Bats of Gandl K'in

Douglas W. Burles
Gwaii Haanas National Park Reserve/Haida Heritage Site
P.O. Box 37, Queen Charlotte City, BC, V0T 1S0, Canada
Doug_Burles@pch.gc.ca

ABSTRACT

Gandl K'in, Haida Gwaii (Queen Charlotte Islands) supports an unusual maternal colony of Keen's long-eared myotis and little brown myotis. Hot water from geothermal springs flow through crevices and under boulders creating warm, moist conditions for roosting bats. Some boulder roosts are unique in that they are in the upper intertidal zone and are periodically flooded by extreme tides. The pattern of seasonal use strongly suggests that the thermally heated roosts are important during pregnancy and lactation, but the bats roost elsewhere once the young are volant. Emergence counts confirmed that at least 110 adult bats used the Gandl K'in roosts during 1998, which is similar to the 140 adults and young estimated in 1991. The 2 species were present in approximately equal numbers in both 1991 and 1998, which suggests they are coexisting with minimal competition. Roost sites do not appear to be limiting, and the preliminary results of feces analysis suggest that different foraging behaviour may be minimizing competition for food.

Key words: hot springs, Keen's myotis, little brown bats, *Myotis keenii*, *Myotis lucifugus*, roosts.

The Haida call them "Guudagiigumhlgahl"—the animal that hangs upside down. Bats may be one of the most abundant mammals in North America. Their ability to fly has enabled them to greatly diversify and to colonize virtually all tropical and temperate regions of the world. The evolution of an advanced echolocation system has allowed them to navigate and forage in total darkness, and thus occupy niches with few competitors or predators.

While the abilities to fly and to echolocate have allowed bats to greatly diversify, they have also imposed significant energy constraints. These abilities require large amounts of energy to maintain, and these costs, especially when coupled with very small body size, make it difficult for bats to maintain a positive energy balance. Bats occupying temperate regions have thus had to evolve both physiological and behavioural strategies to survive. Most have become heterothermic, and use torpor to conserve energy. But torpor delays fetal development, so it is not a good strategy for reproductive females. Instead they seek out day roosts that will provide an external source of heat that will assist in maintaining body temperature. The hot springs of Gandl K'in provide just such roosting conditions.

Sixteen species of bats are known to occur within British Columbia, 9 of which occur along the north coast mainland. Only 4 species have been found on Haida Gwaii (Queen Charlotte Islands), perhaps a reflection of the islands' remote nature. Silver-haired bat (*Lasionycteris noctivagans)*, little brown myotis (*Myotis lucifugus*), and California bats (*M. californicus*) are relatively common, but the fourth, Keen's long-eared myotis (*M. keenii*) is rare.

Keen's myotis has one of the most restricted distributions of any bat in North America, a distribution that may be restricted to mature, temperate coastal rain forests of the Pacific Northwest. First collected near Massett on Haida Gwaii in 1895, it has subsequently been found only rarely along the coast of British Columbia, Washington State, and southeast Alaska. Between 1895 and 1960 only 10 specimens were collected from various locations along the coast of British Columbia (D. Nagorsen, Royal B.C. Museum, Feb 1998, pers. comm.). During the early 1960s a number of Keen's myotis, including juveniles, were collected at Gandl K'in (Hotsprings Island) by Foster (1965). Extensive surveys conducted throughout British Columbia during 1991 documented Keen's myotis at only 1 location, Gandl K'in (Firman et al. 1993). Because of the rarity of this species, its restricted distribution, and its uncertain population status, this species is on the British Columbia Red List of species of concern, and is listed as vulnerable by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

STUDY AREA

Gandl K'in (Haida for "healing waters") is a 15-ha island located about 15 km east of Moresby Island on Haida Gwaii, which is approximately 100 km off the northwest coast of British Columbia. It lies within the Coastal Western Hemlock wet hypermaritime biogeoclimatic subzone.

