lion	3.98	0.02	150	H	788	fo	yes
Whistling: junction	4.17	0.218	100	M	531	cc	
Deerdrop: entrance	4.25	0.136	10	H	820	fo	
Boneyard: outside	4.26	0.6	0	L	5	fo	
Headwall-Redrock	4.67	0.112	100	M	490	fo	
Marmot Maus.: pit	4.68	0.034	25	H	798	cc	
Marmot Maus.: entrance	4.79	0.087	10	H	813	cc	
Crab: 20 m in	4.87	0.335	20	L	60	cc	
Whistling: Canal/sump	5	0.059	100	M	565	cc	
Whistling: mid-entrance	5.35	0.258	10	M	564	cc	
Cave176a: 15 m	5.52	0.287	15	L	50	fo	
Knollhole: 10 m in	6.59	0.264	10	L	65	cc	
Knollhole: 30 m in	7.8	0.043	30	L	50	cc	
Boneyard: tidal sump	7.97	0.053	10	L	3	fo	
Boneyard: mouse dig	8.13	0.019	50	L	6	fo	

[a] Elevation categories: 0–400 m above sea level = LOW (L); 401–650 m = MID (M); 651–950 m = HIGH (H).

[b] Treatment categories: fo = forested, cc = clearcut.

placed 10 m within the cave entrance and deep within the cave (where possible >100 m from the entrance). Surface temperatures were monitored in each treatment category. Data were recorded at 1-hour intervals.

We compared temperatures from data loggers in 28 locations (Table 1). To compare temperature differences and variations throughout the winter, we used data collected between 17 October 1996 and 5 March 1997. Analysis of temperature data included calculating seasonal means and standard errors at logger locations. To compare temperature variability, we calculated the coefficient of variation (CV), a dimensionless quantity that measures the amount of variability relative to the value of the mean; the CV is calculated by dividing the standard deviation by the mean. We used analysis of variance (ANOVA) and Student's t-test (1) to compare mean temperatures and CVs among caves at different elevations and depths to determine if temperatures were constant and within ranges suitable for hibernating bats, and (2) to compare temperatures and variability in caves under clearcuts and those in forested areas. We compared mean temperatures and variability with elevation using simple regression analysis.

BAT ACTIVITY

We delineated the sampling periods based on seasonal patterns of bat use and the net-nights when we first and last noted them: hibernation (mid-October to late May), emergence from hibernation and feeding in early summer (20 May to 8 July), and swarming in late summer (29 July to 13 September).

To document surface and subsurface habitat use by bats we used both direct and indirect inspection methods: hibernation sites were confirmed by cave visits and exploration by cavers; skeletal remains and recently dead bats were collected from caves to confirm bat use and identify species; guano collection mats were deployed in caves to confirm current bat use; remote ultrasonic detectors were deployed to monitor and record bat passes at entrances and selected surface sites; and mist-netting was used at forest edges, ponds, and outside cave entrances to identify species and habitat use.

In 1998, we netted at various elevations and habitat types from 20 May to 10 October, on 82 net-nights. Bats were handled according to Resources Inventory Committee (RIC) standards (Resources Inventory Committee 1998)

Bone identification of bat species, especially *M. keenii,* was based on skull measurements and characteristics defined in van Zyll de Jong and Nagorsen (1994).

RESULTS

WINTER TEMPERATURE MEANS

The average winter temperature at our 28 data logger sites ranged from 0 to 8°C (Table 1). Mean temperatures were significantly lower at high elevations (simple regression, df = 27, $F = 28.6$, $r^2 = 52\%$, $P < 0.05$, Fig. 1A). Temperatures were also significantly higher deep within caves (approx. 100 m) compared with those outside caves (ANOVA, df = 24, $F = 5.14$, $P < 0.05$; Fig. 2A). There was no significant difference between temperatures near caves in clearcuts versus those in forested areas (t-test, $t = -1.0$, df = 23, $P > 0.05$, Fig. 2A).

