AUTOMATED MONITORING OF BAT ACTIVITY

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ABSTRACT

An inexpensive infrared interrupting beam counting system can be used to monitor the activity of bats leaving and returning to a roost and can be constructed from readily available parts. It offers the advantages of collecting data over many nights with no human presence which may disturb patterns of activity. It also provides a simple method of determining long term trends in bat populations and usage that is independent of observer biases. Such a system can be used to make reliable estimates of the number of bats in many instances.

INTRODUCTION

Knowledge of the types and numbers of bats utilizing a roost is an important parameter on which most bat management is based. Traditionally the size of the population and species identification was performed by entering the cave, capturing bats for identification and estimating the total population based on either a manual count or estimating the area covered by bats. These methods are time consuming and require a person skilled in identifying bats and making reliable population estimates. Such methods have also led to major disturbance of roosts and should be used infrequently. In recent years workers have used sophisticated night vision equipment, infrared or star-light scopes to observe and count the numbers of bats exiting a cave. Such methods can provide reliable estimates of the population size, activity and in some instances species identification with reduced disturbance. These methods have the drawback of being expensive both in terms of specialized equipment and trained personnel. It is also questionable whether occasional observations provide a true indication of bat populations or roost utilization. A particular site may be important to bats only during migration or as a night roost. The size of bat populations and activity may also fluctuate due to weather, moonlight, prey abundance and presence of observers.

An inexpensive solution to these problems has been used as part of the ongoing study of bats at Kartchner Caverns State Park in Arizona. Here an infrared beam of light is projected across a small passageway used by the bats. As bats break the beam the interruption is recorded on a small computer (Figure 1). Kartchner Caverns is home to a maternity colony of several hundred myotis velifer bats during the summer. Studies of the bats which inhabit Kartchner Caverns have been conducted since 1988. In order to provide a more complete record of bat utilization an infrared beam counter was installed at the cave in 1992. The bats must traverse a series of small constrictions as they enter or leave the cave. This makes it possible to install an infrared beam across one of the smaller passages and automatically count bats as they leave and return to the cave. The beam counter was installed in the "Blockade Room" approximately 50 feet from the entrance. The passage at this location is approximately 18 inches high and 12 inches wide at the widest. The infrared beam is oriented vertically along the center of the passage. In this location it appears reasonable to assume that any bat leaving or entering the cave would break the beam.

The original counter is a modified infrared beam burglar alarm detector designed for battery operation. It is readily available from Radio Shack electronic stores for less than $40. This unit produces a modulated infrared beam which is highly immune to interference from other light sources. One drawback to the detector is that the relay is closed for several seconds when the beam is broken. This limits the maximum counting speed to 5 or 6 bats per minute. Fortunately the long delay on the relay can be bypassed by tapping into the signal off the indicator LED. I used an optocoupler which allows the detector to be connected to the RS-232 port of a computer. The computer, a Radio Shack Model 100 is ideal for use this purpose because of its low power requirements and rugged design. A simple BASIC program logs the total number of counts which occur each minute to a file for later analysis. Data is recorded only during the night time hours to conserve memory. The computer has sufficient internal memory to save about two weeks of counts. The detector and computer draw a total of 100 milliamps at 12 volts. A deep cycle car battery provides sufficient power for approximately three weeks of unattended operation.

The detector and computer was tested by counting beam interruptions caused by blades from a rotating fan. This showed that the set-up was capable of counting 1200 interruptions per minute with an accuracy of 1 or 2 counts. In the original detector the infrared beam is reflected back to the detector by a plastic reflector. However at Kartchner the reflector is less than two feet from the detector and visual observations indicated that many bats were not being counted. This was found to be caused by bats flying close to the emitter in the small passage. While the beam was still being interrupted the intensity of the I.R. reflected off of the bat prevented the detector from registering the break. To overcome this problem the infrared emitter was detached from the detector and placed on the opposite side of the passage. This arrangement eliminates errors due to reflected I.R. and has proven to quite reliable.