However, because of its location in the rain shadow of the San Christoval Mountains and its southerly aspect, it is relatively warmer and drier than adjacent islands. Two thermal meadows occur where the heat of the springs appears to be preventing trees and shrubs from encroaching. Numerous small warm water seeps occur within and around the edge of these meadows. Water temperatures of up to 77°C have been recorded at some of these seeps (Sadlier-Brown 1994). Bats take advantage of the moist, heated crevices and cavities, including some that are in the upper intertidal zone, to roost and raise young.

Archaeological evidence has shown that the site has been used traditionally for at least the last 2,000 years (D. Fedje, Parks Canada, pers comm., 1998). Historically, the site has been a popular destination; as a result, many facilities have been developed ad hoc. It continues to be one of the most popular locations within Gwaii Haanas, with up to 3,000 visitors stopping each summer to enjoy the hot pools.

RESULTS

Roost Descriptions

Bats were found to roost in 3 areas spread over about 100 m around the hot springs. Roosts were located primarily by observing emergence and by tracking radio-tagged bats. Most bats roosted under large boulders in a boulder field located about 40 m down the beach from the bath house. Numerous passages and galleries occur under these boulders, and the hot water that seeps through them creates warm, moist areas to roost. Water temperatures up to 50°C and air temperatures up to 33°C were recorded in some of these passages and galleries. Most roosts identified here were above the extreme high tides but one roost, used by a radio-tagged little brown bat, was later flooded by extreme tides.

Bats also regularly roosted in a crevice in the cliff further down the beach. This crevice is up to 75 cm deep and is thermally heated by seepage from the bathing pool directly above it. Temperature gradients generally occur within the crevice, with temperatures reaching 32–34°C in the innermost reaches of the crevice, and grading down to the low 20°C near the outer edge. Ambient temperature and cloud cover also influenced temperatures within the crevice. On particularly warm, sunny days, temperatures near the outer edge were similar to or higher than those of the central regions (Fig. 1). Bats using this roost could thus move around to find the most desirable temperature. On 5 occasions the temperature where little brown bats were seen in this crevice was determined using a thermometer with a remote sensor. These temperatures ranged between 27 and 33°C. Bats were occasionally seen in other adjacent cracks in this cliff (K. Hans, Haida Gwaii Watchmen Program, pers comm., July 1998), although most other cracks are not thermally heated.

Bats were also found to roost in thermally heated rocks directly above the main bathing pool. This roost was accessed through a 1 m hole in the salal (*Gaultheria shallon*) cover and consisted of a 3–5 cm wide crevice. At least 18 bats were seen to emerge from this roost on 23 May 1998.

Colony Size

The first estimate of the size of this colony was determined in 1991 by Firman et al. (1993). Using mist netting and emergence counts during late July–early August, they estimated that at least 70 Keen's myotis and at least as many little brown bats were using these roosts. These numbers include volant juveniles and nonreproductive males and females, as well as breeding females.

Roost emergence counts were conducted regularly during 1998 to determine use patterns and numbers of bats using the roosts. Because the bats roost in several locations up to 100 m apart around the hot springs, it was necessary to first determine roost sites and emergence patterns using a number of observers. Once the preferred flight corridor was determined, a location was chosen where emerging bats could be seen against the sky and a single observer could most effectively conduct emergence counts.

Formal counts were scheduled to coincide with periods of moderate and extreme tides to determine tidal influence on the use of roosts. They were usually carried out on 2 consecutive nights to determine nightly variation in use. A bat detector was used during all counts to supplement observations.

