Murchison Mountains Lesser short-tailed bat monitoring report - 2024

David Sagar

Department of Conservation
Te Papa Atawhai

New Zealand Government

Cover: Bats held in cloth bags *Photo:* David Sagar

DOC -

In the interest of forest conservation, we support paperless electronic publishing.

Contents

1 Summary

In 2018 the presence of southern short-tailed bats (*Mystacina tuberculata tuberculata)* was detected on acoustic recording devices in the Ettrick Burn, Murchison Mountains, Fiordland, leading to preliminary monitoring of this newly discovered population being undertaken in 2019. A partnership agreement with Contract Wild Animal Control New Zealand Limited was signed to provide 5 years funding for a study to provide a picture of the population size and potential trend beginning in 2022, although this funding was withdrawn after the conclusion of this third year of monitoring. This 2024 season used fur clipping as a mark-recapture method and took place in February during 13 sessions over 3 weeks, which returned a population estimate of 413 (95% confidence interval 214 - 612). This estimate was obtained following the Schnabel method, with the data for each age/sex demographic analysed separately to account for capture heterogeneity. This estimate is an increase from last season (323, 95% CI 234 – 412), however has a very wide confidence interval likely due to the low recapture rate. The number of juveniles captured was higher than last year, which is promising and suggests the population is holding and not in serious decline. A new source of funding will need to be found to see this project through to complete the last two years of monitoring.

2 Introduction

In 2018 the Save Our Iconic Kiwi (SOIK) programme deployed 160 acoustic recorders over a large area of Fiordland National Park to monitor kiwi abundance throughout the area. These recorders were also set to record bats in the hours after kiwi data was collected, resulting in over 300,000 recordings that were analysed by two individuals organised by the Department of Conservation (DOC) Biodiversity Group.

One recorder located in the Ettrick Burn, Murchison Mountains, picked up 9 southern lesser short-tailed bat (*Mystacina tuberculata tuberculata*) recordings in an area where short-tailed bats had not previously been recorded and 40km away from the known Eglinton Valley population. This was followed up by the deployment of a further 111 recorders in November and December 2018 resulting in over 2000 short-tailed bat recordings. These indicated a putative new population centred in the mid-Ettrick Burn in an area of predominantly red beech forest.

Short-tailed bats are extremely difficult to detect due to their nocturnal nature and small size. Additionally, they spend most of their time foraging deep inside the forest and only emerge from their roosts when it is well dark. This results in large gaps in the knowledge of where bats reside, and these information gaps are difficult to fill without substantial time effort and cost. The development of acoustic recorders by the DOC electronics team that record both New Zealand bat species as well as birds has made surveying far more feasible and is greatly adding to the understanding of bat distribution. However, there is no project aiming to survey New Zealand comprehensively for bat presence and recordings often come from other projects with their own aims.

Historically, *M. tuberculata* could be found throughout the forests of New Zealand and surveys even noted them in urban and peri-urban areas pre-1930 (Parsons and Toth, 2021).

As introduced predator numbers, deforestation of native bush, and urbanisation increased, bat populations rapidly decreased, sightings diminishing between 1931 - 1960 to only native forest areas. The remaining forest populations continued to decline under these new pressures, and now only three populations of the southern subspecies (*M. t. tuberculata)* are known to exist: in the Eglinton Valley and Ettrick Burn in Fiordland, and on Whenua Hou/Codfish Island off the northwest coast of Rakiura/Stewart Island.

Bats in New Zealand are vulnerable to introduced predators (rats, stoats, feral cats, possums) throughout the year (Pryde et al. 2005), and short-tailed bats are only known to have stable or increasing populations where intensive predator controls occurs (Eglinton Valley), or on predator free islands (Whenua Hou). Stoat trapping alone has been shown to be ineffectual in protecting bat colonies and large-scale rat control is required for protection (Jackson and Pryde 2019). Limited, isolated populations make the species more vulnerable to inbreeding, disease and other stochastic events. The Murchison Mountains in which the Ettrick Burn is located is a special takahē protection area with a large-scale stoat trapping network; however, it has never had any form of rat control, leaving the short-tailed bat population at serious risk of decline. Elsewhere throughout the South Island, populations of short-tailed bats have become locally extinct where rodent control was not in place.

