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REDISCOVERY OF SHORT-TAILED BATS (*MYSTACINA* SP.) IN FIORDLAND, NEW ZEALAND: PRELIMINARY OBSERVATIONS OF TAXONOMY, ECHOLOCATION CALLS, POPULATION SIZE, HOME RANGE, AND HABITAT USE

Summary: Short-tailed bats (*Mystacina* sp.) were rediscovered in *Nothofagus* dominant rainforest in the Eglinton Valley in February 1997, representing the first records of these bats in Fiordland since 1871. Breeding females, adult males and juveniles were captured. This paper presents preliminary observations of taxonomy, echolocation calls, population size, habitat use, activity patterns, home range size, movements, roosting, and singing behaviour. Compared to lesser short-tailed bats (*M. tuberculata*) on Codfish and Little Barrier Islands, the Fiordland bats were heavier, had larger wings and smaller ears, and were sexually dimorphic. The *Mystacina* echolocation calls were of low intensity (quiet), making them difficult to detect. Call durations in free-flying bats were only 1.0-2.9 ms long. In a comparative trial the majority of calls that were detected at 25 kHz using the Batbox III bat detector were not recorded at 40 kHz, indicating that there was little overlap with the calls of long-tailed bats (*Chalinolobus tuberculatus*). In February, roosting groups numbered from 107 to 279 individuals and the bats ranged over 130 km² of the valley. Bats began emerging c. 20 minutes after sunset and were active at the roost sites throughout the night. Radio-tagged bats were active for an average of 372 minutes at a time. All roosts were in large diameter (67-146 cm dbh) red beech (*N. fusca*) trees.

Keywords: Short-tailed bats; *Mystacina*; New Zealand; temperate rainforest; taxonomy; echolocation; population size; habitat use; activity patterns; behaviour.

Introduction

Short-tailed bats (*Mystacina* spp.: Mystacinidae) belong to an endemic New Zealand family. They are classed as Vulnerable (= threatened, Bell, 1986) and information on their ecology is currently being sought in an effort to better understand the threats that the species may be facing (Molloy, 1995).

On 12 February 1997, short-tailed bats (*Mystacina* sp.) were discovered in the Eglinton Valley, Fiordland National Park, after a juvenile male bat was caught in a harp trap in mountain beech (*Nothofagus solandri* var. *cliffortioides* Hook. f.) forest at McKay Creek (44°58'S, 168°01'E). This bat was fitted with a transmitter before release and was radio-tracked to a number of communal short-tailed bat roosts in the upper Eglinton Valley. The only previous sighting of short-tailed bats in Fiordland was in 1871 at Milford Sound when "a few" short-tailed bats were found in the furled sails of the ship HMS *Clio* (Daniel and Williams, 1984).

This paper presents observations from February 1997 describing taxonomy, echolocation calls, population size, habitat use, home range size,

movements, roosting and singing behaviour, and outlines the significance of the find.

Study Area

The Eglinton Valley (Fig. 1) is glaciated with steep sides and a flat floor 0.5-2 km wide, with an active shingle riverbed on the valley floor at c. 250-550 m above sea level. Tussock grasslands dominated by *Festuca rubra* L. and *Anthoxanthum odoratum* L. and small patches of *Discaria toumatou* Raoul and *Corokia cotoneaster* Raoul shrubland cover much of the valley floor. Forest on the valley floor is dominated by red and silver beech (*Nothofagus fusca* Hook. f., *N. menziesii* Hook. f.). Forest composition varies, ranging from pure stands of silver beech c. 20 m tall along the forest margin to tall stands of red beech up to c. 60 m tall further into the forest. Mountain beech occasionally contributes to the canopy at low altitudes, and becomes more common with increased altitude. Under the canopy the forest is generally open with few understorey plants and a ground cover of mosses. The most

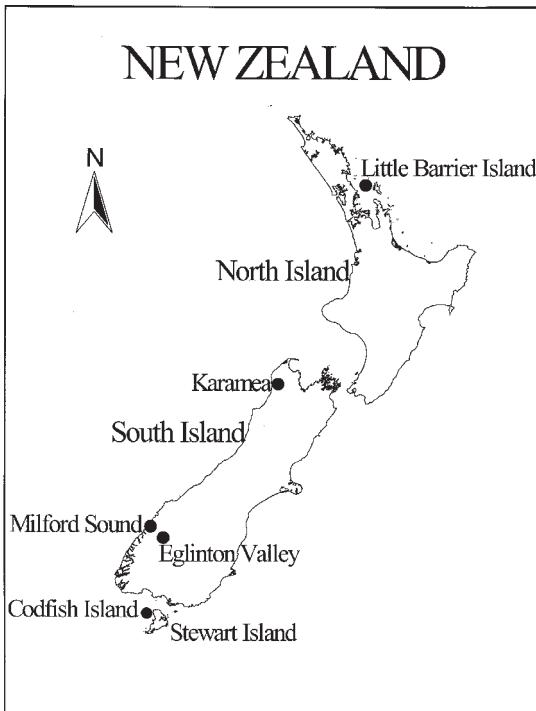


Figure 1: Location of the Eglinton Valley, Southland, New Zealand, and place names mentioned in the text.