A total of 23 formal counts were conducted over the summer (Fig. 2A). Early in the season relatively few bats were using the thermally heated roosts. A dead bat was found in March (I. Wilson, Haida Gwaii Watchmen Program, pers comm., June 1998), suggesting some early season use, but no bats were seen during preliminary study surveys on 12 and 13 May (this study). Systematic counts began on 23 May with 21 bats being counted. Numbers increased dramatically during late May–early June with the highest count of the summer (110) being made on 29 May ($\bar{\chi}$ = 42, range = 3–110, N = 7). During late June–early August (the period of late pregnancy and parturition), counts were similar, averaging 46 bats per count (range 15–87, N = 10). Numbers decreased dramatically during mid- to late August, with a mean of only 11 being counted (range 1–35, N = 4). A count on 24 September revealed that 1 bat was still using the Gandl K'in roost.

The high number of 110 bats is probably the best estimate of the number of females of both species using this maternity colony, as all bats captured at Gandl K'in during May–June were adult females. This figure is not directly comparable with the estimate by Firman et al. (1993) because the counts were taken at different times of the year; however, it does confirm the relatively small but stable size of the colony.

Why Such Variation in Counts?

Weather significantly influences bat activity, and was a factor in the variable use of the Gandl K'in roosts. On 7 June, for example, weather conditions were optimal and 61 bats emerged. However, on the next evening, the sky was overcast, and rain threatened; only 28 bats emerged. Around 2345 on 8 June, a steady rain began to fall and continued until 1200 the next day. This rain seems to have prevented bats from returning to the roosts as only 3 bats emerged the following night. Similarly, on 6 August a misty rain persisted throughout the evening, and only 1 bat was seen to emerge.

Early investigations of the Gandl K'in colony indicated that the roosts were intertidal, and were thus periodically abandoned during extreme tides (Firman et al. 1993). One intertidal roost was identified during this study, but most were supratidal. Emergence counts were compared with the daytime high tide level (Fig. 2B), and with the state of the tide at approximately the time that bats would be returning to the roosts (Fig. 2C). No correlations could be identified; in fact, the highest count of the summer occurred when the lower roosts were being flooded daily.

Seasonal use of the roosts accounts for much of the variation in count numbers. Few bats used the roosts early in the season, and then only irregularly. Many bats arrived in late May, but not all remained there. Numbers using the roosts remained high during June and early July (period of pregnancy and early post-parturition), and increased during mid-July, probably a reflection of onset of volancy by young and the arrival of nonreproductive females and males into the area. The first male, juvenile, and nonreproductive female were captured on 19, 20, and 31 July, respectively. Numbers using the roosts began to decrease by late July, as post-lactating females and volant young abandoned the roosts for more favourable locations. By late August and September, only a few bats were still using the roosts.

Incomplete coverage during counts may account for some of the variability. Because the roosts were spread over about 100 m, all exits could not always be monitored. A protocol