WINTER TEMPERATURE VARIATION

The mean CVs were greater at higher elevations (simple regression, df = 26, $F = 4.25$, $r^2 = 15\%$, $P < 0.05$, Fig. 1B). The CV was also significantly different among cave depth categories. Locations outside caves and at entrances (0–10 m) had higher temperature variations than did deep (50–200 m) within caves (ANOVA, df = 24, $F = 3.44$, $P < 0.05$, Scheffe's pairwise comparisons, depth category 0–10 m differs from 15–45 m, and from 50–200 m, $P < 0.05$; Fig. 2B). There was no significant difference in coefficient of variation between caves in clearcuts and forested areas (t-test, $t = 0.06$, df = 23, $P > 0.05$, Fig. 2B).

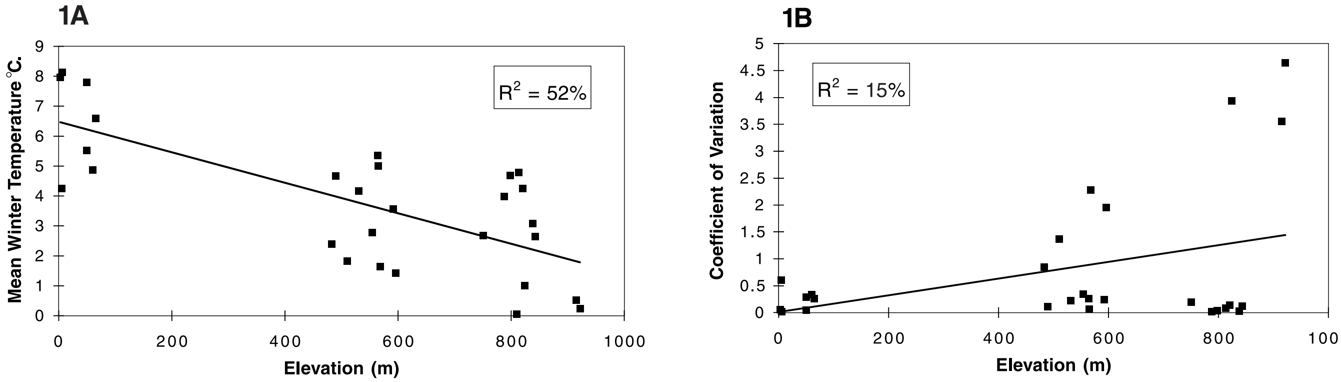

Figure 1. Simple regression relationships between (A) winter temperatures at cave sites and (B) coefficients of variation (CV) versus elevation ($p < 0.05$).

Table 2. Bat capture summary, 1998.

Category	Net-nights	Total captures[a]	No. females, juveniles	Capture ratio[b]
Caves: mid- to high, early summer	8	0		0
Surface: mid- to high, early summer	10	1, EPFU		0.1
Caves: low, early summer	1	0		0
Surface: low, early summer	3	1, MYKE	1, F	0.333
Caves: mid- to high, late summer	46	33, MYVO;15, MYLU, 9; MYKE; 2, MYYU, 4; MYLU/YU; 2, MYKE/EV TOTAL: 65	1, F 1, J(F) 3 J(M)	1.413
Surface: mid- to high, late summer	8	0		0
Caves: low, late summer	7	3, MYKE	2, F; 1, J(M)	0.429
Surface: low, late summer	4	0		0
TOTALS	87	70	5, F;5, J	0.805 (avg)

[a] EPFU, *Eptesicus fuscus,* big brown bat; MYKE, *Myotis keenii,* Keen's long-eared myotis; MYYU, *M. yumanensis,* Yuma myotis; MYLU, *M. lucifugus,* little brown myotis; MYLU/YU, bats that were indistinguishable between *M. lucifugus* and *M. yumanensis;* MYKE/EV, bats that could be *M. evotis*. A skull, collected from Weymer, and identified as a possible *M. evotis* (D. Nagorsen, pers. comm.) raises taxonomic questions.

[b] The number of bats caught divided by the number of net-nights (1 bat net/3 hour+ sampling period).

HIBERNACULA TEMPERATURES AND HUMIDITY

We found evidence of bats hibernating in 5 deep cave locations between 592 and 843 m (Table 1). The average winter temperatures in the hibernacula ranged from 2.6 to 3.9°C. The average CVs ranged from 0.02 to 0.24 (Figs. 2A, 2B).