In 2021 the Department of Conservation entered into a partnership agreement with Contract Wild Animal Control New Zealand Limited (CWAC NZL) to provide DOC with funding for a five-year monitoring project to increase understanding of the density and distribution of the Ettrick Burn *M. t. tuberculata* population, beginning with the 2022 season. This report details the methods and results of the third year of monitoring through February 2024.

3 Objectives

To obtain a population estimate of the Ettrick Burn southern lesser short-tailed bat colony using mark-recapture and gather information on population relatedness between the two Fiordland colonies (Ettrick Burn and Eglinton Valley).

4 Methods

Mist netting was undertaken the first night to catch bats for transmitter attachment, using bat squeakers to attract bats. Ideally the transmitter would be attached to an adult parous female to increase chances of being led to a communal maternity roost. These bats were radio tracked the following day to locate occupied roost trees. Harp nets were suspended outside roost entrances to capture bats as they left during dusk. A camera was attached to the harp trap to monitor the number of bats and was lowered by 100 bats caught as any more would be unrealistic for two people to examine within the 2-hour maximum that bats should remain captured to reduce stress to them. Bats were held in cloth bags suspended from a line while awaiting handling, with no more than 5 bats per bag. 13 mark-recapture sessions took place with individuals being marked by trimming a small patch of fur on the back on the individual, and the age, sex, and female reproductive status recorded. Mark-recapture sessions took place every night weather allowed, as rain cancelled some sessions to avoid bats becoming wet and cold during storage and handling. New transmitters were deployed on new bats as the previous signal weakened. All bats were scanned to detect Passive Integrated Transponders (PIT) tags – these tags are not used in the Murchison Mountains, but more than 3000 PIT tags have been deployed to bats in the Eglinton Valley, 40kms away.

The fur clippings from 50 bats were collected for isotope analysis (Animal Ethics Committee Application AEC425).

4.1 Schnabel method

This study opted to follow the Schnabel method for mark-recapture. All unmarked bats caught during all sessions were marked before release, continuously increasing the number of marked bats at large in the population, which was considered closed during the monitoring period (3 weeks). Marking was undertaken using fur clipping as a way of temporarily marking bats. A small patch of fur was trimmed on the back using scissors and marks were only used to identify marked vs unmarked bats, not to differentiate individual bats from each other or separating out different capture sessions. Data was input to a custom script written for this project in Programme R to calculate the population estimates and confidence intervals.

5 Results

5.1 Mark-recapture

A total of 270 individual bats were marked during the 3-week monitoring period over 13 separate nights, with 170 recaptures (Table 1.). Catches of juvenile males and post-lactating females were higher than previous years, but the ratio of recaptures to total catches was much lower across all demographics, 0.39 in 2024 compared with 0.58 in 2023, with more unmarked bats caught than recaptured marked bats (Table 2.).

					Marked					Unmarked				
					Male		Female			Male		Female		
Site	Date	Total	Marked recapture*	Unmarked	Adult	Juvenile	Adult Nulliparous	Adult Post-Lactating	Juvenile	A	J	A NP	A PL	J
ME6	7/02/2024	3	0	3						1		1		1
RE8	8/02/2024	72	0	72						1	43		5	23
RE8	9/02/2024	33	8	25		5			3	4	1	3	13	4
RE8	11/02/2024	69	23	46	2	10		5	6	5	11	3	19	8
RE8	12/02/2024	60	24	36	2	9		4	9	16	2	6	9	3
RE8	13/02/2024	53	21	32	2	5	2	4	8	19	1	7	5	
RE8	15/02/2024	37	28	9	1	13	1	1	12	2	2			5
RE24	16/02/2024	79	38	41	14	8	4	7	5	23	1	7	10	
RE8	17/02/2024	9	7	2		3			4	1		1		
RE8	18/02/2024	1	1	0		1								
RE8	20/02/2024	12	11	1	1	2	1	4	3			1		
RE8	21/02/2024	11	8	3	1	1		2	4				3	
ME8	22/02/2024	1	1	0	1									
		440	**170**	**270**	**24**	**57**	**8**	**27**	**54**	**72**	**61**	**29**	**64**	**44**

Table 1. Capture data (note ME6 and ME8 are mist net sites).
**Bats captured that night that were found with marks from previous nights.*