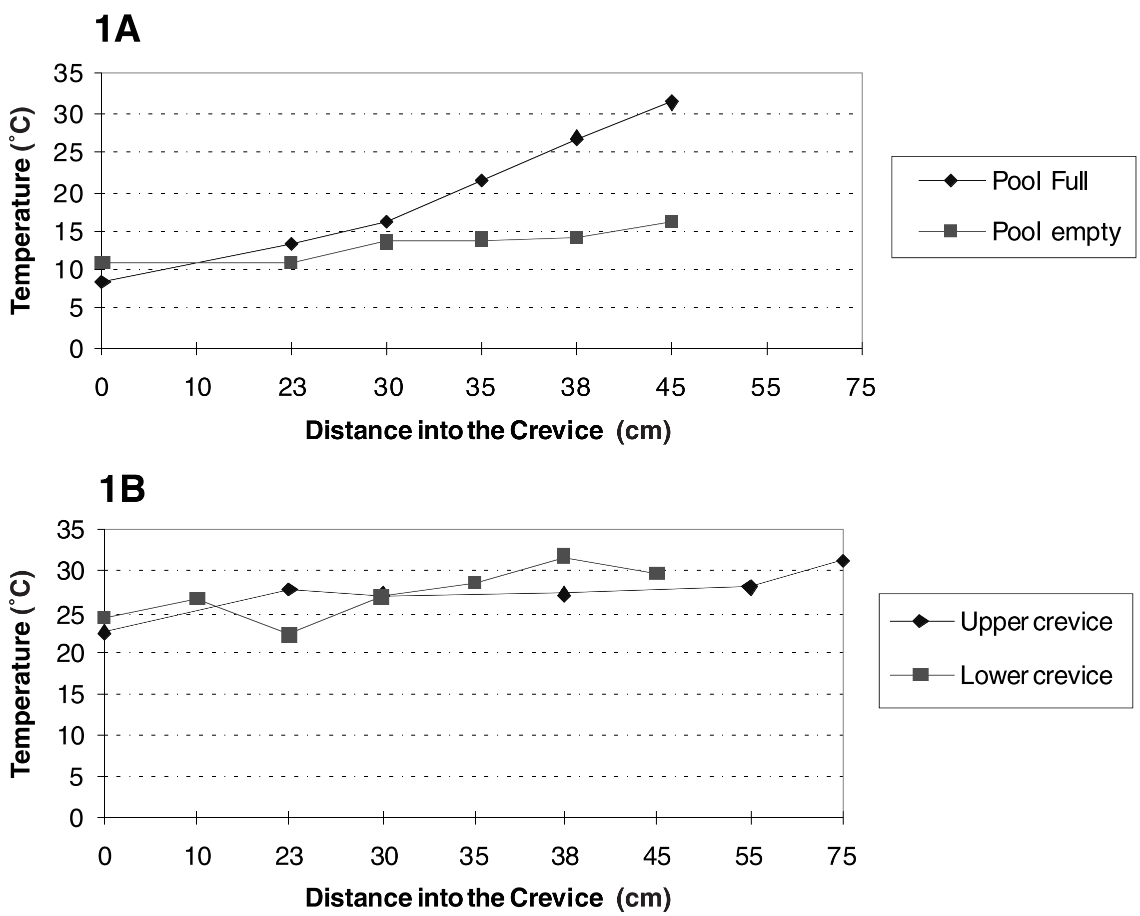

Figure 1. Temperature gradients observed in a crevice used by bats for roosting, Gandl K'in, Haida Gwaii. 1A demonstrates the importance of warm water seepage on crevice temperature, 22 Feb 1998; while 1B demonstrates the importance of radiant heat on crevice temperatures 1 July 1998, when ambient temperature was 22–24°C.