common understorey plants are mountain toatoa (*Phyllocladus asplenifolius* var. *alpinus* (Labill.) Hook f.), broadleaf (*Griselinia littoralis* Raoul) and *Coprosma* spp. Mean annual rainfall averages 2300 mm at Knobs Flat, but increases markedly in a gradient to >5000 mm further up the valley (where most bat foraging occurred). Mean maximum daily temperatures around the roosting area are warmest in late summer (February, 14.7°C) and coldest in mid-winter (July, 3.3°C) (Works Civil Construction, Te Anau, unpubl. data).

Methods

Capture and measurement of bats

Free-flying bats were caught using forest-mist-net rigs (Dilks, Elliott and O'Donnell, 1995) within 200 m of roost trees in the forest interior. Mist-netting occurred on eight nights in February for 1-2 hours after dusk and 1-2 hours before dawn. All bats were weighed and measured using standard techniques (Daniel and Baker, 1986).

Recording echolocation calls

Echolocation calls were recorded on the nights of 13, 17 and 20 February 1997, using an ANABAT II detector (Titley Electronics, Ballina, Australia) interfaced directly to a laptop computer. Six files of calls resulted, two from captured bats which were recorded as they were released just outside the edge of the forest, and four more from bats in the vicinity of a roost (roost found by tracking bats fitted with transmitters, see later). The calls were examined using ANALOOK version 3.5.

A trial was undertaken to determine the sensitivity of the Batbox III (Stag Electronics, Sussex, UK) bat detector, the most common detector in use in New Zealand. Two Batbox III detectors were used together c. 100 m from a short-tailed bat roost. One was set at 25 kHz and one at 40 kHz (the latter being the frequency most commonly used to survey long-tailed bats (*Chalinolobus tuberculatus* Gray) in New Zealand). An observer recorded the frequency of occurrence and times at which bat calls were detected at each frequency.

Radio-tracking bats

Wild-caught bats were fitted with 0.7 g transmitters (BD2A, Holohil Systems, Canada). Transmitter weight represented 4.4% of the average bat weight. Transmitters were attached between the scapulae using a latex based contact adhesive glue (F2®, Ados Chemical Co, New Zealand) after the fur had been partially trimmed. An ATS scanner-receiver (Advanced Telemetry Systems, Minnesota, USA) with vehicle-mounted 160 mHz omnidirectional aerial (Tait Electronics, Christchurch, New Zealand) and rotating 3-element Yagi aerials (Sirtrack, Havelock North, New Zealand) were used to track and obtain radio-fixes on bats. In addition, whenever bats were located, hand-held TR4 receivers (Telonics, Arizona, USA) and hand-held, 3-element Yagi aerials were used to check fixes, and to find roosting trees.

Bats were followed from the night after the transmitter was attached until the transmitter fell off. Bats were monitored either continuously for the whole night (n=5 nights) from the time of emergence from their day roosts until their return to their roost for the next day, or continuously for the first or second half of the night, so that a balanced sample was obtained for each bat at all times during the night. Fixes were taken every 15 min and whenever the bats moved their location. Bats were very mobile and could cross their range in < 15 min, thus a 15 min independence interval was considered appropriate. Fixes were mainly obtained by close

approaches, although some triangulation was used. Direction of signal and signal strength were recorded. The approximate location of the bat was plotted on New Zealand Map Series 260 topographical maps D41 and D42. Triangulation was used only when bats appeared not to be moving rapidly and we had a high degree of confidence in interpreting the range and direction of the signal. Each location was recorded as a six figure grid reference (± 100 m). Location of the bat was estimated using a combination of signal strength, knowledge of the terrain and observer experience.

Fixes were calibrated with fixed transmitters placed high in the forest canopy, with radio-tagged bats in known roost sites, and with free flying bats at known locations. When signal strength was matched against terrain, there was a high degree of confidence in fix estimates (C. O'Donnell *unpubl. data*). For example, a bat, when 50 m high, and with a transmitter aerial 160 mm long, could not be heard further than 1200-1300 m away; where a river terrace obstructed the signal, the range of the signal was limited to 200-400 m; conversely, when radio signals were very loud, the bats were within 150 m of the receiver. Observers were conservative in their estimations of distance. If the observer felt there was poor resolution with a fix (signal very faint, direction uncertain), then the fix was omitted from the analysis.