					Marked					Unmarked				
					Male		Female			Male		Female		
	Recap Ratio	Total caught	Marked recaptured	Unmarked	Adult	Juvenile	Adult Nulliparous	Adult Post-Lactating	Juvenile	A	J	A NP	A PL	J
2023	0.58	662	384	278	99 (0.47)	121 (0.72)	20 (0.40)	30 (0.40)	114 (0.72)	112	47	30	45	44
2024	0.39	440	170	270	24 (0.25)	57 (0.48)	8 (0.22)	27 (0.30)	54 (0.55)	72	61	29	64	44

Table 2. Summarised catches for 2023/24 seasons with ratio of recaptures to total catches in brackets for each demographic (2 s.f.). Note that these are cumulative captures, i.e. there were likely not 440 individuals caught in 2024 as the same bats would have been caught across multiple nights. Only the unmarked numbers could be considered to be individuals.

The Schnabel Method was used to obtain an estimate of the population ($\hat{N}$) (Equation 1.):

$$\hat{N} = \frac{\sum_t (C_t M_t)}{\sum_t R_t}$$

Equation 1. Schnabel equation calculates a population estimate as a weighted average of a series of Lincoln-Petersen estimates (Krebs 2014, Chapter 2).

Where:

C_t = total number of bats caught in sample *t*
R_t = number of bats caught in sample *t* that were already marked
M_t = number of marked bats currently at large during sample *t*

Confidence intervals are obtained on the reciprocal of the population estimate. If recaptures (R_t) are less than 50, the confidence limits can be obtained from Poisson distribution and be substituted for the denominator in Equation 1. Recaptures greater than 50, distribution can be derived from the Student's t-table with s-1 degrees of freedom (Krebs 2014, Chapter 2):

$$Var\left(\frac{1}{\hat{N}}\right) = \frac{\sum R_t}{(\sum C_t M_t)^2}$$

Equation 2: Variance of the population estimate reciprocal

$$S.E.\frac{1}{\hat{N}} = \sqrt{Var\left(\frac{1}{\hat{N}}\right)}$$

Equation 3: Standard Error of the population estimate reciprocal

$$\frac{1}{\hat{N}} \pm t_\alpha \, S.E.$$

Equation 4: Confidence limits of the population estimate reciprocal when R_t >= 50

s = number of samples
Var = Variance
S.E. = Standard Error
t_α = value from Student's t-table for 100 – α% confidence interval.

The data were analysed separately for each demographic class, with a summed total population estimate of 413 (95% confidence interval 214-612).

	Pop estimate (N)	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Adult male	126	89	201
Juvenile male	70	54	98
Adult NP Female	62	36	166
Adult PL Female	106	75	168
Juvenile Female	50	38	71
Total population	**413**	**214**	**612**

Table 3. Population estimates by demographic class

Analysing the population as a whole without separating demographics gives a smaller population estimate with much narrower confidence intervals, however this is considered to be less true due to the known difference in detection probabilities between demographic classes i.e., adult females having lower catch rates during the monitoring period.

	Population (N)
2022*	343 (321 – 370)
2023	288 (258 – 325)
2024	368 (315 – 442)

Table 4. Population estimates by monitoring year when analysed without separate demographic classes, 95% confidence intervals within brackets
** 2022 estimates were gained using the Lincoln-Petersen index*

	Adult Male	Juvenile Male	Adult Nulliparous Female	Adult Post-lactating Female	Juvenile Female	Total Population
2022*	131 (*121 - 144*)	43 (42 – 46)	83 (*67 – 107*)	104 (*66 – 178*)	40 (*38 – 43*)	401 (*324 - 483*)
2023	134 (*109 – 172*)	48 (*40 – 60*)	35 (*24 – 59*)	61 (*45 – 92*)	45 (*37 – 57*)	323 (234 – *412*)
2024	126 (*89 – 201*)	70 (*54 – 98*)	62 (*36 – 166*)	106 (*75 – 168*)	50 (*38 – 71*)	413 (214-612)

Table 5. Demographic class population estimates by monitoring year, 95% confidence intervals within brackets.

** 2022 estimates were gained using the Lincoln-Petersen index*

	Minimum Number Alive
2019	208
2022	219
2023	278
2024	270

Table 6. The minimum number of bats alive during each monitoring period, as determined by the number of unmarked individuals caught which were then marked. 2019 data comes from roost emergence counts.

The data from previous seasons were initially analysed in Microsoft Excel to obtain the population estimates and confidence intervals. With the new R script for this season, these data were run through the script to provide a higher level of precision. Population estimates saw no change, but some confidence limits shifted slightly.

