Heated and Insulated Bat-box

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The bat is a protected species group in many countries. Many die over the winter from cold or starvation. Bats hibernate over winter, and this requires an environment with an ambient temperature between -2°C and +10°C, (28°F – 50°F). Below -2°C they freeze to death because, whilst hibernating, their metabolism is so slow that they cannot generate enough heat to stop body fluids from freezing. Above 10°C their metabolic rate rises and they may wake up from hibernation; then their metabolism speeds up and they need to feed, but at 10°C in winter there are few, if any, of their insect prey flying, so they burn energy without having the means of recovering it. Many die of starvation during a mild spell in winter.

Most of the information in this document refers specifically to British bats. If you want to help bat conservation in another country, please research the data for your country's native bats to get the correct values for the variable parameters discussed below.

Bats spend a big part of the year hibernating. They like to hang by their feet, head down, in a space that they consider safe from predators. When threatened by a predator, it can take a bat around twenty minutes to wake up from hibernation; they have to raise their core temperature from 2°C to 38°C before they can fly properly. A predator can devastate a colony of bats in a roost long before they are awake enough to escape. For this reason, the bat box entrance must be at least 3m, (10ft), above the ground and any place that a predator could reach, which may include windowsills, ivy or creeper, tree branches touching the wall the box is mounted on, waste pipes, trellises. Rooves and roof guttering can also be a risk for predator access; the bat-box should be at least 1m, (3ft 4in), clear of such items. If the roof has an overhang beyond the wall and where there is a downward-facing soffit, this adds to the security. If you make an excellent bat box then mount it in a place the bats consider unsafe, it will not be used.

I have designed a heated and insulated bat-box that will allow bats to survive in climates where many would die over the winter but where there is plentiful insect prey during the summer months. This should extend the range of habitats served by bats. In my area, midges and other blood-sucking insects are a problem; their numbers rise enormously during the late summer, especially after the swallows have flown, and I suffer itchy bites all over my body, each of which torments me for many days. Bats, especially the smallest ones, pipistrelles, include midges in their diet and help to keep the numbers down, but bats do not survive well in this area: we can get temperatures that stay below -5°C, (23°F), all day for several weeks, and can drop below -20°C, (-4°F), overnight. We also get the occasional mild spell in winter with temperatures that go over 12°C, (54°F).

Providing this heated and insulated bat-box is a quid pro quo: if I provide a comfortable and safe home for the bats, the midge numbers in my garden and surrounding areas reduce significantly. The electricity cost is minimal, (I have estimated about 20 kWh per year in the worst winters and less than 5 kWh in most), and solar panels or a small rooftop wind turbine, (or both) could generate all the power required. The insulation means that only a prolonged mild spell in winter would wake them up from hibernation. The optimum hibernation temperature for bats is a core temperature of 2°C, which requires an air temperature in the roost-box above 0°C; below 1°C, (core), their metabolic rate increases to try to prevent freezing; above 4°C their metabolic rate rises as the depth of hibernation decreases. The heater only comes on if the temperature inside the roost box drops below 0.3°C.

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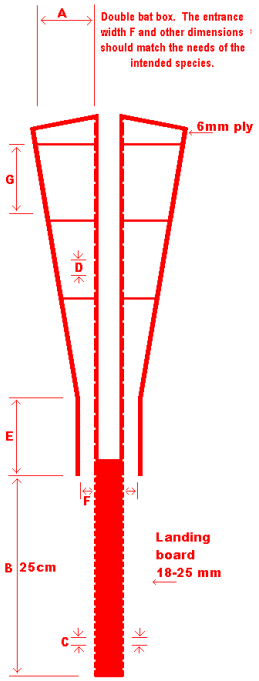
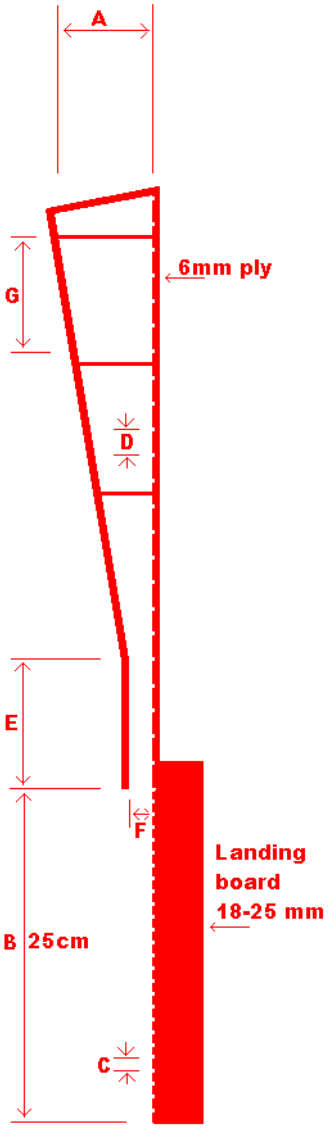
Roost-box:

