Bats: roost occupancy and indices of bat activity—infrared beam counters

Version 1.0

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Contents

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Department of Conservation
Te Papa Atawhai

Synopsis

Infrared sensors and counters can be mounted directly outside a roost exit and used to gain an index of exiting bats. A beam or several beams of infrared light are passed over the exit hole (Fig. 1). 'Active' infrared counter systems are triggered each time a beam is broken by a bat (or any other object) passing through the beam, and 'passive' counter systems are triggered when a moving object's infrared signature is detected. Each time the system is triggered, a data point is either registered on a simple counter or stored on a data logger. A computer and appropriate software is required to interrogate data loggers and retrieve count data. Systems usually include a timing mechanism that enables the system to operate remotely.

Infrared beam counters are very useful for determining presence/absence of bats at a roost over long time frames (roost occupancy), although it is not possible to tell whether all registrations are caused by bats. Any movement, such as other animals or branches moving in the wind, can trigger the counter.

Infrared beam counters can also be used to count the number of bats exiting roosts. However, systems trialled in New Zealand appear to be far less accurate than video cameras and recorders at counting numbers of bats. For example, beam counters often record a group of bats that are exiting quickly as a single individual, resulting in an underestimate of total number of bats exiting a roost. Conversely, most simple or single-beam counter systems cannot distinguish between bats entering and exiting the roost, resulting in many more registrations and, subsequently, an overestimation of the number of individuals using a roost. Infrared beam counters may not be effective in all situations, and for count data, great care should be used when interpreting results. Infrared beam counter systems should be calibrated against video counts wherever possible.

Unless accuracy improves, we *do not recommend* the use of infrared beam counters as a sole inventory method for indexing numbers of bats exiting roosts, nor for estimating population size. Likewise, infrared beam counters *should not be used* for monitoring changes over time. Developments in technology and research focusing on calibrating registrations of bats recorded from infrared beam counters with actual numbers emerging from roosts, and with actual population size, may improve the accuracy of infrared beam counters with time. The 'Introduction to bat monitoring' (docdm-590958) contains summary tables of methods for counting bats at roost sites. These include 'Bats: exit counts at roosts—cameras and recorders' (docdm-590789) and 'Bats: exit counts at roosts—simple visual counts' (docdm-590804).

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Figure 1. Single through-beam, active infrared beam counter system positioned directly outside a lesser short-tailed bat roost hole in a red beech tree.

Assumptions

- Bats will leave a roost on a particular night.
- All bats leave the roost.
- All exit holes have been accounted for.
- All individuals trigger the counter.
- The beam is triggered by bats and not something else.
- The number of registrations is closely correlated with the number of bats.

Advantages

This technique is very useful for determining presence/absence of bats at a roost over long time frames.

- The infrared beam counting systems are much less expensive than 'Bats: exit counts at roosts—cameras and recorders' (docdm-590789), and generally less expensive than 'Bats: counting away from roosts—automatic bat detectors' (docdm-590733) (known as automatic bat monitors or ABMs).
- Power consumption will be less than camera and video set-ups and possibly lower than the current DOC ABM units. Therefore, infrared beams can be run for relatively long periods of time before batteries need to be changed.
- Infrared beam counter systems are smaller and easier to transport into remote locations than video systems and ABMs, and potentially easier to set up than a camera and video system.
- The qualities listed above make infrared beam counters a useful alternative when multiple roosts are occupied simultaneously and there are insufficient resources to use cameras and video recorders at every roost.

- Infrared beam counters and data loggers can operate remotely and be timed to record emergence over several nights.
- They can be used both to count evening emergence and record activity patterns at roosts throughout the whole night.
- Roost occupancy and activity data can be used to plan future surveys and determine the best time to undertake counts at roosts using other methods.