Upon further investigation, it was also revealed the confidence intervals for the summed total population in previous seasons had been obtained incorrectly by simply summing the confidence limits for the demographics. As shown in equation 2, the variances of each population estimate are calculated on the reciprocal of N (1/N). However, as the total population estimate is summed from multiple independent demographic population estimates and their respective variances, you are summing direct estimates and not reciprocals. As a result, the variance of the sum, assuming independence, is:

$$Var\left(\sum_i \widehat{N}_i\right) = \sum_i Var(\widehat{N}_i)$$

Equation 5. Variance of the sum of estimates

The standard error and confidence intervals are then calculated as per equations 3 and 4.

Only 2 roost trees were occupied over the monitoring period. These two roosts (RE8 and RE24) were only 270m apart on the true right of the river. A new roost, RE26, was discovered but thought to be a solitary roost due to lack of an obvious hole and since it was a mountain beech rather than red beech.

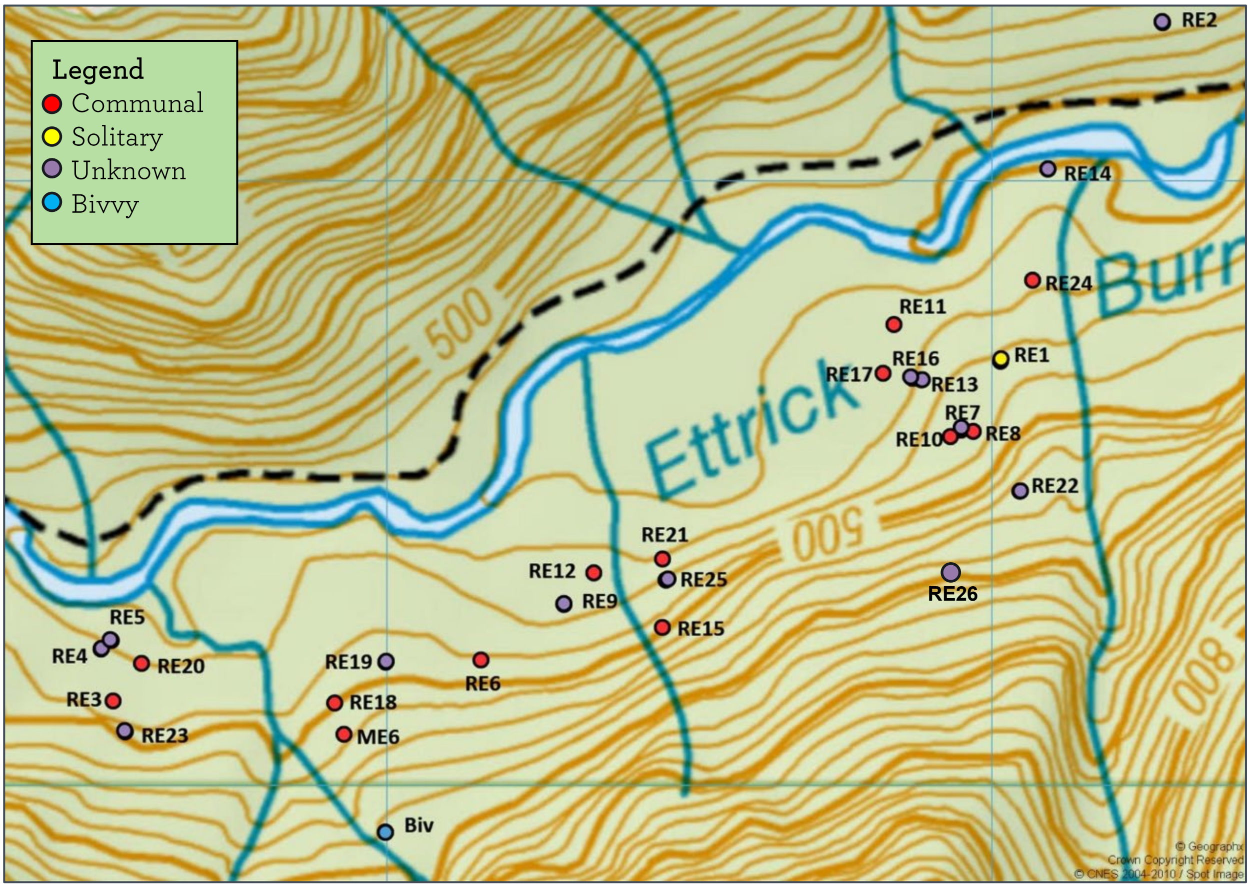

Figure 1. Short-tailed bat roost locations in the Ettrick Burn, Fiordland.