In the diagrams, the roost box and all bat-contact areas are shown in red. There are many British species of bat, and the dimensions of the roost box should match the needs of the species it is designed for. If you wish to make a single heated and insulated bat-box to serve multiple species with different needs, two or more roost boxes could be built within the same heated and insulated enclosure. For a back-to back landing board, the box should be mounted perpendicular to the wall so that the bats have easy access to fly to both sides of the landing board.





The front, back and top of the roost box should be made of thin plywood: 6mm, (¼in), is proposed. This is thick enough to enable the ladder grooves to be cut into it, but thin enough to allow the heater to do its job effectively. The sides of the roost box do not need to transmit heat from the heater, and may be of thicker timber that will provide the dimensional stability and robustness needed. The internal width of the roost box is 30cm, (1ft); this is to match the size of the heating element.

Entrance: The entrance needs to be a slot at the bottom, (F in diagram). They excrete as they hang from the top of the box, and the excreta drops out of the entrance slot onto the ground beneath. The largest of the British bats is the Noctule Bat. It requires an entrance slot of 21mm, (0.83in). The smallest is the Pipistrelle, which requires an entrance slot of 12mm, (0.47in). The other British bat species all require an entrance slot of 17mm, (0.63in). If the entrance is too large, bigger bats can take over roost space from the smaller ones, and predators can more easily gain access. The entrance slot extends downwards for the full insulation thickness, (E, more detail below).

Landing board: There should be a landing board at the bottom of the box facing away from the wall that it is hanging on. This board should be a vertical piece of wood the full width of the bat box entrance and about 25cm, (10in), high. It works best if it is covered in horizontal grooves 1-2mm, (0.04 – 0.08in), deep and the full width of the board. The spacing of the grooves is C in the diagram. For pipistrelles, the grooves should be about 10mm, (0.4in), apart, for the others 15mm, (0.6in). These grooves, as well as providing something to hold onto when they land, also form a ladder for them to climb through the entrance slot into the roost.

Ladder grooves: Within the box, the grooves may be further apart, (D in diagram), once they have landed they can reach up to climb. They should be about 20 mm, (0.8in), apart for pipistrelles, 30mm, (1.2in), for the other species and continuing right up the back wall to the top.

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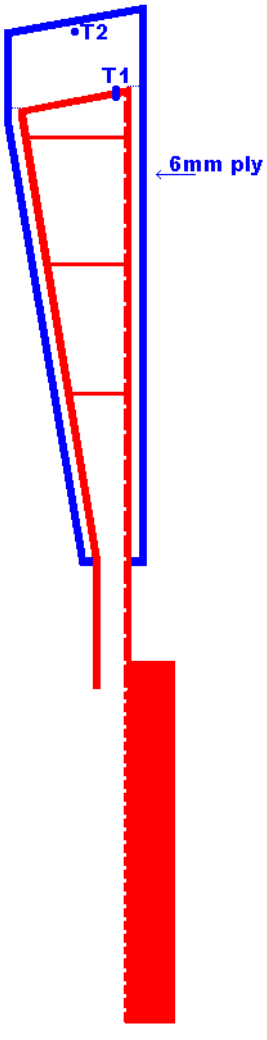
Roosting space: Inside the box, the roosting space may be larger than the entrance slot, up to 8 times bigger front to back, but not too big, as they like to be close together when hibernating, (A in diagram).