During the summer of 1992 the infrared beam counter was in place from April 21 to October 21. During this time the counter was in operation for 148 of the 184 days (80% of the time.) The most common problem was not being able to schedule trips for battery replacement before it had totally run down. Results for a single night are shown in Figure 2. Here the number of counts during each minute is plotted for the entire night. The exit flight shows up as a sharp peak at 19:00, activity remains low until 4:00 in the morning when there is a broad peak of activity as bats return. The counter allows us to collect considerably more data than can be done with manual methods. The automated system makes counts each day independent of the weather or other variables. The data on time of emergence shows a much more definite pattern over the course of the summer, Figure 3. This plot shows that the time of emergence varies from slightly before sunset early and late in the year to much later than sunset during the middle of the summer.

In order to determine if the I.R. counter could be used to make reliable estimates of the bat population manual counts of the bat exit flight were made on 33 dates from May 10 to October 4 . The entrance sinkhole of Kartchner Caverns is ideally situated to allow accurate counts of the exit flight to be made as bats leaving the cave are silhouetted against the sky. Visual counts were tallied on a laptop computer which recorded the exit time of each bat to the nearest second. On nine occasions there were two independent observers counting the exit flight. The average discrepancy between the two visual counts was 3% with a maximum discrepancy of 8.5%.

A comparison of the counts recorded by the I.R. counter and the visual counts (Figure 4) shows that they have the same overall shape and that the I.R. counter records approximately 4 to 5 counts per night for each bat which was seen to exit the cave. This appears reasonable if we assume that each bat makes two trips out of the cave per night, crossing the beam a total of four times. Visual counts were then used to develop a correlation between the values recorded with the infrared beam counter and the number of bats observed.

Visual to I.R. Exit Count
Visual = 0.735 X I.R. Exit + 23
Corr = 0.89 n=23
F=71.46 P=0.0000

Visual to I.R. Return Count
Visual = 0.948 X I.R. return + 104
Corr = 0.93 n=21
F=115.39 P=0.0000

Visual to Total Night I.R. Count
Visual = 0.244 X I.R. total -14
Corr = 0.96 n=24
F=210.9 P=0.0000

Visual to Preceding Morning's I.R. Return Count

Visual = 0.870 X I.R. Preceding Morning -113
Corr = 0.911 n=18
F=78.26 P=0.0000

The best correlation is between the exit visual count and the total nightly I.R. count. The exit and return correlations show that the I.R. counter records more counts than the observed number of bats in each case. In the evening exit flight the I.R. detector counts about 36% more counts than bats. This is not unexpected as the bats frequently make several test flights before deciding that it is safe and dark enough to leave the cave. The counts recorded for the morning return flight correspond much more closely to the observed number of bats leaving the cave the previous evening. The I.R. detector records about 5% more counts than bats. This is apparently due to less in and out activity by the returning bats. These correlations are useable only for the set-up used at Kartchner Caverns, a separate calibration would be necessary for each location.

The concept of using an interruptable beam to monitor the activity of bats is not new, it has been used by a number of European researchers in the last 30 years. While the concept appears to be quite simple some researchers have raised questions about the method. The counter use at Kartchner Caverns counts only each break of the beam and does not indicate whether a bat is leaving or entering the cave. For this reason the counts may seem to be only roughly correlated to the true number of bats. There are many other sources of errors. A bats may make several passes through the beam before deciding to leave the cave. Several bats may cross the beam at the same instant and produce a single count. The beam may also be broken several times by the tip of a beating wing, producing multiple counts from the same bat. Despite all of these possible sources of false counts the results do show an excellent correlation to the number of bats counted visually.

A second problem encountered with single beam counters is the inability to resolve multiple bats which exit at the same time. Two or more bats may break the beam simultaneously and produce a single count. This error increases for higher numbers of bats. It is possible to statistically correct the count for this type of error. If bats are assumed to leave at random intervals (over a short time period) and the average time the beam is blocked by a single bat is known, then a statistical correction factor can be calculated. As can be seen in Figure 5 the correction is quite small for rates of less than several hundred bats per minute.