Because all hibernacula were found in deep cave sites we looked at the differences between mean temperature and variation in all deep cave sites at different elevations to determine consistent temperature characteristics of bat hibernacula. Deep cave sites at low elevations had much higher mean temperatures than did those at mid-elevation and those at high elevation (ANOVA, df = 11, $F = 28$, $P < 0.05$, Fig. 3A). The CV in deep caves did not vary with elevation (ANOVA, df = 10, $F = 2.16$, $P > 0.05$). The mean temperatures within deep caves with hibernating bats were significantly lower than those without (t-test, df = 9, $t = -3.1$, $P < 0.05$, Fig. 3B); however, the CV was not different for deep sites with and without hibernating bats (t-test, df = 9, $t = 0.75$, $P > 0.05$, Fig. 3B). We found no differences in mean temperatures or CVs between deep cave sites under clearcuts and under forests (mean: t-test, df = 9, $t = -0.45$, $P > 0.05$; CV: t-test, df = 9, $t = -0.61$, $P > 0.05$, Fig. 3B).

Relative humidity at the largest hibernacula (Labyrinth) was a constant 100% in winter. Other sites have not been analyzed yet.

CAVE HABITAT USE BY BATS

During the summer/early fall season in 1996 and 1997 we captured 91 bats of 5 species over 21 net-nights: *Myotis volans,* 46; *M. keenii/evotis,* 6; *M. lucifugus,* 29; *M. lucifugus/yumanensis,*

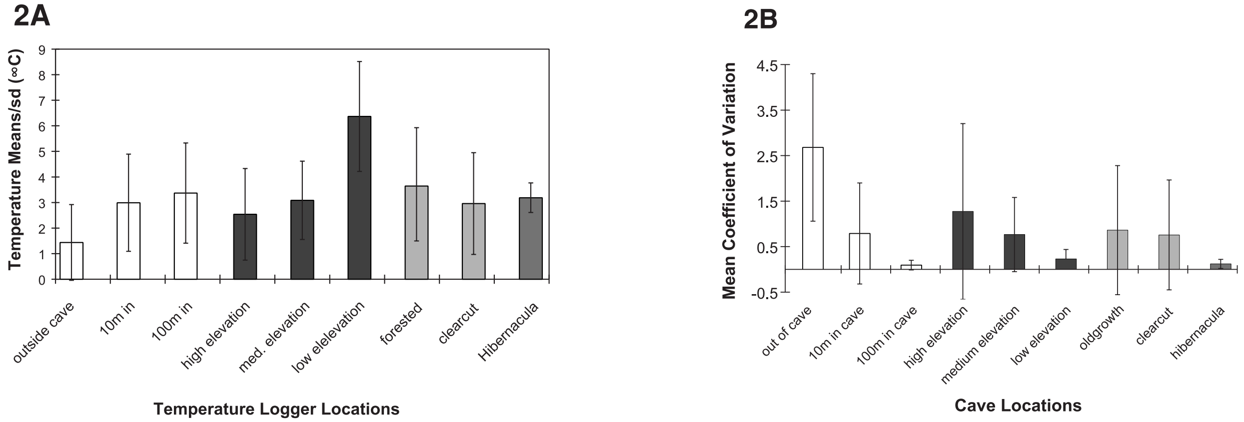

Figure 2. Means and standard deviations (SD) show variations in (A) winter temperature and (B) coefficient of variation in and near caves at different elevations, depths, and cover.

Table 3. Bat use of Weymer Caves.

Cave	Elev.[a] (m)	Length[b] (m)	Treatment[c]	Visual insp.	Ultrasonic detection[d]	Guano	Swarming[e]	Skeletal remains	Hibernation[f]
Cathedral	945	6,230+	fo	X[g]	X	X	X		X
Labyrinth	925	6,230+	fo	X	X	X	X	X	X
Keyhole	875	6,230+	fo	X		X	X	X	X
Calypso	800	6,230+	fo				X	X	X
Ursa Major	910	6,230+	fo		X			X	X
Waymore	840	119	fo				X		
47H	890	?	fo				X		X
Drafty Drop	885	75+	fo		X				
47I	860	91	fo				X		
Fracture	840	163+	fo	X	X		X		X
Deer Drop	820		fo	X	X	X	X	X	X
Wormhole	760	1,583+	cc	X		X	X	X	X
Marmot Mausoleum	780	27	cc					X	
X Cave	705	97+	cc				X		X
Skypot	690	5,365+	cc		X		X		X
Boggle	740	358+	fo		X		X		X
Slot Canyon	550	5,365+	fo	X	X	X	X		X
Fallen Giant	540	1,680+	fo		X		X		
Headwall	480	1,680+	fo		X				
Whistling	560	782	cc		X				
Liquid Sky	380	385+	fo					X	
Knoll Hole	70	90	cc			X	X		
Crab Crevice	70	25	cc						
Cave 176A	60	17	fo						
Boneyard	4		fo						