Hanging perch: A set of thin wooden dowels spanning from front to back can provide a comfortable perch to hang from. Dowels for pipistrelle should be 1-4mm, (0.04-0.16in), diameter, or 2-6mm, (0.08-0.25in), for the larger bats; cocktail sticks or wooden kebab skewers can be used. They should be spaced 2-3cm, (0.8-1.2in), apart right across the width about 2mm, (0.08in), below the ceiling for pipistrelles, 4-5mm, (0.14-0.2in), for the others. There may be other rows of these dowels lower down, leaving about 7cm, (3in), between rows for pipistrelles or 10-12 cm, (4-5in), for the larger bats. There should be gaps between the dowels on each lower row of about 2½ times the spacing on the top-most row. This allows those whose roosting place is higher up to climb through the lower rows when they need to go outside to feed or fly.

Front wall of roost box: The front wall is sloping inwards towards the entrance slot. Excrement will fall on this sloping surface, which must be designed to cope with this. There are two alternatives:

1. It should have a slope of no more than 10° from the vertical and be covered with a sheet of PTFE-coated reusable baking liner.
2. It should have a slope of no more than 5° from the vertical, and the plywood needs to be protected from the damaging effects of this excrement. Bats cannot tolerate most of the available varnishes and waterproof surface treatments, but it is possible to obtain a completely aroma-free waterproof but water-based wood glue, (PVA). Diluted 2:1 with water, this glue makes a thin varnish that will protect this surface. Once it has dried for 24 hours, it has no smell and will not disturb the bats.



Heater enclosure and temperature control:

Heater: Everything to do with the temperature and heater enclosure is shown in blue in the diagrams. It is possible to obtain 12v heating foil 30 cm wide with a rating of 150W/m^2. This foil is designed for underfloor heating in caravans and camper vans. For a roost box of 30cm wide and 50cm high with a panel of this foil at front and back, this would give a heat input of 55W. This is far too much for our purpose and it is proposed to wire the two panels in series to provide a total heat input of 11.25W from a 12v supply.

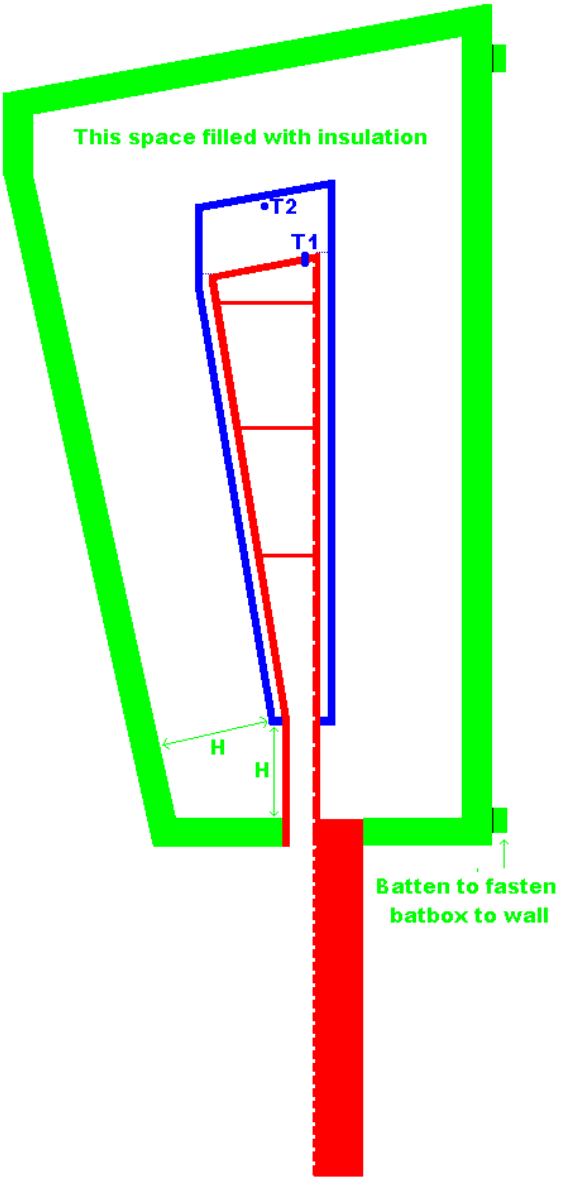
Warning: The German company I ordered this heater foil from provided a 1m length of foil with one set of connections. I needed to cut this foil in half and so required a second set of connections. A second connection set was available, but I didn't discover this until after the delivery of the foil; as a consequence I had to pay a second delivery fee from Germany. If I had ordered both at the same time, I could have saved some money and time.