Even without calibrating the I.R. counter with a visual count a reasonable approximation of the true number of bats can be made based on the geometry of the opening. For large numbers of bats the counter can be considered as "sampling" a section of the opening. The area being sampled is the distance between the emitter and detector times the average wingspan of the bats. The true number of bats is then the ratio of the sample area to the passage cross sectional area times the infrared count. This method can be further refined by estimating the area of the passage which is actually used by the bats. Bats typically will avoid flying close to the walls and floor. The usable area of the passage can be estimated by subtracting out these avoidance areas (Figure 6). It is also better to orientate the beam in a vertical direction rather than horizontally across the opening as many bat flights are vertically stratified. While it may appear that many assumptions need to be made these are compensated for by the fact that this is usually only necessary for large roosts.

Here the large number of bats exiting produces a more statistically uniform flight which is more in line with the assumptions.

Overall the beam counter system installed at Kartchner Caverns has shown that valuable data can be collected from a simple low cost system. The system has the following advantages:

* The system is reasonably low cost, a digital readout system could be assembled for approximately $100. A system utilizing a small computer could be assembled for approximately $500.

* By utilizing the exact same beam location useful long-term population trends can be followed. The method is reproducible and counts are independent of observer bias.

* Correlation's with visual counts allows the counter to be used to estimate the population size. Where visual counts are not available the population size can be reasonably estimated from the number of counts and passage geometry.

* Multiple days of data allow the effect of human disturbance and natural fluctuations in population size to be differentiated.

* The counters are inexpensive enough to allow several sites to be monitored simultaneously with multiple counters. This allows small bat populations to be economically monitored.

* The equipment is simple, readily available and quite reliable.

It should also be remembered that a beam counter has the following disadvantages:

* A beam counter cannot distinguish between different species of bats.

* Changes in the number of counts can be caused by changes in the number of bats or by changes in activity patterns. The system records beam interruptions not individual bats.

* The current system does not indicate the direction of travel of the bat.

* The beam may be broken by other animals using the cave. When mounted vertically the beam could be broken by an animal as small as a cave cricket.

* Two or more bats which overlap will produce a single count. At higher flight densities the likelihood of overlapping bats increases but can be statistically corrected.

OTHER POSSIBILITIES:

The beam counter used at Kartchner Caverns used a computer to record counts at one minute intervals. The computer can be replaced by a simple electronic counter which will keep a running total. While this provides less information about the time distribution of bat activity it is considerably less expensive and still provides qualitative information about the number of bats. Additionally the computer uses a large proportion of the battery power. A simple beam counter and electronic counting module can be made which will run for several days off a 9 volt battery.

For use in other locations a set of I.R. emitter and detector were constructed from commonly available electronic components. These have the advantage of being smaller and are capable of operating off of a 9 volt battery for several days. The emitter and detector can be separated by as much as 70 feet. By adding a simple 2" lens to the detector the range can be further increase to several hundred feet.

Directional counting. By adding a few simple circuits the direction of travel, out of or into the cave can be determined. This may allow for a more accurate determination of the number of bats. It will also double the amount of data that must be collected. Such a system may not be as accurate as a single beam arrangement.

The use of an infrared beam counter is not limited to use at a cave. An infrared beam can be projected several hundred feet. This would enable us to monitor the activity of bats in other habitats. A beam counter could be installed across a pond where bats come to drink or between the walls of a canyon. In either case such a counter would provide information on the use of a specific area by all bats not just those who roost together in a large colony. Multiple beam counters at different elevations would provide information about the spatial distribution of bats. Long term monitoring from fixed locations could provide evidence for general population trends over several years.