Disadvantages

- Infrared beam counters are much less accurate than camera and video systems.
- It is impossible to know whether all registrations are caused by bats. Any movement, such as other animals or branches moving in the wind, can trigger the counter.
- Beam counters often record a group of bats exiting quickly as a single individual, which may result in an underestimate of the total number of bats exiting the roost.
- Most simple or single-beam counter systems cannot distinguish between bats entering and exiting the roost, resulting in many more registrations and, subsequently, an overestimation of the number of individuals using a roost.
- It can be difficult to cover large or irregularly shaped entrances with single beam counters; therefore accuracy of counts will vary from roost to roost.
- To date, it has not been demonstrated that there is a consistent correlation between registrations from beam counters and actual numbers of bats either in a roost or in a population. To have confidence in the accuracy of counts it is necessary to calibrate infrared beam counters with cameras and video recorders or direct visual counts of long-tailed bats.

Suitability for inventory

Infrared beam counters can be used to determine whether bats are using a roost. However, it is not possible to tell whether all registrations are caused by bats. Unrelated movements can trigger the counter. There are alternative techniques available for determining simple presence/absence of bats at roosts, which may be simpler and cheaper. These include ‘Bats: roost occupancy and indices of bat activity—field sign’ (docdm-590882), ‘Bats: exit counts at roosts—simple visual counts’ (docdm-590804) and ‘Bats: counting away from roosts—automatic bat detectors’ (docdm-590733).

Infrared beam counters are useful for determining whether bats are using a roost site over long time frames (roost occupancy). See ‘Suitability for monitoring’ for more details.

As noted for monitoring, infrared beam counters can also be used for recording numbers of bats exiting roosts. Unfortunately, at the time of writing, the systems trialled in New Zealand appear to be far less accurate than counts derived using cameras and video recorders. Unless accuracy improves, we do not recommend that infrared beam counters are used as the sole inventory method for indexing numbers of bats exiting roosts, nor for estimating population size. Developments in technology and research focusing on calibrating registrations of bats with actual numbers emerging from roosts, and with actual population size may improve accuracy of infrared beam counters.

Generally, exit counts at communal roosts will usually be poor estimators of total population size. Members of a bat colony or population are always spread among several communal roosts and a large number of solitary roosts on any one night and they may change roost sites frequently. Minimum population estimates derived from roost counts will always be directly correlated to sampling effort and the number of roosts found during the sampling period.

Suitability for monitoring

Infrared beam counters and data loggers are very useful for monitoring roost occupancy over time, but again, it cannot be assumed that it is always bats that trigger the counter. Infrared beam counters can also be used to record numbers of bats exiting a roost, but at present can only provide a relatively crude index (which will vary according to the quality of the system). Roost occupancy and activity data can be used to plan future surveys and determine the best time to undertake counts at roosts using other methods.

At the time of writing, we do not recommend using infrared beam counters for estimating population size and monitoring changes in population size over time. If, in the future, the accuracy of the method is improved and it is demonstrated that counts from infrared beam counters can provide a consistent index of the number of bats in a roost or population, it may be possible to monitor trends.

Skills

Unless inventory and monitoring is to be undertaken at known roosts, workers will need skills to locate new roosts, in addition to the skills necessary for using the infrared beam counters.

Skills required for finding roosts

Workers must be able to:

- Demonstrate a basic level of bushcraft.
- Identify areas of bat activity by using bat detectors to survey for bat calls. See ‘Bats: counting away from roosts—bat detectors on line transects’ (docdm-590701) and ‘Bats: counting away from roosts—automatic bat detectors’ (docdm-590733) for more information.
- Distinguish between long-tailed bats and lesser short-tailed bats by their calls. See ‘Background to bat detectors’ in the ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465) for further information.
- Set up harp traps or construct mist net rigs in areas of bat activity. Training may be needed to learn how to optimise capture rates. The section ‘Catching bats’ in the ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465) provides details on trap construction and placement.

- Handle bats competently and humanely.
- Identify bat species; age, sex and measure bats and apply transmitters.
- Meet minimum standards—anyone wishing to catch and handle bats must receive appropriate training and must meet the minimum requirements for catching, handling, examining, measuring, and releasing bats described in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465).
- Use radio-tracking to follow tagged bats and locate their communal roosts (see 'Bats: trapping at roosts—estimating survival and productivity'—docdm-590867).