Temperature sensors: In the diagram, the two items labelled T1 and T2 are the temperature sensors for the two thermostats. T1 measures the temperature at the top of the roost box and T2 measures the temperature at the top of the heater enclosure. Each is wired to a 12v thermostat. T1 will switch the heater on if

the temperature at the top of the roost box drops below 0.3°C, (33°F); T2 will switch the heater off if the temperature at the top of the heater enclosure rises above 2°C, (36°F).

The temperature sensors that are an integral part of the commercially available thermostats typically have just 1m, (3ft 4in), of cable. The sensor is a thermistor with a resistance at 20°C of about 10kΩ; this cable can easily be extended using telephone extension cable or bell-wire, (but be sure to maintain the correct polarity), so that the thermostats can be installed in a convenient position for monitoring them.

Materials of construction: The front, back and top of the heater enclosure can be made of 6mm, (¼in) plywood. The sides of the heater enclosure may be of thicker timber that will provide the dimensional stability and robustness needed. This may be fastened to the ends of the roost box, or, by using a router to provide a rebate or groove, may use the same piece of wood. It is suggested that the cables could be brought out of the side of the whole enclosure via a small flexible tube that acts as a conduit into a separate weatherproof terminal box that covers and protects the hole in the wall that the wires must pass through.



Access for maintenance: All of the electrical items are accessible via the top of the heater enclosure, which should have a detachable or hinged lid. In the event of a fault, this will allow maintenance of the electrics without disturbing the bats. This lid may be fastened with catches to hold a tight seal onto the enclosure.

Insulation and weatherproof outer shell:

The insulation box is shown in green in the diagrams. It should be airtight as any draughts can seriously compromise the insulation properties of the material.

Insulation material: The insulation material should project below the heated roost space, and for this reason the entrance slot is extended downwards for the same distance (H) as the insulation thickness.

Access for maintenance: The top lid needs to be removable or hinged to allow access to repair the electrical equipment in the event of a fault. There may be sealing strips on the mating surfaces that are lightly compressed by the catches that hold the lid closed. The insulation material should be constructed to fold back to facilitate maintenance without disturbing the bats. Bear in mind that this work will be done at the top of a ladder.

Materials for the outer shell: If you want to use pressure treated timber for the outer shell, all surfaces need to be fully exposed to the air for at least six months before use, or the lingering smell will keep the bats away. Cedar cladding is weatherproof but tends to be draughty, so a layer of marine ply covered by cedar cladding may be used. The joints in the marine ply should be sealed against draughts with the same weatherproof wood glue as mentioned above, (front wall

of roost-box). It has no smell after 24 hours of setting in a dry place, and will not disturb the bats.

The top may have slates to keep the rain out, but avoid using roofing felt, as the tarry smell lingers for years and will be distressing for the bats. A sheet of tough polythene under the slates may be used as the bats will not smell this. Lead may also be used.

Insulation Materials: There are several possible insulation materials that may be considered.

- The most effective is a composite material generically called “multilayer foil insulation” and names like “Thinsulex” and “Superquilt” are used commercially. The thickness required for the bat box gives the dimension H on the diagrams. The material is 30mm, (1.2in), thick with a λ value of 0.018 Wm^2/K, and for the bat box we are aiming for a λ value of 0.01, so we need a double layer; H needs to be 60mm, (2.4in).
- Sheep’s wool is often obtainable relatively cheaply in rural areas. A dirty fleece needs to be washed thoroughly before it is used. Sheep’s wool insulation can be purchased in rolls of 25mm, (1in), thickness giving a λ value of about 0.034. This means that you will need 3 or 4 layers so H is 75mm, (3in) or 100mm, (4in).
- Rock-wool or glass wool give λ values of around 0.02 for a 100mm, (4in) thickness so we need about 200mm, (8in), for H.

Do not be tempted to compress the insulation material, as this will compromise its performance.

Wall attachment: The box needs to be attached to wall and for this, a pair of horizontal battens at top and bottom of the insulation box are proposed, projecting about 30mm each side of the box. Alternatively, steel or aluminium brackets may be used, (but if you are close enough to the sea for salt-spray corrosion to be a problem, you should use stainless steel).