Analysis of radio tracking information

Home range analyses were undertaken using the Ranges V analysis system (Kenward and Hodder, 1996). Fully revealed home ranges were expressed as Minimum Convex Polygons to facilitate comparison with other studies (Harris *et al.*, 1990). Core areas were determined by plotting fixes against range size on an utilisation plot (Ford and Krumme, 1979), and cluster analysis (Kenward, 1987) was used to describe core areas. Cluster analysis is ideal for focusing on areas of high use in multi-core ranges and appropriate in this study because range distributions were highly skewed; movements were constricted by the narrow valley shape.

Estimating population size

Counts of bats as they emerged from roosts were recorded using infrared video. A wide-angle, buttonhole lens video camera (K.R. & J.A. Eccles, Upper Moutere, New Zealand) surrounded by 900 nm infra-red light emitting diodes was mounted on a bracket outside roost cavity entrances. Numbers of bats and traffic rates into and out of the roost cavities were recorded using a Panasonic AG-1070DC time-lapse video recorder (Matsushita Electric, Japan).

The tapes were reviewed at slow speed to obtain accurate counts.

Measuring roost cavity characteristics

Trees containing bat roosts were located during the day by radio-tracking. Roost cavities were identified by observers on the ground either listening for the vocalisations of the bats, looking for accumulations of guano at the cavity entrance or by climbing the tree using a single rope technique (O'Donnell, Dilks and Elliott, 1996) and using the TR4 receiver at close range. The dimensions of roost cavities were measured once the cavities were vacated. We used a torch bulb connected to a flexible piece of wire and a telescopic dentist's mirror to see inside the cavities. Dimensions were measured with a flexible metal tape-measure.

Results

Taxonomy and morphology

Forty-four bats were caught: 27 adult females, 4 adult males and 13 juveniles (young of the year). At least 33% of the females had bred during the summer (Table 1).

The Eglinton Valley bats were clearly short-tailed bats (*Mystacina* sp.), resembling lesser short-tailed bats *M. tuberculata* Gray. However, their measurements differed from published measurements of *M. tuberculata* (e.g., Daniel, 1990; Arkins, 1996). They were large in comparison with *M. tuberculata* on Codfish (subsp. *tuberculata*) and Little Barrier (subsp. *auporica*) Islands (Table 1), but smaller than the few *M. robusta* Dwyer (considered to be extinct) which have been measured (Worthy, Daniel and Hill, 1996). Forearm length for *M. robusta* has been cited as 45.3-47.5 mm (Worthy *et al.*, 1996) whereas the largest bats from the Eglinton Valley had forearms of 45.5 mm.

Compared to adult female short-tailed bats on nearby Codfish Island, females (parous and nulliparous combined) in the Eglinton Valley were significantly heavier ($t = 2.66$, d.f. = 40, $P = 0.01$), and had longer forearms ($t = 3.49$, d.f. = 40, $P = 0.001$). They were about one third bigger than *M. tuberculata* from Little Barrier Island (Table 1). However, ear length appears to be short compared with *M. tuberculata* (Table 1 compared with Daniel, 1990). The sample size for comparison of males was too small.

The sizes of the Eglinton Valley bats varied significantly between age and sex classes (Table 1). There was significant sexual dimorphism, with parous

Table 1: Morphology of short-tailed bats from the Eglinton Valley, Fiordland, and a comparison with Little Barrier Island and Codfish Island short-tailed bats. (Means \pm 1 S.D. shown. Range shown in brackets. Statistical tests are One-way Analyses of Variance).