Skills required for using infrared beams

- Infrared beam counters and data loggers can be technologically complex and are often difficult to set up in the field. Training may be required to ensure units are functioning correctly, calibrated, and maintained regularly.
- In some circumstances workers may need tree-climbing experience to set up the beam counter and data logger.

Resources

This method is less expensive in terms of equipment than camera and video systems, but intensive effort may be required to locate the roosts and set up the equipment, particularly if multiple roosts are to be counted at simultaneously. However, once in place, they can be run for relatively long periods of time.

DOC has developed an infrared beam counter and data logger system with accompanying computer software. The DOC Electronics Workshop in the Research and Development Group should be contacted for further information and to discuss new developments. There are also commercial systems available, e.g. Faunatech[1] and TrailMaster[2], but these are likely to be far more expensive than any developed by DOC 'in house'.

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

If the aim is to gain an index of how many bats exit a roost, observers only need to record the total registrations. Some sophisticated systems with multiple beams can register the direction the bat was flying when it broke the beam so it may be possible to calculate net emergence (number exiting minus

[1] http://www.faunatech.com.au/
[2] http://www.trailmaster.com/

number entering). No systems of this type have been trialled in New Zealand so far, so we cannot assess their accuracy.

If the study aims to investigate timing and patterns of emergence, it is necessary to record the exact time bats exit and enter. Start and finish time, and times of registrations may be recorded automatically, depending on the type of system used.

It is important to record temperature and weather variables because these can influence patterns of emergence (and whether the bats will even emerge at all). Recording time of first emergence is useful for planning further counts, to ensure that timers are set correctly.

Minimum attributes to record when recording over a single night:

- Observer's name and contact details
- Details of the system used, i.e. type and identification number (quality and accuracy will vary according to type of infrared beam system used)
- Location: place name and GPS coordinates
- Roost details and any roost identification number
- Date
- Start time
- Start temperature and weather conditions (cloud cover, wind, rain)
- Time of first bat activity, i.e. the time the first bat exited or entered
- Time of last bat activity, i.e. the time the last bat exited or entered
- Finish time
- Temperature and weather conditions at finish time
- A tally of the total number of registrations
- If the infrared beam system is sophisticated, it may also be possible to:
    - Tally the number of registrations in each direction (number exiting and number entering)
    - Tally the net number of registrations emerging from roost (number exiting minus number entering)

Minimum attributes to record when recording long-term presence/absence or monitoring roost occupancy:

- Observer's name and contact details
- Details of the system used, i.e. type and identification number (quality and accuracy will vary according to type of infrared beam system used)
- Location: place name and GPS coordinates
- Roost details and any roost identification number
- Start date
- Finish date
- Daily temperatures, including dusk temperatures and minimum temperatures if possible

- Basic daily weather summary—rain, snow, fine, etc.
- Dates and time of registrations
- Number of registrations per night

Minimum attributes can be recorded on standardised field sheets available in 'Blank forms for recording counts from IR beams at roosts' (docdm-211173). This document includes three separate field sheets:

1. Simple systems (number of registrations) over a single night.
2. Sophisticated systems (number of registrations exiting and entering) over a single night.
3. Summary sheet for longer-term inventory and monitoring.

Data storage

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Summarise the results in a spreadsheet or equivalent. Arrange data as 'column variables', i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given survey plot was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Roost count results are best summarised in a spreadsheet (e.g. Microsoft Excel). Columns in the spreadsheet should include all data recorded on the original field sheet because the influences of factors such as location, observer, weather, etc. need to be accounted for in any analyses.

At present, there are no standardised spreadsheets or databases maintained by DOC to store bat roost count data. However, counts could be recorded in the DOC bat database. Each DOC conservancy should have a separate Excel spreadsheet for this purpose, with access rights held by the conservancy bat contact (see 'Bat Recovery Group contacts'—docdm-132033). If a conservancy has not set up its own spreadsheet, one can be created using the 'National bat database template' (docdm-213136). See the 'Canterbury Conservancy bat database' (docdm-213179) for an example of a spreadsheet containing data. Many of the data entry fields will not be relevant, but there are fields for location, GPS coordinates and for comments that could be used to describe count results (Fig. 2).