Power supply and circuitry:

Safety: For the safety of the bats and of the personnel caring for them, everything is powered at 12v DC. 12v DC can be provided in many ways and the choice should take into account the availability of renewable energy, the reliability of the local mains power supply and how much you are willing to spend. For this reason, the circuit shown has a number of options that can be added or omitted as you decide. The essential items are shown in black, the rest in colours.

When doing maintenance on the heaters, disconnect the battery by removing the fuse, or an accidental short circuit will cost you a new fuse.

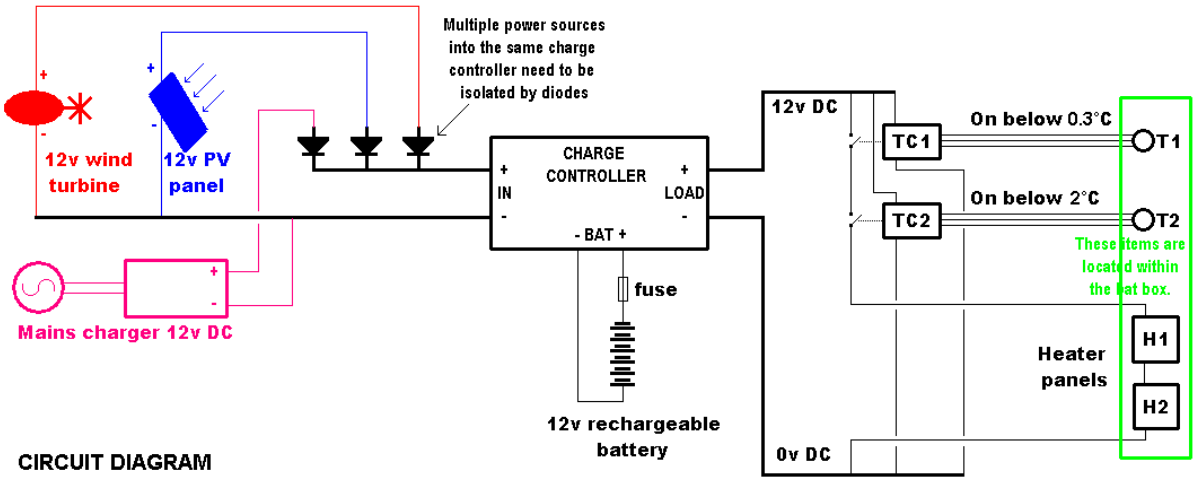
Rechargeable battery: I have included a rechargeable battery as an essential item, as everyone is aware of the potential for mains power failure in winter, especially during the sort of extreme weather that is becoming more common and which also threatens the bats’ survival. Several types of battery are available. The simple lead-acid battery found in cars and boats can be used and needs no complex charge management circuitry. The best batteries for this purpose are lithium based, and many of those used for renewable energy conservation have built-in charge management circuitry; however, they tend to be very expensive. Please be very careful to follow the manufacturer’s advice on the charging circuitry for these batteries as overcharging can lead to overheating of the battery, which shortens its life and may lead to leakage of the electrolyte, a dangerous and messy event. Also, some types of lithium batteries must never be fully discharged as they may not recover their ability to hold charge. If the

battery is located outside, it should be in a ventilated but weatherproof plastic box. If it is inside, it should be in a plastic tray that will stand an electrolyte spill, and in a ventilated room, or in a covered box with a vent to the outside. If you have a very dependable mains electricity supply, you may consider the battery as optional.

Renewable energy: Small wind turbines are available for a moderate price. They should be mounted high up. The bats can easily detect them and so they do not pose a danger, however mounting one too close to the entrance to the bat box could frighten them and deter them from using it. The turbine blades should never intrude into their flight path to and from the landing board. Many wind turbines generate AC power and will need a rectifier to connect to the circuit shown. Photovoltaic panels are sold for charging 12v car batteries and these are entirely suitable for connecting directly into this circuit.

Mains charger: The mains charger should have sufficient capacity to charge the battery and power the thermostats. It does not need to have sufficient power to run the heater pads as this power is only intermittently required and comes from the battery. During the summer months when the bats are active, insects are available and their survival is not threatened, the mains power supply may be switched off. Some batteries will benefit from an occasional charge during the summer months – the battery manufacturer's guidelines should be followed. If you are using a lead-acid car battery, it is possible to switch the mains charger on automatically with a voltage-sensing switch when the battery voltage drops below about 11.6v. Thus mains power will only be used after a prolonged spell with low temperatures but no sunshine and little wind.