	Body mass at capture (g)	Forearm length (mm)	Ear length (mm)	Wing depth at 5th digit (mm)
Eglinton Valley				
Parous Female	19.0 \pm 1.54 (16.9-22.0) n=9	44.3 \pm 1.27 (41.3-45.5) n=9	16.9 \pm 1.06 (15.2-18.0) n=5	65.1 \pm 1.35 (63-67) n=7
Nulliparous Female	15.6 \pm 1.18 (14.0-18.3) n=18	43.1 \pm 0.88 (41.2-44.6) n=18	17.2 \pm 0.52 (16.8-18.0) n=6	64.1 \pm 1.46 (62-67) n=16
Juvenile Female	14.8 \pm 0.65 (14.0-15.5) n=6	42.9 \pm 0.33 (42.5-43.4) n=6	17.3 \pm 0.66 (16.5-18.0) n=4	63.0 \pm 2.44 (59-66) n=6
Adult Male	14.7 \pm 0.90 (13.6-15.8) n=4	43.0 \pm 0.39 (42.6-43.5) n=4	16.7 \pm 0.50 (16.3-17.0) n=2	64.5 \pm 1.91 (62-66) n=4
Juvenile Male	14.3 \pm 0.92 (13.2-16.0) n=7	41.8 \pm 0.89 (40.7-43.7) n=8	16.7 \pm 0.79 (15.1-17.3) n=8	62.5 \pm 1.51 (61-66) n=8
ANOVA F =	22.16 $P < 0.0001$	7.94 $P < 0.0001$	Not tested (sample size small)	2.99 $P = 0.03$
Codfish Island				
Adult Female	15.2 \pm 0.96	42.4 \pm 0.79	(n=14, J. Sedgely, unpublished data)	
Adult Male	15.0 \pm 1.09	41.9 \pm 0.69	(n=31)	
Little Barrier Island				
Adult Female	12.6 \pm 1.67	40.9 \pm 0.81	(n=387, Arkins, 1996)	
Adult Male	11.4 \pm 1.06	40.8 \pm 0.96		
Juveniles	10.2 \pm 0.69	40.7 \pm 0.87		

(breeding) females being significantly heavier and with longer forearms than other classes (Tukey's pairwise comparison of means, $P < 0.05$). Juveniles tended to be smallest (Table 1). This differs from the *M. tuberculata* populations on Little Barrier Island (Arkins, 1996) and Codfish Island (J. Sedgely, *unpubl. data*) which show little variation in size between adult males, females and juveniles.

Echolocation calls

Sensitivity of the Batbox III detector

The majority of calls which were detected at 25 kHz using the Batbox III detector were not recorded at 40 kHz. Of 100 calls which were recorded in the forest at 25 kHz, only 5% were detected at 40 kHz.

Call structure

Two types of calls were recorded, though there is some gradation between them. All calls consisted of a steep downsweep with a fundamental frequency

ending at a mean of 21.0 kHz (range 19.5-22.7, n=51). High clutter calls, recorded shortly after release or departure from the roost, were of short duration, 1.24 ms (1.0-1.6, n=30); the fundamental had an initial frequency of 32.5 kHz (27-35, n=30) and high minimum slope, 248 octaves per second (OPS) (159-316, n=12). Such calls were typically least steep at the start of the call, and steepest at the end. Twenty-eight calls were initially detected on the second harmonic but swapped to the third harmonic about half way through. One was detected only on the second harmonic and another only on the third. A typical example might be detected initially at 65 kHz, sweep down to 60 kHz, jump up to 80 kHz and finally sweep down to 62 kHz.

Low clutter calls were recorded in the forest close to the roost. They were of longer duration, 1.9 ms (1.5-2.9, n=14); lower initial frequency, 26.8 kHz (24-28.5, n=8) and lower minimum slope, 110 OPS (60-167, n=10). These calls were least steep in the middle of the call, with a steeper initial downsweep

and a tendency to droop at the end. Of 14 such calls, ten were detected throughout on the second harmonic, three were detected throughout on the fundamental, and one was detected initially on the fundamental and later on the second harmonic. A typical example would be detected as sweeping down from 54 kHz to 42 kHz.

Home range and movements

Four short-tailed bats (2 post-lactating females, 1 nulliparous female, 1 juvenile male) were tracked for 2-12 days each (24 radiotracking days, 269 fixes) between 13 February and 8 March 1997. The short-tailed bats ranged over 130 km², spanning a 26.5 km

length of the Eglinton Valley, from Lake Gunn, Cascade Creek and Mistake Creek in the north, to Walker Creek in the south (Fig. 2). Individual ranges varied from 3.2 to 69.3 km² (3,150-69,332 ha), with core areas (80% of fixes) concentrated in much smaller areas of forest (Table 2). However, sufficient fixes were recorded for only one bat ("Sherlock", a juvenile male) to fully reveal the home range area. Signals from the remaining bats were lost for part of the night when they entered inaccessible valleys (Mistake and Cascade Creeks).