[a] Elev. = entrance elevation. Elevation categories are: 0–400 m above sea level = LOW; 401–650 m = MID; 651–950 m = HIGH.
[b] "+" indicates cave is longer than mapped length.
[c] fo = forested; cc = clearcut.
[d] Indicates visual verification of hibernacula.
[e] Swarming indicates multiple bats flying in and out of caves from late July to mid-September.
[f] Hibernation indicates high probability of hibernacula. Hibernation period is mid-October to mid-June
[g] X indicates documented evidence of activity.

6; *M. yumanensis,* 3; and *M. californicus,* 1 (Davis 1997).

In 1998 we caught 70 bats of 5 species over 87 net-nights (Table 2). All but *Eptesicus fuscus* and *M. californicus* have been captured at cave entrances.

At mid- and high elevation caves in early summer, no bats were caught. Emergent bats were documented at high elevation cave entrances between 23 May and 27 May. ("Emergent" bats are bats that are found roosting or in torpor just inside the Weymer cave entrances in May–June, typically 10–30 m within. Individuals have been observed to remain for up to 2 weeks at the same location). However, we were surprised to find 2 bats, probably *M. volans*, hibernating in Wormhole Cave on 21 June, over 300 m from the nearest known entrances. This date was later than has previously been observed in the study area.

There was no recorded activity at low elevation caves in early summer during a single night's netting effort.

By late July, there was swarming activity (multiple bats flying in and out of caves that are used for hibernation) by male *Myotis* of 4 species (*M. volans, M. keenii, M. lucifugus, M. yumanensis*) at the mid- to high elevation caves (capture ratio: 1.4 bats/net-night) (Table 3). The greatest swarming activity occurred at entrances to the longer caves with the most stable temperatures, such as the Weymer System, Ursa Major System, and Wormhole Cave. Guano collection sheets record the highest rates of deposition in caves at high elevation (229 droppings on 18 sheets). At mid-elevation caves, we documented most bat activity at entrances that are lower exits to lengthy, deep cave systems that originate at higher elevations and have stable, cool airflows, such as the Slot Canyon entrances to the Weymer System. Caves with all entrances at mid-elevation, such as Fallen Giant, Headwall, and Whistling, yielded few bat captures and detections: 1 capture out of 5 net-nights and 18 passes out of 8 detector nights over 2 years. Guano collection sheets also showed little deposition at this elevation (15 droppings on 14 sheets).

Swarming activity in August began at 2330, whereas forest commuting and feeding activity began at dusk (about 2130). Swarming began progressively earlier as the day length shortened. By 2 September, bats were being caught by 2120. The swarming activity increased through August and by early September appeared to peak. Our highest capture ratio, 5.25 bats/net-night, occurred on 2 September. In 1996 and 1997, however, the swarming peaked in mid-August (11–14 Aug.). Females and juveniles did not appear with the swarming males until early September in 1998. The relative abundance of females for this period was only 3% that of males, over 3 years of netting. The overall capture ratio of bats at cave entrances during late summer was 1.28 bats/net-night.

The capture ratio for low elevation caves during late summer was 0.429. Two significant low elevation caves (Boneyard and Liquid Sky) exhibited no bat activity. However, a 100-m long cave, Knoll Hole, showed activity during netting on 11 August 1998 between 2030 and 2100. Two post-lactating females and 1 juvenile male *M. keenii* were captured at the cave; 2 more long-eared bats were briefly caught, but escaped. Other than this finding at this site, no other cave-related bat activity was detected below 550 m elevation.