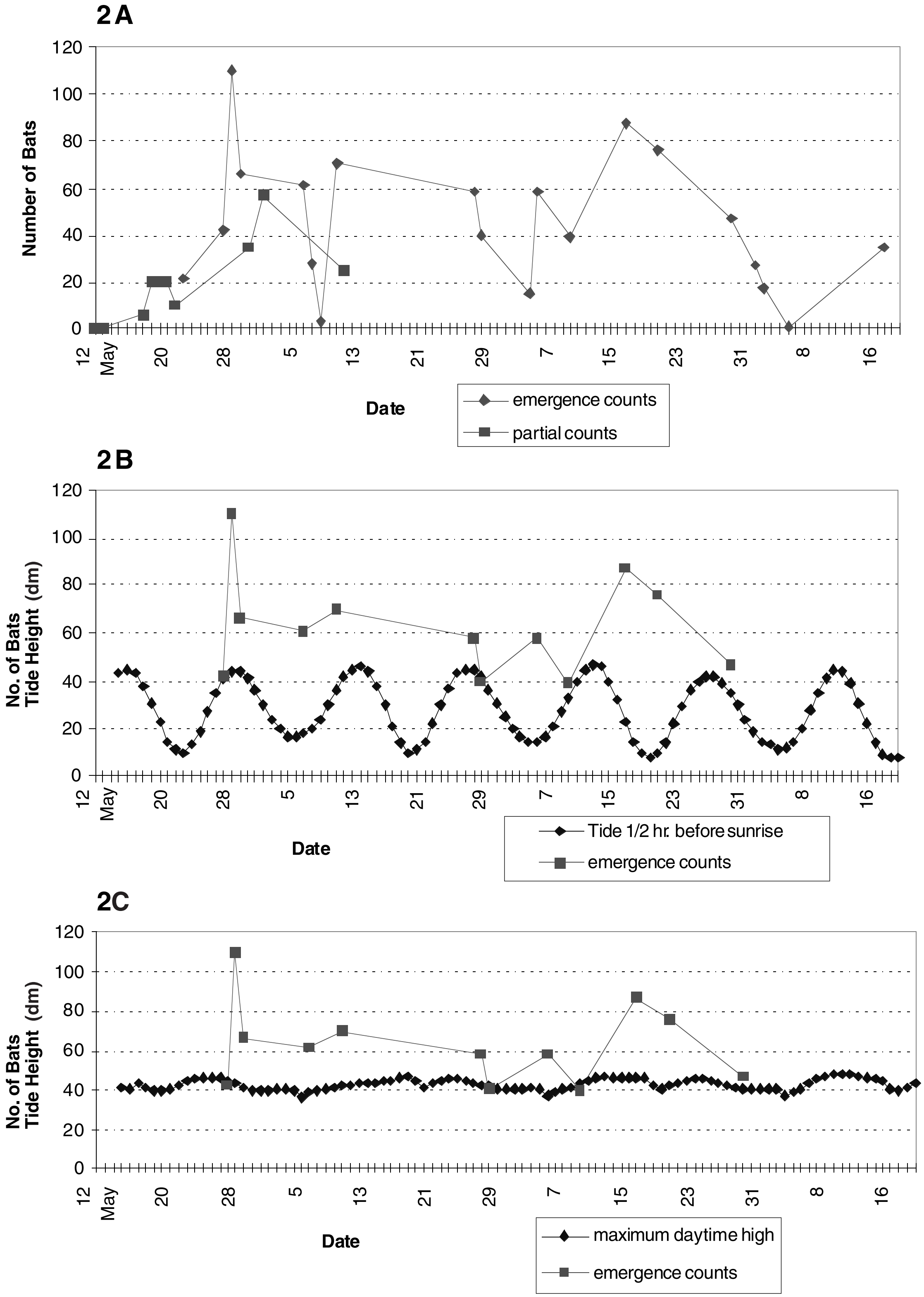

Figure 2. Summary of emergence counts taken at Gandl K'in, Haida Gwaii during 1998 and their relation to tide height. 1A: Emergent vs. partial counts. 1B: Emergent counts vs. tide height 1/2 h before sunrise. 1C: Emergent counts vs. maximum daytime tide height.

Table 1. Summary of classified counts of *M. keenii* and *M. lucifugus* at Gandl K'in 1998.

Date	Total no. counted	No. of *M.keenii*	No. of *M.lucifugus*	Percent *M.keenii*
18 May	6	3	3	50.0
28 May	42	3	3	50.0
29 May	110	18	17	51.4
2 June	57	23	23	50.0
3 June	42	13	6	68.4
7 June	61	11	16	40.7
8 June	28	13	9	59.1
28 June	58	11	9	55.0
5 July	15	3	4	42.9
6 July	58	21	5	80.8
17 July	87	17	26	39.5
21 July	76	2	3	40.0
				$\bar{\chi}$ = 52.3

was established to monitor the preferred emergence route. Some counts were conducted using multiple observers and/or automated bat detectors to monitor all exits from the roosts. These counts confirmed that not all bats were using the flight corridor identified, but the small numbers of detections (up to 7) could not explain all of the variation observed.

What Species Use Gandl K'in?