Charge Controller: Rechargeable lead-acid batteries last much longer if a charge controller is used; lithium batteries **must** have a charge controller. If you are using multiple renewable power sources, they should be isolated from one another by diodes or undesirable interactions can occur.



CIRCUIT DIAGRAM

A brief note for farmers with animal feed stores: bats can help prevent infestation of the stored feed by insects and mites.

Storage rooms for animal feedstuff are carefully designed to keep rats and mice out. However, other much smaller creatures, insects and mites, can get in and devastate the feed stocks. If bats can roost in the feed store, they will keep control of these harmful small creatures. The problem is: how to allow bats to enter and leave the store whilst preventing rodents from getting in.

The entrance for bats needs only a narrow slot, 12mm, (0.4in), high for pipistrelles, 17mm, (0.67in), for most British bats or 21mm, (0.83in), for noctules bats. A louvered slot that slopes outwards will help keep rain out. The entrance needs to be at least three times wider than the height, and provided with a grooved landing board about 25 cm, (10in), high below the entrance on both inside and outside. To prevent rodents from entering, the slot should be on a vertical surface more than 3m, (10ft), from the ground and surrounded by a smooth surface, (sheet metal or plastic), that extends 1.5m, (5ft), in every direction from the entrance and landing board. Even though the rodents can climb the wall to this height, (squirrels easily accomplish this), they cannot reach the bat entrance as they cannot grip the smooth sheet.

Placing one or more bat boxes among the rafters of the feed store will enable bats to protect the feed from infestation by insects and mites. If the feed store is naturally frost-free, (perhaps animals are over-wintered in the barn below), no heater is needed, otherwise the bat box may be designed as described above. The boxes should ideally be grouped together with a tarpaulin or plastic sheet underneath them to catch the excrement. The annual removal and cleaning or replacement of this sheet should be all the attention that this proposal requires.

A brief note for those owning or maintaining disused mine workings: Bats like to live in disused mines, the underground tunnels maintain an acceptable ambient temperature all year round, and the ancient wooden shoring and pit-props provide plentiful roost and brood spaces.

Bats also provide a useful service in that they keep the wooden pit-props and shoring free from wood-boring insects and thus prevent subsidence of the ground above the mine-shaft and workings. Unfortunately, many people cap the mine-shaft for reasons of personnel safety without considering the needs of bats. Bats do not return to most disused mines whose shafts are capped unless special provision is made for bat access. The reason is that mine authorities tend to provide tall hollow vent-stacks to ensure ventilation of the mine workings as this reduces the risk of spontaneous combustion of underground coal seams. The reason that bats do not return is that the ventilation stacks are too high, (often 15-20m, 50-75ft), and too narrow, (0.8m, 32in), for the bats to use.

Most bats cannot fly through a vertical stack with a diameter of less than 2m, (6ft 8in), (2.6m or 9ft for noctules). They need to fly in a spiral to gain height, and their wings clip the sides and the wing-tips of other bats on the far side of the spiral. Bats are equipped for high-speed manoeuvrability, but it is far too exhausting to fly vertically rather than in a spiral, over any significant vertical distance. By providing a louvered bat entrance as described above, (see: animal feed stores), between 3m and 4m, (10-20ft), above the ground, and keeping the stack diameter to the recommended diameter up to this point, bats will willingly return to disused mines. The stack can be tapered to a smaller diameter above the bat entrance; a tapered vent stack will be more stable in high winds than a cylindrical one. Although the underground temperature is often a little above their ideal hibernation temperature, many insects seek to overwinter in the dry and temperate conditions and the bats can thus feed all year round without venturing into the winter weather during their more frequent awakenings from hibernation.

A brief note for those doing research into bats: Some of my own observations suggest that bats may be able to see a long way into the infrared spectrum. As they manoeuvre towards flying insect prey even in total darkness, the last 10cm or so seems

to be guided visually rather than by acoustic echoes. If you wish to video their activities inside the roost boxes using infrared illumination, you may find that near infra-red sources may cause them to leave the roost, and that you need to go a long way into the far infra-red for them to remain undisturbed.