SURFACE HABITAT USE BY BATS

Early Summer

Some bat use was documented (through ultrasonic detection and netting) at all elevational ranges. Bats were seen and detected flying along the littoral zone of Tahsis Inlet and the Leiner River estuary from February 1998 to 5 September 1998. In a quiet back eddy of the Leiner River, several *Myotis* sp. bats were detected based on call frequencies ranging from 50 to 80 kHz. *Eptesicus fuscus* was heard flying along the Leiner River (based on calls from 20 to 30 kHz). One lactating female *M. keenii* was captured at the Green Creek estuary on 8 July. The capture ratio for low elevation surface netting was 0.333 bats/net-night.

At mid- to high elevation, occasional feeding activity occurred in the forest/clearcut margins and marshes. The capture ratio in the mid- to high elevation surface was 0.1 bats/net-night.

Late Summer/Early Fall

As late as 4 September, calls consistent with *Myotis* bats were heard regularly over Tahsis Inlet and the adjacent Leiner estuary. Feeding activity occurred along the forest margins and marshes at high elevation but no bats were captured. Bats were also seen flying along trails in the forest and heard feeding over dolines, large sinkholes (>10 m deep) of solutional origin. At Weymer, they are typically devoid of trees within and provide open, uncluttered feeding zones within the forest.

SKULL IDENTIFICATIONS

All bat skulls were collected from cave passages above 730 m, except for 1 specimen (*Myotis* sp.) from Liquid Sky Cave at 380 m. This skull was coated with calcium carbonate, common to caves, which suggests an older specimen. It was not identifiable at the species level. *M. lucifugus, M. yumanensis, M. keenii*, *M. volans,* and possibly *M. evotis* were identified from skulls, including recently deceased (<2 years) individuals.

DISCUSSION

Temperature monitoring in caves showed that mean winter temperature declined with increasing elevation (Fig. 1A), whereas the coefficient of variation (CV) increased with elevation (Fig. 1B). However, the increased CV at higher elevation is due to variation from sites at cave entrances and outside caves (in Fig. 1B, all the points with low CV in higher elevation sites are from deep cave sites). Deep cave sites showed consistently low temperature variation (Fig. 2B, 3B).

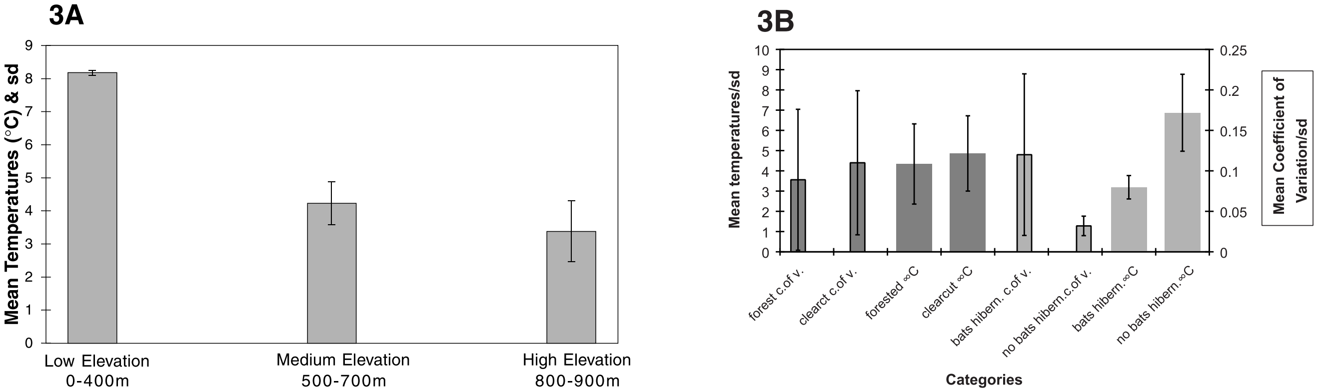

Figure 3. Bar graphs show differences in means and coefficients of variation (CV) of winter temperatures in deep cave sites, (A) at different elevations, and (B) with and without hibernating bats, under clearcuts and forest.