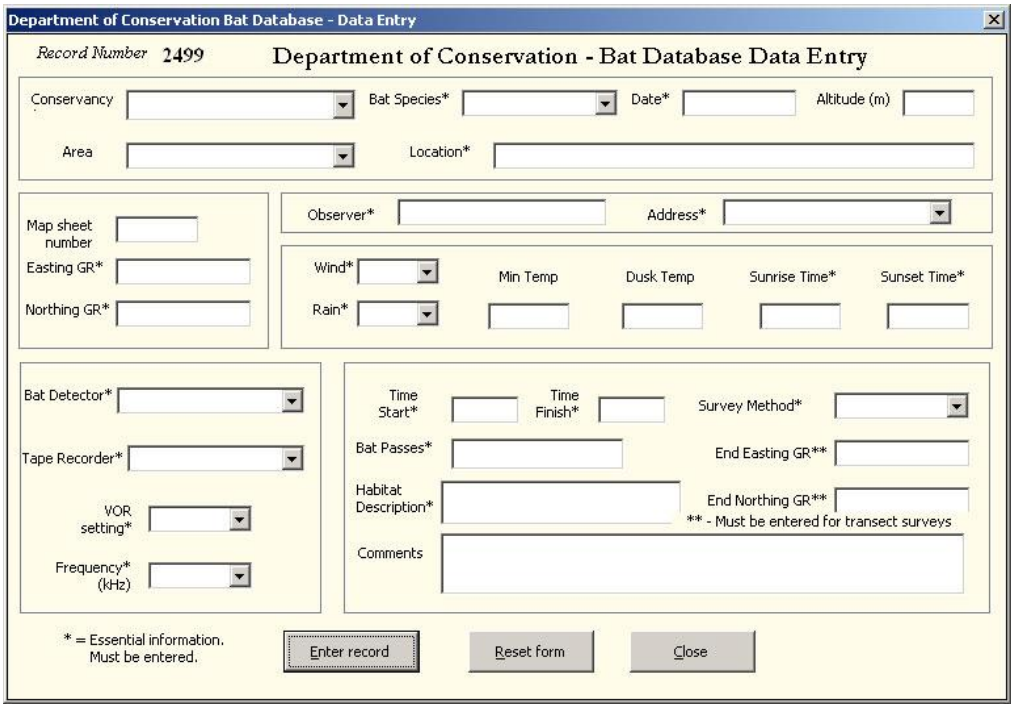

Figure 2. Screenshot illustration of data entry page from the DOC bat database.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.

The measures gained from application of this method are:

- Presence/absence of bats at a roost
- Presence/absence of bats at a roost over long time frames (roost occupancy)
- Bat activity patterns
- Index of the number of bats exiting a roost

Data from infrared beam counters appears to be less accurate than video counts (see 'Case study A') and to date no one has demonstrated a consistent correlation between registrations from beam counters and actual numbers of bats either in a roost or a population. Research is required to calibrate registrations against numbers of bats. If infrared beam counters are used, it is advisable to run camera and video recorder systems and beam counters simultaneously at the same roost for several nights to obtain error estimates for the infrared beam counters. These error estimates can then be used to calibrate future counts using only infrared beam counters. If, in the future, the method is demonstrated to provide a consistent index of the number of bats in a roost or population, more detailed statistical analysis of population trends may be possible. For further information, consult the 'Analysis, interpretation and reporting' sections in 'Bats: exit counts at roosts—cameras and recorders' (docdm-590789) and 'Bats: exit counts at roosts—simple visual counts' (docdm-590804).