"Sherlock" had a pattern of activity which was similar on most nights (Fig. 3). On ten of 12 nights he flew south down the valley from a roosting area in the central valley to near Walker Creek. His nightly range averaged 16.0 km² (*S.D.*=7.8, Range 10.4-25.0 km²), traversing a 14±2.3 km length of the valley. On two nights he flew 10-14 km to the north of the roosting area. Cluster analysis revealed that

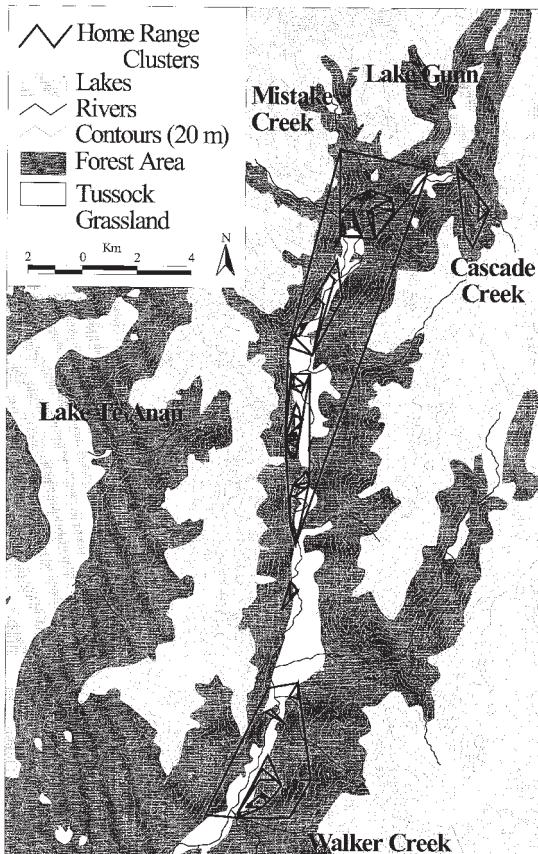


Figure 2: Collective home range as revealed by cluster analysis of four short-tailed bats radio-tracked in the Eglinton Valley, February 1997. The outer polygon contains 100% of foraging fixes; successive polygons represent increasing intensity of bat use. (Base map published under Department of Survey and Land Information Licence 1991/60/12).

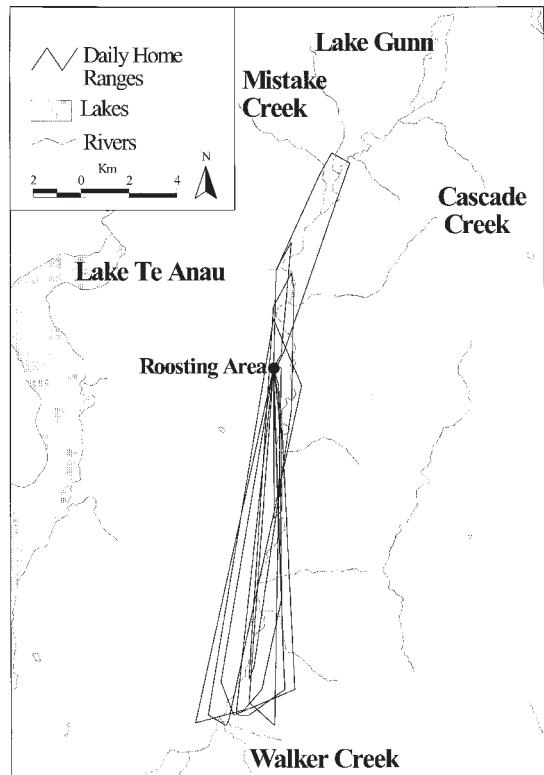


Figure 3: Daily home ranges (100% Minimum Convex Polygons) emphasising similar, overlapping ranges for a juvenile male short-tailed bat in the Eglinton Valley, February 1997. (Base map published under Department of Survey and Land Information Licence 1991/60/12).

Table 2: Home range characteristics of short-tailed bats in the Eglinton Valley, February 1997 (*Fully revealed Minimum Convex Polygon (MCP) home range).

Bat no.	Age/sex	No. days	No. fixes	100% MCP (km ²)	Range width (km)	80% Core area (km ²)
1	Juvenile Male	12	195	69.3*	23.6*	4.64
2	Adult Female	7	30	21.3	11.8	-
3	Adult Female	2	12	3.2	6.5	-
4	Adult Female	3	32	38.5	12.1	-
Total		24	269	130.0	26.5	-

there were four separate areas within the range in which 80% of fixes were collected. These were probably foraging areas and they covered a much smaller area of the range (4.6 km²).

Habitat use

Radio-tracked short-tailed bats ranged over the open grasslands on the valley floor when commuting to foraging areas, sometimes crossing open areas up to 2 km wide. The majority of activity appeared to occur within the *Nothofagus* rainforest dominated by red and silver beech which covered gentle glacial terraces and outwash fans on the lower hill-slopes. A feature of many areas where short-tailed bats were tracked to was a dense ground cover of ferns dominated by *Polystichum vestitum* Forst. f. and *Blechnum discolor* Forst. f., some of which were up to 1.5-1.8 m tall.