Figure 1 - Initial I.R. Beam Counter Set-up

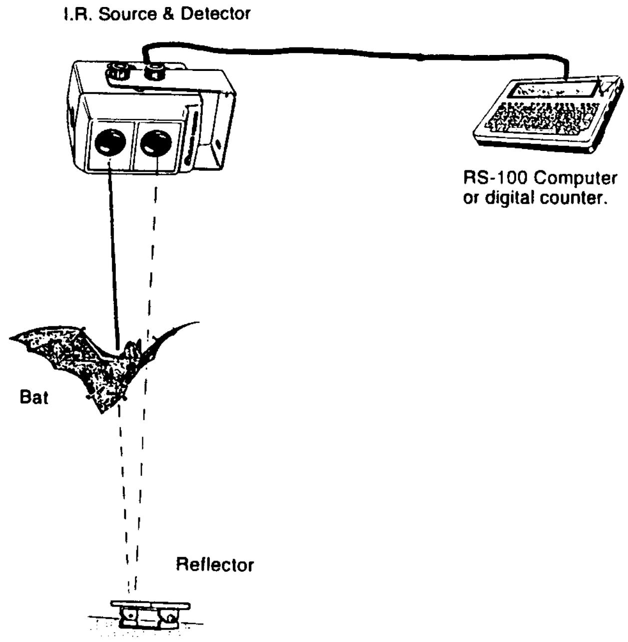


Figure 2 - Typical All Night Plot Of Bat Activity

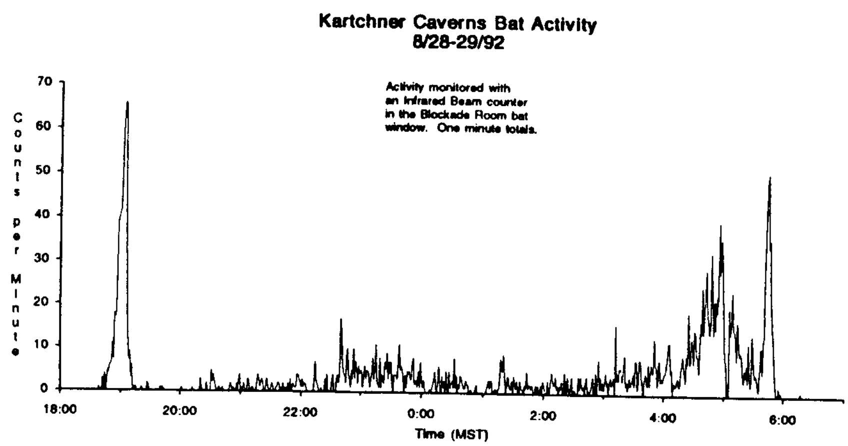
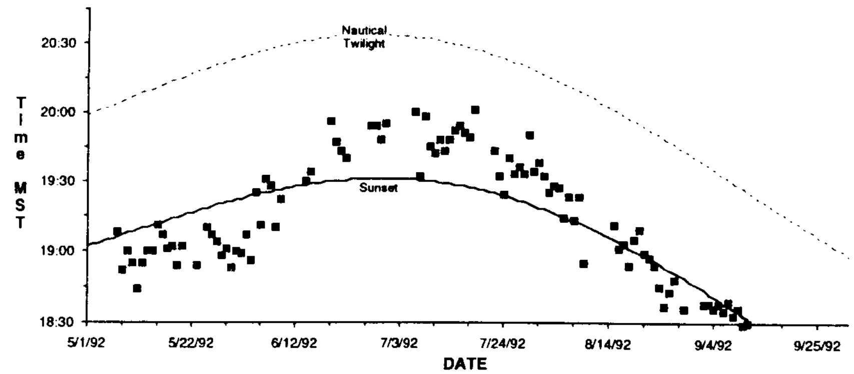


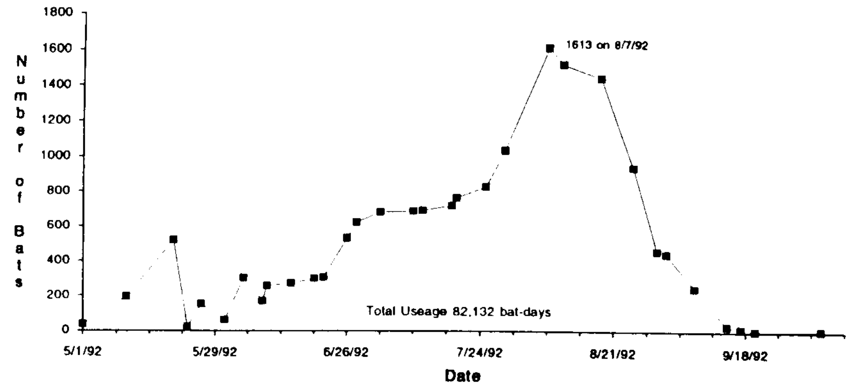
Figure 3

Kartchner Caverns - I.R. Counter
Bat Exit Times in Blockade Room



Visual Counts

Kartchner Caverns Bat Exit Counts 1992



I.R. Beam Counter

Kartchner Caverns Bat Activity
Infrared Beam Counter at Blockade Room
Total Nightly Activity