Until calibration work is done, only simple analyses of data obtained using infrared beam counters are advisable. Raw data can be graphed and used to show daily patterns at single roosts (Fig. 3). Maximum counts (either the largest number of registrations from any roost during the sampling period, or the sum of the number of registrations from simultaneously occupied roosts) or average counts per season can also be graphed. This data can only be interpreted simply. For example, data can show whether a roost is occupied (and for how many days), how often bats return to a roost and at what intervals, and when the roost is occupied (apparently) by a large number of bats (e.g. on 28/10/02 in Fig. 3). Note, however, that the relationship between the number of bats present and the number of registrations can be variable (see 'Case study A').

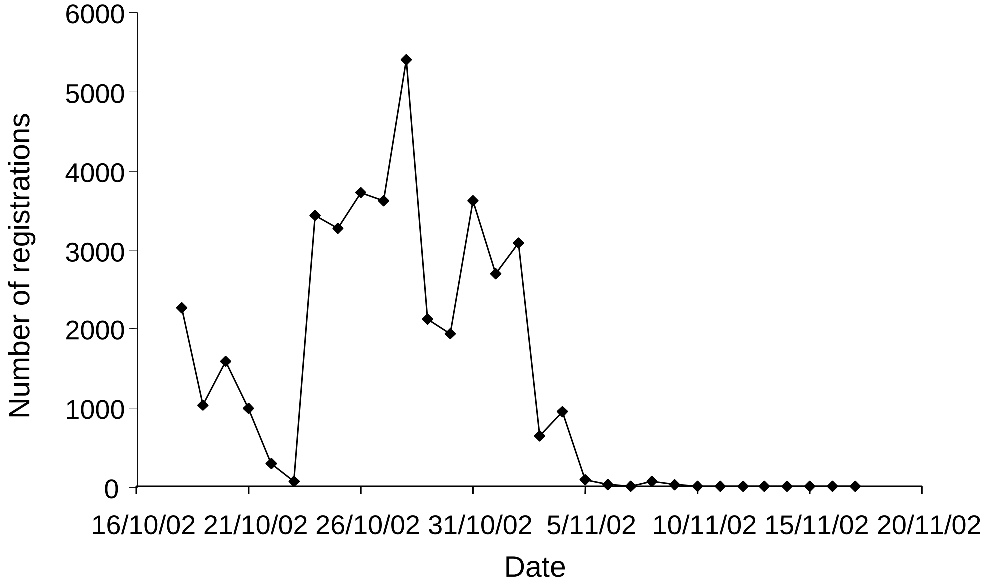

Figure 3. Daily registrations from a single lesser short-tailed bat roost. The graph shows the total number of registrations recorded by an infrared beam counter positioned at the roost exit (from Specht 2002).

Simple statistical comparisons could be made (e.g. comparing average or median number of registrations per roost). However, in most circumstances, statistical comparisons should only be made between standardised monitoring sessions at the same site. Comparison between sites can be misleading because sessions could have been undertaken in different conditions.

Case study A

Case study A: video-surveillance and infrared beam counters at lesser short-tailed bat roosts in Rangataua Forest, central North Island, New Zealand

Synopsis

Lloyd & McQueen investigated the distribution, ecology and molecular ecology of short-tailed bats in the central North Island (Lloyd 2003). They used aerial tracking and video surveillance to study roosting behaviour and measure population size of short-tailed bats in 100 km² of old growth *Nothofagus* forest, in Rangataua Forest. Over the 5–6 years of this study, more than 30 large communal roosts were discovered. Bat numbers ranged from a few hundred per roost to more than 5000. Estimates of the population size ranged from 5000 to 7000 bats. Once these studies were completed, Tongariro/Taupō Conservancy continued to undertake an annual count of the population within the Rangataua Forest.

Objectives

The aim of Tongariro/Taupō Conservancy's annual count of the Rangataua short-tailed bat population was to provide an estimate of minimum population size. The aim of this case study is to illustrate why index counts derived from infrared beam counters should be treated with caution.

Sampling design and methods

The survey was conducted in October and November 2002. Initially, active roosts were identified by direct inspection or by setting up infrared beams and data loggers at previously-used roosts. The infrared beam counters and data loggers were set to run daily from 20:00 hrs to 23:00 hrs, and data loggers stored data in 30-minute intervals. The data was summed to give an index of the number of bats leaving the roost per day (as in Fig. 3).