Roosting behaviour

Six communal roosts (cavities occupied by >1 bat) and five solitary roosts (cavities occupied by a single

bat) were located in February (Table 3). Three communal roosts were occupied for 9, 8 and 5 days respectively. Bats moved between the roosts, and not all roosts were occupied every night. Radio-tagged bats used solitary roosts on 18.5% of radio-tracking days. The solitary roosts were occupied for one night each, although one was used on two occasions.

All roosts were in the trunks of large diameter (67-146 cm diameter at breast height (dbh)) red beech trees and roost cavities ranged in height from 1-18 m above the ground (Table 3). Communally roosting bats occupied large cavities (Table 3). They were all within c.1 km of each other and were relatively close to the forest edge (220-530 m).

Population size

We monitored the emergence of bats from one communal roost for seven nights. Numbers of bats emerging at sunset averaged 216 (*S.D.*=59.4, Range=107-279). However, on some nights we knew that at least three roosts were active at the same time. Therefore, the estimate of 279 bats is an absolute minimum of the total population size.

Table 3: Characteristics of short-tailed bat roosts in the Eglinton Valley, February 1997. All roost cavities were in the trunks of red beech trees.

	Roost 1	Roost 2	Roost 3	Roost 4	Roost 5	Roost 6	Roost 7	Roost 8
Communal/Solitary	C	C & S*	C & S	S	C	S	C	C
Cavity type	Split	Knot	Split	Knot	Basal hollow	Split	Knot	Split
Aspect	SW	SW	SW	NW	NW	SE	SE	SW
Stem diameter (dbh cm)	67	72	91	146	135	81	115	91
Stem diameter at roost (cm)	62	63	83	86	135	80	110	100
Tree height (m)	34	35	39	31	35	34	30	39
Roost height (m)	8.7	3.5	9.0	18.0	1.0	8.0	11.0	12.5
Cavity entrance (height x width, mm)	8700x30	(a) 200x50 (b) 90x50	250x35	150x55	2500x120	?	?	550x55
Inside cross section (mm)	100x170	300x200	350x300	180x50	320x480	?	?	180x130
Internal cavity height (mm)	1300	480	2500	200	>2000	?	?	1200
Internal cavity depth (mm)	0	950	0	80	0	?	?	700
Distance from forest edge (m)	260	260	220	360	350	300	530	220

* Occupied on two occasions by solitary bats after the communal roost had moved.

Activity patterns and time budgets

In February sunset was at about 2050 h and the short-tailed bats first began emerging from their communal roosts, on average, 21 min after sunset ($S.D.=4.7$, $n=7$). Time of first emergence ranged from 2101 to 2113 h. The emergence period lasted on average 42 min ($S.D.=11.2$, $\text{Range}=30\text{-}53$ min; Fig. 4) and was followed by a spell of 15-30 min of inactivity at the roost hole. Mean exit rate was 5.8 bats min^{-1} ($S.D.=0.96$, maximum 14 bats min^{-1} , $n=7$). Radio-tagged bats left their roosts within the normal emergence period, between 2101 and 2138 h ($n=12$ radio-tracking nights).

There was some bat activity at all communal roosts throughout the night in temperatures ranging from 6.5-13.9°C. There were peaks in traffic rates (bats entering and leaving the roost) 3-4 h after sunset and again in the two hours before dawn (Fig. 5). Activity was lowest at the roost sites in the middle of the night. The last bats to return to the roosts did so between 0634 and 0642 hrs, on average 35 min ($S.D.=3.3$) before sunrise.

One of the radio-tagged bats ("Sherlock") was tracked continuously for five full nights. Recorded radio signals indicated that it was actively flying for most of each night it was tracked. Nights were split into two active periods separated by a roosting spell.

The first bout of activity was the longest, averaging 372 min ($S.D.=117.6$, $\text{Range}=210\text{-}530$ min), while the second period lasted 103 min ($S.D.=55.5$, $\text{Range}=60\text{-}180$ min). Inactive periods lasted 40 min ($S.D.=47.4$ $\text{Range}=10\text{-}110$ min).

Singing behaviour and singing trees

Male short-tailed bats are believed to attract mates by using audible song at the entrances of singing cavities (Daniel, 1990). Audible calling by stationary bats was recorded throughout the night on all eight nights in February when we were camping in the forest. Six singing trees were located (Table 4). Other singing bats were heard but the trees not located. Singing trees were large diameter (44-85 cm dbh) red and silver beech. Singing cavities ranged from 3.4-12 m above ground (Table 4). The trees and cavity sizes were generally smaller than those occupied by communal roosts. They were all within 100 m of communal roosts 1, 2 and 3. Infra-red video monitoring indicated that there were frequent visits to these singing trees by other bats throughout the night. Single bats usually called from the cavity entrance for periods of 10-40 minutes. Many bats (up to four at once) visited these calling bats. Some were allowed to enter the cavity while others were repelled aggressively.