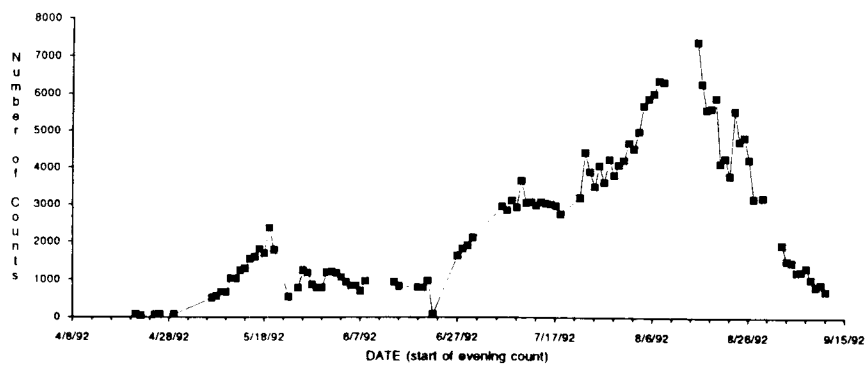


Figure 4 - Comparison of Visual Counts To I.R. Counter

Figure 5

Correction for Simultaneous Counts

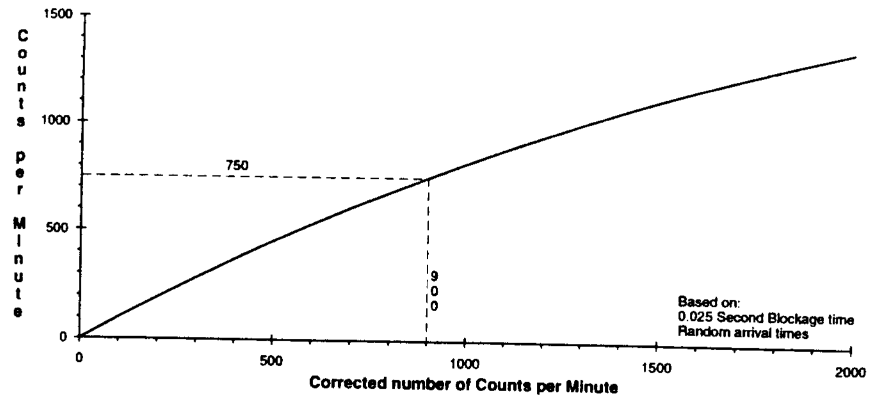
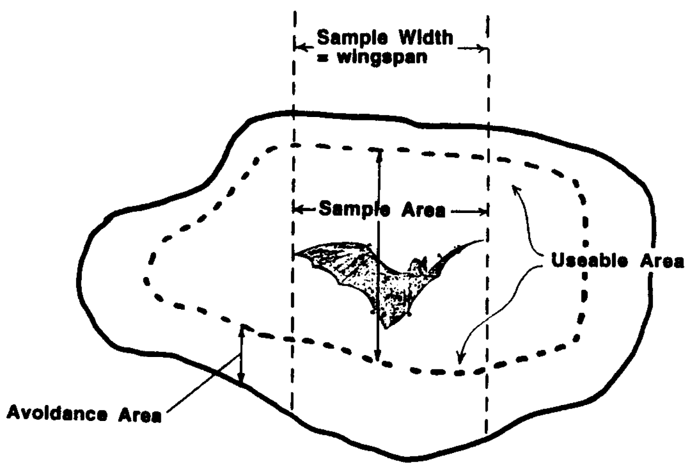


Figure 6 - Area of Passageway Utilized by Bats



Total Number = Corrected Count X Factor $\left(\frac{\text{useable area}}{\text{sample area}}\right)$

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