5.2 Search for Tagged Bats.

No bats were found to have PIT tags implanted.

6 Discussion

This season's population estimate shows a potential increase in abundance; however it is difficult to determine whether this is genuine population growth or an inaccurate estimation as a result of the low ratio of recaptures against total captures with more unmarked bats captured than marked bats. The effect of this skewed ratio can be seen in the confidence intervals, demographics with a lower R/C ratio have much wider intervals than the higher R/C classes (Table 2., Table 3.). One explanation for this occurrence is due to all transmittered bats remaining in one roost tree (RE8) for the majority of the monitoring period while others bats departed for other roost trees. Without our transmitter bats relocating, we were unable to find other active roosts. The exception was the night of February 16th which saw a transmittered bat relocate to another roost (RE24), resulting in higher counts of both marked and unmarked bats. The next night it returned to RE8, and RE24 was found to be silent and empty again. This is a great example of how challenging it can be at times to obtain sufficient or meaningful data from microbats, as sometimes despite best efforts they cannot be found. As with the previous years, it is promising to see the abundance of juveniles, with more unmarked individuals being caught than before. Comparing this with the Minimum Number Alive (Table 6.) suggests that the population is not in serious decline and still holding steady. Further hypotheses on the status of the population and any trend will require, at minimum, the remaining two years of the project to make any informed insights.

No genotyping has been carried out on the population to determine its relatedness to the Eglinton Valley population, 40km away. One indication of lack of movement of individual bats between these populations is the absence of bat flies in the Ettrick Burn colony, which the Eglinton colony has. The New Zealand bat fly (*Mystacinobia zelandica*) is a dipteran that has a commensal relationship with *M. tuberculata*. Residing within bat roosts, they feed on bat guano and rely on the bats for transportation; clinging to the bats fur as they travel between roost trees (Holloway 1976). If there were movement between the two populations, it would be expected that bat flies from the Eglinton Valley would be transported to the Ettrick Burn, and the lack of any bat flies in the Ettrick combined with no PIT tags detected would suggest a there is not ongoing migration or exchange between these populations. Comparing a genetic analysis of both populations would provide more detail as to whether this Ettrick Population is a recently established splinter population based on the large expansion of Eglinton bats, or whether this population is an original remnant of once widespread populations across the South Island. Understanding this has significance for how we understand and manage bat populations across the country.

In 2023 a new set of tracking tunnels was deployed in the central Ettrick Burn covering the same section of the valley in which the bat roosts can be found. The rodent tracking data that will be obtained from this can be compared with future monitoring results to look for correlation between rat abundance and the bat population in the valley.

Recently discussions have been had around what can be done to provide further protection from rats for this population. The Eglinton Valley population is protected multiple ways: a trapping network targeting mustelid (which also catches rats), and toxic aerial sodium monofluoroacetate (1080) operations aided by pindone bait stations during mast events and when rat tracking increases above 5%. This combination has proven very effective for the Eglinton Valley short-tail population, which has shown an increasing population trend with a survival rate of 95% for tagged adult females (Jackson et al. 2023). The Ettrick Burn has a comprehensive mustelid trapping network along both sides of the river and up major tributaries and ridgelines, but as the Ettrick Burn is within the special takahē protection area, aerial 1080 has not been used to control rats due to the risk of takahē mortality. As discussions continue regarding what rodent toxin operations in the Ettrick Burn could look like, banding communal roost trees could provide protection in the meantime. This involves wrapping >1-metre-wide aluminium sheets around a communal roost tree both above and below the entrance to a roost, creating a smooth surface that prevents predators from climbing and predating upon bats while they roost. It is likely it wouldn't be possible to band every known communal roost tree, as some won't be possible to create a completely smooth surface due to their shape or have hollows at ground level that would negate them. Bands would also need to be regularly checked and adjusted as the tree grows (C. O'Donnell, personal communication June 18, 2024).