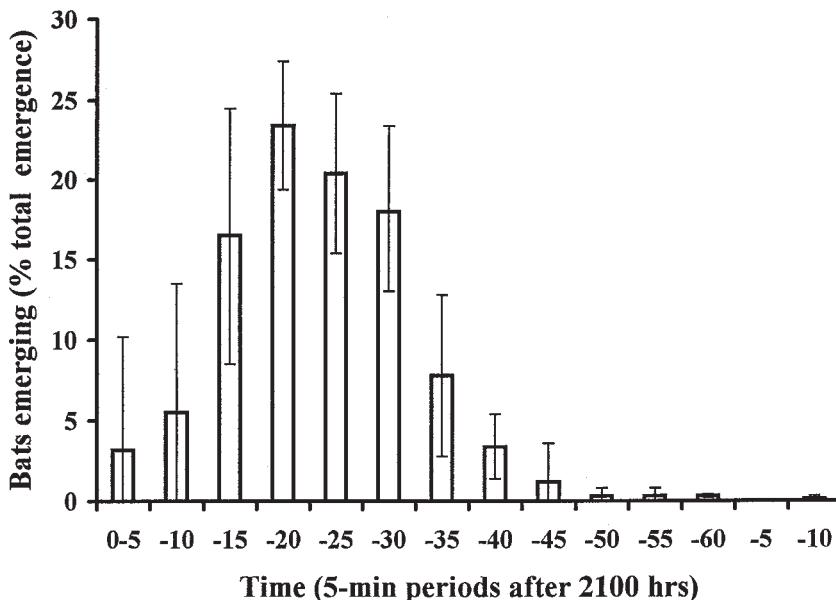


Figure 4: Emergence rates of short-tailed bats from communal roosts in the Eglinton Valley, February, 1997 (Expressed as average proportion (% \pm 1 S.D.) of total bats emerging in 5 min periods).

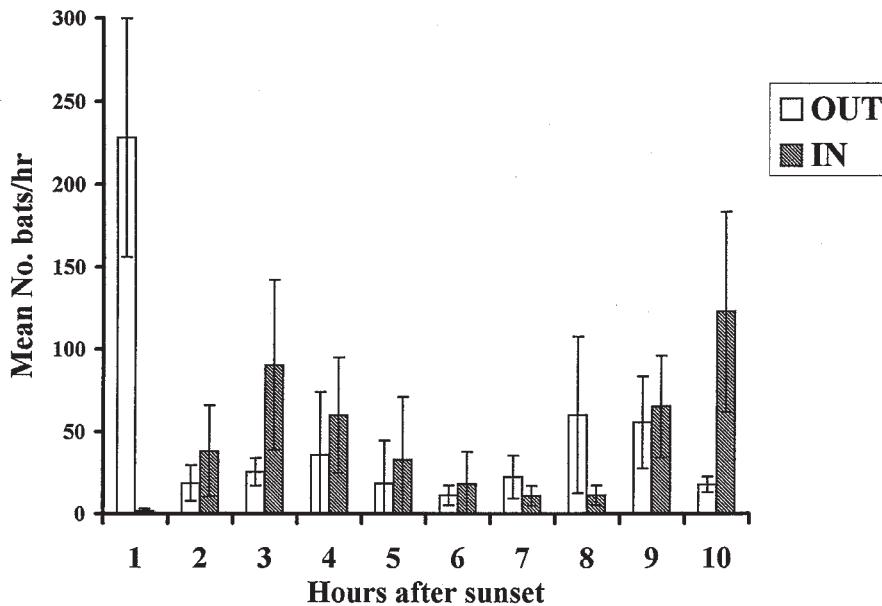


Figure 5: Average numbers of short-tailed bats entering and leaving communal roosts through the night, February, 1997 (Expressed as mean \pm 1 S.D.) of total bats entering and leaving roosts at 1 h intervals through the night.

Table 4: Characteristics of short-tailed bat singing trees in the Eglinton Valley, February 1997. All singing cavities were in tree trunks.