Additionally, six bats were caught in their foraging areas, radio-tagged and aerially radio-tracked back to their roost sites. Cameras and videos were set up on all active roosts, and counts of exiting bats were recorded simultaneously. Counts were summed to obtain a maximum count per night.

For the purpose of this case study, we examined exit counts from two roosts where two counting methods had been used simultaneously. Results from infrared beams and data loggers were compared with those from camera and video recorder systems.

Results

Counts derived from the two methods were very different for the two roosts examined (Table 1). When compared with counts derived from video recordings, counts from infrared beams and data loggers underestimated numbers of bats exiting Roost A and overestimated those leaving Roost B.

Table 1. The number of bats counted at two roosts using cameras and video recorders compared with the number of registrations logged by infrared (IR) beam and data loggers running simultaneously (data derived from Specht 2002).

	Days monitored									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Roost A										
Video recording	0	280	294	960	883	794	676	282	149	341
IR beam registrations	11	6	58	22	2	2	0	0	4	10
Roost B										
Video recording	128	-	207	109	0	0	0	0	0	0
IR beam registrations	245	137	386	171	9	0	1	0	0	0

Limitations and points to consider

It seems the accuracy of infrared beam counters is variable and they may not be effective in all situations. For example, at Roost A we noted there was very little bat activity recorded by the infrared beam system in comparison with the count derived from the video recorder (Table 1). In contrast, Specht (2002) noted that during a different sampling period at the same roost, the number of registrations logged by the infrared beam and data logger was closely correlated with the number of bats recorded on the videotape.

Accuracy is likely to vary in response to how well the exit hole is covered by the infrared beams, how many bats exit at a time, and how quickly they are flying. These results indicate that caution should be used when interpreting count data derived from infrared beams counters. These systems should be calibrated against video counts wherever possible.

References for case study A

Lloyd, B.D. 2002: The ecology and molecular ecology of the New Zealand lesser short-tailed bat *Mystacina tuberculata*. PhD thesis, Massey University, Palmerston North.

Specht, P. 2002: Short-tailed bat population census 2002. Unpublished report to the Department of Conservation, Ōhakune Field Centre.

Full details of technique and best practice

Types of counters in use

There are two types of infrared counters: passive and active. Passive infrared counters operate by detecting a moving object's infrared signature. Factors that determine the signature include the object's temperature relative to the background, its infrared reflective and emissive characteristics, and its size, speed of travel, and direction of travel relative to the counter.

The active counters use two systems, retro-reflective and through-beam systems. In retro-reflective systems, an infrared beam of light is emitted to a reflector. The reflector returns the light beam to a receiver which is housed in the same unit as the emitter. The size of the beam is roughly the diameter of the reflector. If the beam is broken, a count is registered and usually stored as a data point on a data logger. In the through-beam system, the emitter and receiver are housed in separate units. The emitter sends an infrared beam directly across to the receiver unit. Again, if the beam is broken, a count is registered. This configuration provides several advantages over the retro-reflective type. The beam travels only half the distance, enabling the beam to travel further and the unit to use less power for a given distance.

Both retro-reflective and through-beam active systems require an emitter to be mounted at one side of the exit hole and a receiver or a reflector at the other. The beam needs to be orientated to cover the biggest dimension of the hole. So, for example, for a roost with a vertical slit-shaped opening, the emitter and receiver are placed at the top and the bottom of the slit (Fig. 1). The two units need to be carefully aligned in order to function. Alternative systems using several beams can be used to cover larger holes, and double banks of beams have been used to detect flight direction (Thomas & LaVal 1988).