The first few nights at roost trees saw a handful of older adult post-lactating females (FPL) showing what appeared to be old marks from the previous season. This was obvious the first night at roost RE8, as we had not yet marked any FPLs at that stage. None of the other demographic classes showed any sign of old marks. Perhaps older individuals do not regrow their fur at the same pace as younger bats, or possibly as they were all parous females it was due to energy being used in reproduction instead. Future monitoring seasons and other fur clipping projects could begin to alternate the fur clipping locations each season between the upper and lower back to avoid potential confusion if old marks stay visible between seasons.

7 Recommendations

1. The Te Anau Biodiversity Team should obtain funding to continue monitoring the population for minimum another 2 years to form a good understanding of the population and how it is responding to pest management.
2. The Te Anau Biodiversity team and National Predator Control Programme should continue to investigate options to deploy landscape scale rat control during the next beech masting event.
3. The Te Anau Biodiversity team should conduct a costing and feasibility analysis for how to protect colony trees via metal tree bands. This should include potential funding options.
4. Consider taking wing biopsies for genetic analysis to determine relatedness with the Eglinton Valley population.
5. Continue with Schnabel method to provide consistent data set across monitoring periods.

8 Acknowledgements

Huge thanks to the bat monitoring team; Rebecca Jackson, Louise McLaughlin, Warren Simpson, and Linda Kilduff. Also, to Ellen Cieraad and Ian Westbrooke for their statistical expertise, and bat experts Moira Pryde and Colin O'Donnell. A big thank you to Contract Wild Animal Control for their sponsorship of the project. And thank you to the Bat Cave for keeping us safe and sound.

9 References

Holloway, B. (1976). A new bat-fly family from New Zealand (Diptera: Mystacinobiidae). *New Zealand Journal of Zoology 3* (4). 279 – 301. https://doi.org/10.1080%2F03014223.1976.9517919

Jackson R.J., Pryde, M., McLaughlin, L. (2023). *Eglinton Valley Lesser Short-tailed Bat Monitoring 2022 – 2023* (Unpublished report). Department of Conservation, Te Anau (DOC-7415262) https://www.doc.govt.nz/globalassets/documents/our-work/eglinton-valley/eglinton-short-tailed-bat-report-2022-23.pdf

Jackson, R.J., Sagar, D.M. (2023) *Murchison Mountains Lesser Short Tailed Bat Monitoring 2023* (Unpublished report). Department of Conservation, Te Anau (DOC-7493619) https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/bats/short-tailed-bat-murchison-2023-monitoring-report.pdf

Jackson, R.J. (2022). *Murchison Mountains Lesser Short-tailed Bat Monitoring 2022* (Unpublished report). Department of Conservation, Te Anau (DOC-6980631) https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/bats/short-tailed-bat-murchison-2022-monitoring-report.pdf

Jackson, R.J. (2019) *Murchison Mountains Lesser Short Tailed Bat Monitoring* (Unpublished report). Department of Conservation, Te Anau (DOC-6270665) https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/bats/short-tailed-bat-murchison-2019-monitoring-report.pdf

Jackson, R.J. (2019). *Murchison Mountains Lesser Short-tailed Bat Survey 2018* (Unpublished report). Department of Conservation, Te Anau (DOC-6036530)

Jackson, R.J. & Pryde, M.A. (2019). *Eglinton Valley Lesser Short Tailed Bat Monitoring Programme 2018/2019* (Unpublished report). Department of Conservation, Te Anau (DOCCM-5989516)

Krebs, C.J. (2017). *Ecological Methodology* (3rd Edition, unpublished). https://www.zoology.ubc.ca/~krebs/books.html

Parsons, S. & Toth, C. (2021). Families Vespertilionidae and Mystacinidae, Lesser short-tailed bat. In C.M. King & D.M. Forsyth (Eds), *The Handbook of New Zealand Mammals, 3rd Edition* (pp. 95 – 130). CSIRO Publishing, Melbourne.

Pryde, M.A., O'Donnell, C.F.J., Barker, R.J. (2005). Factors influencing survival and long-term population viability of New Zealand long-tailed bats (Chalinolobus tuberculatus): Implications for conservation. *Biological Conservation 126*, 175–185.

Sedgeley, J., O'Donnell, C. Lyall, J., Edmonds, H., Simpson, W., Carpenter, J., Hoare, J., McInnes, K. (2012). *DOC Best Practise Manual of Conservation Techniques for Bats. Inventory and Toolbox: Bats* (http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/im-toolbox-bats/im-toolbox-bats-doc-best-practise-manual-of-conservation-techniques-for-bats.pdf