	Singing tree number					
	1	2	3	4	5	6
Beech tree species	Red	Red	Red	Red	Red	Silver
Cavity type	Knot	Split	Knot	Split	Split	Split
Aspect	SW	SW	SE	SE	SW	NW
Stem diameter (dbh cm)	72	91	88	82	51	63
Stem diameter at cavity (cm)	63	83	85	77	44	51
Tree height (m)	35	39	43	37	33	38
Cavity height (m)	3.5	9.0	12.0	3.4	5.2	11.0
Cavity entrance (height x width, mm)	200x50	250x35	?	260x25	200x25	230x60
Inside cross section (mm)	300x200	350x300	?	420x140	200x150	220x170
Internal cavity height (mm)	480	2500	?	1600	1200	1000
Internal cavity depth (mm)	950	0	?	0	0	0
Distance from forest edge (m)	260	220	220	240	210	200

Discussion

The presence of short-tailed bats in the Eglinton Valley is a significant find. The southern subspecies of short-tailed bat (*M. t. tuberculata*) is only known from near Karamea in North-West Nelson (J. Lyall, *pers. comm.*) and on Codfish Island (Daniel, 1990). The Eglinton site may be unique, in that it supports relatively large populations of both species of New

Zealand's bats (the other being the long-tailed bat), both of which are endemic and threatened. The Eglinton Valley is atypical compared to other Fiordland valleys. It is dominated by tall red beech forest on fertile, relatively low altitude outwash fans. Other valleys have typically higher altitude valley floors, supporting less fertile, more stunted, forest types (dominated by silver beech), and have significantly higher rainfalls (Wardle, 1984).

The Department of Conservation has run a research project on long-tailed bats in the Eglinton Valley since 1991, which has involved many hours of mistnetting in the lower valley. That the short-tailed bats were not detected for so long reflects their cryptic nature, with most foraging occurring in the upper Eglinton Valley (a different part of the valley to where the long-tailed bat research was undertaken) and their use of the forest interior (all long-tailed bat mist-netting was at sites along the forest edge).

The Eglinton Valley short-tailed bats illustrate several differences from other short-tailed bats in New Zealand (Daniel, 1990; Arkins, 1996). Compared to short-tailed bats elsewhere they appeared to be heavier, had larger wings and smaller ears and size differences between the sexes were larger. Call duration was considerably shorter than that recorded for short-tailed bats from Codfish Island (Parsons (1996) recorded call durations of 7-9 ms). However, larger sample sizes, and genetic analysis of biopsy samples taken from wing tissue of 30 bats during this study, are required before the degree and significance of any taxonomic distinctiveness can be determined.

Qualitatively, the *Mystacina* calls were of low intensity (quiet), making them difficult to detect, and recorded call sequences (each series of pulses) in free-flying bats were only about 2 s long. All the sequences analysed were recorded in some degree of clutter, so it remains to be determined just how the species calls in a completely open situation when commuting. The calls recorded were typical of bats which fly in moderate clutter (e.g., within the forest) (*cf.* Neuweiler, 1990). The Eglinton site could be used to determine the extent of overlap in echolocation calls between long and short-tailed bats when using standard bat detection equipment used for survey of New Zealand bats (O'Donnell and Sedgeley, 1994). The initial trial indicated that the majority of calls that were recorded at 25 kHz using the Batbox III bat detector were not recorded at 40 kHz, indicating that there was little overlap with the calls of long-tailed bats.

Further information is needed on the size of the Fiordland population and its habitat and range requirements. Surveys need to be undertaken in other parts of Fiordland and Aspiring National Park, particularly in forest types similar to the Eglinton Valley. Range estimates were conservative because (a) range information is preliminary (limited to February) and sample sizes small, (b) distant and uncertain fixes were omitted from the analysis, and (c) sometimes when animals were not found it was assumed that they were outside the study area. Despite these limitations the preliminary data indicated that

short-tailed bats range over a very large area of the Eglinton Valley, and over a variety of *Nothofagus* forest types. They were not confined to the forest areas, commuting over open grassland areas.

The short-tailed bats used very large diameter beech trees which may be 400-650 years old (*cf.* Ogden, 1978; Wardle, 1984). Use of large, old trees as roosts, relatively high roost lability (*cf.* Lewis, 1995), and extensive foraging ranges primarily within forest, implies that short-tailed bats may require very large areas of unmodified forest. They may also be vulnerable in forests managed for timber production where old trees are selected and removed. A radio-tracking study needs to be undertaken to determine the habitat types and area of habitat used by the short-tailed bat population throughout the year so that useful management recommendations can be made for this population.

The Eglinton Valley provides an important opportunity for studying both New Zealand bat species. The Eglinton Valley is the only site known where both species occur sympatrically in relatively large numbers, and the study of their ecological relationships is logistically feasible. Results would have implications for management and restoration of bat communities. In addition, an ecological restoration programme aimed at restoring natural biodiversity in the Eglinton Valley through introduced predator and browser control is already in progress. Determining the response of the bat populations to these restoration measures, including the use of toxic baits for pest control, will provide a valuable baseline for restoration projects nationally.

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