Although 4 species have been recorded on Haida Gwaii, only Keen's myotis and little brown bats have been captured on Gandl K'in (Firman et al. 1993, this study). In 1991, Firman et al. captured 77 bats, 29 (37.7%) of which were Keen's myotis. During the first year of this study, 67 bats were captured on Gandl K'in, 24 (35.5%) of which were Keen's myotis. These ratios must be used cautiously, however, as one species may be more susceptible to capture than the other.

A second method for establishing a ratio of the 2 species present was developed based on differences in the strength of their echolocation calls. The more intense call of little brown bats was detectable at a range of about 10 m while the lower intensity call of Keen's myotis was only detectable at about 3 m. For bats that could be seen as they approached, the distance of first detection could be determined. Keen's myotis also tend to fly erratically and very low and close to vegetation, while little brown bats usually fly in a straight line 3–5 m above the vegetation.

A total of 262 sightings were classified to species, 52.3% of which were Keen's myotis (Table 1), a ratio similar to that proposed by Firman et al. (1993). Using this figure, it is estimated that at least 58 female Keen's myotis used the Gandl K'in roosts in 1998. The consistency in ratios between 1991 and 1998 suggests that these 2 species are coexisting with little or no competition for roost sites.

How Do These Two Species Coexist?

Whenever 2 similar species are found together, their ability to coexist depends on their level of competition for resources. If there is a high degree of competition, the superior competitor should eventually outcompete, and thus displace, the inferior one. The 2 species in this study are of the same genus, have similar roosting requirements, and are both insectivores. The data show that they have coexisted in almost equal numbers at Gandl K'in for the last 8 years, and from all appearances are not competing for roosts.

Two species with similar diets might be expected to forage in a similar manner and thus compete for food. As part of this study, feces samples were collected from all captured bats for diet analysis. Table 2 provides a preliminary summary of arthropod remains found in scats of Keen's myotis (N = 13) and little brown bats (N = 11). Both species appear to be feeding largely on Lepidoptera, although this may be misleading, as in all cases only a small number of scales (usually less than 15) were found. The remainder of their diets differs. The relatively high proportion of arachnids in the diet of Keen's myotis suggests that these individuals may be deriving a considerable part of their diet by gleaning spiders from vegetation. The high proportion of dipterans and neuropterans in the diet of little brown bats is consistent with the identification of this species as an aerial insectivore. These results, while preliminary, suggest that diets only partially overlap, and different foraging behaviour may be minimizing competition between the two.

MANAGEMENT IMPLICATIONS

Given the popularity of the site and the number of visitors each year, the potential for disturbance exists. On warm, sunny afternoons bats can often be seen in the crevice near the cliff pool as they edge their way out to cool off. Visitors occasionally peer in to see the bats, which causes them to scurry deeper into the crevice. This disturbance probably causes heat stress to the bats, although the significance of this is unknown.

Table 2. Summary of arthropods found in scats collected from bats captured during 1998. All figures are numbers of occurrences expressed as a percent of total number of occurrences for each species.

Species	Lepidoptera	Diptera	Neuroptera	Coleoptera	Hemiptera	Arachnida
M. keenii	38.5	11.5	11.5	0	3.8	34.6
M. lucifugus	36.4	27.3	27.3	4.5	0	4.5

Human activity during the evening may delay emergence. The emergence generally began about one-half hour after observed sunset, or after 2200 during May, June, and July. Current policy is that no visitors are allowed to camp on Gandl K'in, and they must leave the island by 2230, so disturbance is generally minimized.

An important part of the study was the review of redevelopment plans to identify activities that may disturb this maternity colony. A major health concern for humans is that the flow of water through the pools is insufficient to allow rapid turn over. To address this concern, it was proposed to seal the pools to prevent seepage. An investigation of the cliff pool revealed that the flow of hot water through the crevice in which the bats roost depends on the pool being full. Sealing the pool would thus alter the thermal regime of this crevice and possibly eliminate it as a roost. Plans have been altered to allow the water to continue flowing through this crevice.

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