Through-beam active infrared counter systems have been trialled at lesser short-tailed bat tree roosts in Rangataua Forest, and to a limited degree in Eglinton Valley, Fiordland. One of the systems used in Rangataua Forest incorporated a Sunx BME-CY1 Thru-beam Infrared Sensor and a Datataker-5E Events Logger (4KB memory). The emitter and receiving sensors were mounted close to the roost entrance on fully-articulated brackets, with the infrared beam crossing the roost entrance. The data logger was mounted at the base of the roost tree in a waterproof housing. Amphenol plugs and sockets were used for connecting to the sensor and the battery, as well as for downloading data. The sensor was powered from a single 17 Ahr 12 V lead-acid gel-cell which needed to be replaced approximately every 8 weeks. Data was downloaded from the data loggers in the field using a laptop computer. The number of events in each 30-minute period was logged. With this logging interval, the data required downloading every 3 months.

Technology may well have improved since this system was created. The DOC Electronics Workshop (Research and Development Group) should be contacted to discuss new developments and options. Alternatively, there are commercially available systems. For example, see units made by Faunatech in Australia and TrailMaster in the USA. An example of a home-made system used for monitoring bats in artificial roost boxes can be found at www.zwergfledermaus.de. Please note that none of these systems have been trialled in New Zealand, so we cannot comment on their accuracy for counting bats. Commercial systems are likely to be far more expensive than any developed by DOC 'in house'.

The counters used in New Zealand seem to work fairly well at roosts with relatively small exit holes, and are useful for long-term monitoring of roost use. However, the accuracy of this method for obtaining counts of bats exiting and entering roosts is questionable and requires further assessment. Currently, the type of counters used in New Zealand can only provide a relative index of the number of bats exiting a roost because sometimes not all bats exiting roosts trigger the beam, and sometimes bats flying around the entrance can trigger the beam several times. However, count accuracy might be improved by using a different system, and counts from existing units could be adjusted if the infrared beam counter is calibrated and an error margin calculated. Calibration and error calculations can be achieved by running infrared beam counters and cameras/video recorders simultaneously at the same roost, then determining how closely the numbers of bats counted are correlated.

Recommendations for conducting counts

There are currently no standardised procedures for inventory and monitoring of bats at roosts using infrared beam counters. Best practice guidelines (see below) are aimed at providing practical advice to achieve the most accurate counts.

Best practice guidelines for using infrared beam counters

- Equipment must be tested before use in the field and users must be familiar with operating systems (setting timers, recording modes, etc.) and attachment systems before use in the field.
- General disturbance must be minimised at roosts sites, i.e. keep noise levels to a minimum.
- Vegetation obscuring exit holes must only be trimmed back if absolutely necessary, and trimming must be kept to a minimum.
- To achieve accurate counts, roosts must be checked for multiple exit holes, and multiple counters used if necessary.
- To achieve accurate counts, recording must begin at least 30 minutes before sunset for long-tailed bats, and at sunset for lesser short-tailed bats.
- Infrared beam counters should be calibrated by running infrared beam counters and cameras/video recorders simultaneously at the same roost, then determining how closely the numbers of bats counted are correlated.
- All equipment should be serviced and repaired at the end of each season.

References and further reading

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Unknown. Website of batworker in Kiel, Germany. Includes information on a home-developed infrared beam counter used to count bats using roost boxes, and presents some preliminary results. http://www.zwergfledermaus.de/index_e.html

Walsh, A.; Catto, C.; Hutson, A.M.; Racey, P.A.; Richardson, P.; Langton, S. 2001: The UK's bat monitoring programme. Department of Transport, the Environment and the Regions Contract Report CRO18, UK.

Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-132033	Bat Recovery Group contacts
docdm-590733	Bats: counting away from roosts—automatic bat detectors
docdm-590701	Bats: counting away from roosts—bat detectors on line transects
docdm-590789	Bats: exit counts at roosts—cameras and recorders
docdm-590804	Bats: exit counts at roosts—simple visual counts
docdm-590882	Bats: roost occupancy and indices of bat activity—field sign
docdm-211173	Blank forms for recording counts from IR beams at roosts
docdm-213179	Canterbury Conservancy bat database
docdm-131465	DOC best practice manual of conservation techniques for bats
docdm-590958	Introduction to bat monitoring
docdm-213136	National bat database template
docdm-146272	Standard inventory and monitoring project plan