At low elevations, temperature variation was consistently low among cave depths, possibly due to the influence of the sea in some low caves, particularly one with a tidal sump. At mid- and high elevation the temperature variation increased nearer to entrances because of high temperature changes outside the cave and fluctuations in air flow direction between the surface and the stable deep cave environment. We found no apparent effect of clearcutting on winter temperature and variation in and near caves.

Our sampling showed that bats hibernate in Labyrinth, Wormhole, Deer Drop, Fracture, and Slot Canyon caves. These caves range in elevation from 592 to 843 m. They are all deep and long (>100 m). Their deep-cave mean winter temperatures range from 2.64 to 3.98°C , and the CV is very low (0.020–0.242). These conditions are best for long, undisturbed periods of torpor and low oxygen and fat consumption (McManus 1974, Tuttle and Stevenson 1977, Nagorsen and Brigham 1993).

No bats were found hibernating below 592 m elevation. Although deep, low elevation caves appear to have stable temperatures, the mean winter temperatures and metabolic costs may both be too high for hibernation (Hock 1951, Stones 1965, Davis 1970, McManus 1974, Tuttle and Stevenson 1977).

Bats use the entire study area at all times of year. The mid- to high elevation deep caves are used for hibernation by *M. keenii, M. volans, M. lucifugus,* and *M. yumanensis* from mid-October to mid-June, then for swarming from late July to late September. Low elevation riparian areas and littoral zones are used for feeding. At low elevation streams and Knoll Cave, we captured only female and young Keen's long-eared myotis. It appears that female *M. keenii* bats are feeding and raising young at low elevations and then moving to higher elevation caves for swarming and hibernation. This result suggests that the study area is very important to Keen's myotis for 2 critical aspects of its life history: rearing young and hibernation.

Climate has been shown to affect timing of reproduction in bats (Grindal et al. 1992), and probably affects timing of hibernation also. Thus, the late emergence of the 2 *Myotis* bats in Wormhole Cave may be due to a cool, wet spring. Likewise, the annual variation in swarming behaviour might be linked to weather patterns as discussed by Fenton (1969).

Bats use caves under both clearcuts and forests for hibernation and swarming. We noted that *M. volans* used a 15 X 15 X 25 m pit (Skypot) in a clearcut for feeding. This was the only recorded summer feeding use within a clearcut. However, we are not sure if the use of this cave for feeding is related to its unique thermal characteristics, which may be related to clearcutting, because we did not monitor temperatures here.

In summer, males predominate at higher elevation cave and surface sites. Females and young of the year appear with swarming males at the caves in mid-August. This difference in sexual distribution over an elevational and temporal range may be due to various physiological and abiotic factors such as variable energy demands between the sexes, prey availability, and climate. Females require warmer areas with greater insect abundance to meet the demands of raising young (Thomas 1988, Barclay 1991). Furthermore, the low number of bats documented feeding at high elevation bogs and marshes could be explained by a relatively wide distribution of more productive aquatic feeding areas at lower elevations. Green Creek and Leiner River at sea level, and Malaspina and Perry lakes at 100 m elevation provide good feeding areas. However, we do not know where bats roost during the early or late summer period.

Skeletal remains confirmed the presence of *M. keenii, M. volans, M. lucifugus,* and *M. yumanensis* in the caves. However, one of the *M. keenii* skulls collected has measurements that fall within the *M. evotis* range. To clarify taxonomic uncertainties, DNA is currently being sampled and analyzed. Until taxonomic uncertainties for field identification of *M. keenii* are resolved, we cannot identify the species with certainty (Firman and Barclay 1993).

At Weymer, diverse habitats at a wide range of elevations combined with deep caves create make for excellent conditions for hibernating, feeding, and raising young. We hope our hibernation model will be useful for locating other hibernacula on Vancouver Island.

CONCLUSIONS

1. Myotis bats hibernate in caves with stable temperatures between 2.4 and 4°C and 100% relative humidity. In this coastal montane environment, these are deep caves (>100 m long), and occur above 500 m elevation. The largest aggregations are found above 800 m.
2. Clearcutting appears not to affect winter temperatures deep in caves.
3. Myotis bats use the mid- to high elevation caves from mid-June to late July. Swarming occurs from late July to late September. Hibernation occurs from mid-October to mid-June.
4. Low elevation forest and riparian areas are used by Keen's long-eared myotis for feeding and raising young.

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