BAT ROOSTS IN THE ALPINE AREA: GUIDELINES FOR THE RENOVATION OF BUILDINGS

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WE WOULD VERY MUCH LIKE TO EXTEND OUR WARMEST THANKS TO ALL OF THEM, NOT LEAST FOR THE HUGE AMOUNT OF TIME THEY HAVE INVESTED IN THIS PROJECT!

Table of contents

1 Introduction

Many bat species in the alpine area almost invariably make use of the insides of buildings or their external fittings for their nurseries. Among them are some of those listed in Appendix II of the EU's Fauna-Flora Habitat Guidelines, such as the greater horseshoe bat (*Rhinolophus ferrumequinum*), the lesser horseshoe bat (*Rhinolophus hipposideros*), the lesser mouse-eared bat (*Myotis bythii*), the greater mouse-eared bat (*Myotis myotis*), and the Geoffroy's bat (*Myotis emarginatus*). When buildings are rebuilt or altered, or when there are disturbances, their roosting places are seriously jeopardised and so too are the bats themselves.

Because of its near-natural state and its varied climate and landscape, the alpine area is characterised by a fauna rich in bat species. However, many species here are heavily dependent on buildings for their roosting places. This is because natural hiding places have become rare in woodlands as a result of particular forms of cultivation. Caves are not suitable for raising the young because of the alpine area's climate – this is in contrast with Southern Europe where caves are important roosting places in the summer months. Indeed, places at higher altitudes in the alpine area are characterised by particularly high percentages of buildings that accommodate bat roosts (HOLZHAIDER & ZAHN 2001). In the alpine area some bat species, such as the greater mouse-eared bat, fly every day to hunting grounds that are up to 20 km away (GÜTTINGER 1997). This means that the loss of roosting places in buildings can be of decisive significance for the bat population in large areas. Consequently, if bat fauna in the alpine area is to be permanently preserved, it is all the more important that roosting places are preserved in such locations, when buildings are renovated or rebuilt.

Measures have been, and continue to be, put in place in various countries to monitor building works from the point of view of bat studies. In this way, it has already been possible to accumulate experience about preserving roosting places during the course of renovation and rebuilding. Yet, most of this work has at best been only partially documented or published and at worst not at all (the so-called "Grey Literature"). It is therefore not available to a broader circle of users.

The first key works dealing with this subject came from Switzerland (BLANT 1992), Belgium (FAIRON et al. 2002), and England (MITCHELL-JONES 2004). However, these works place their main emphasis on procedures for the general conservation of buildings (BLANT 1992, MITCHELL-JONES 2004) or on the implementation of such measures (FAIRON et al. 2002). The task of this present study is to deal with the effects of renovation, as seen from the point of the species, and in the process to give specific definition to a framework of conditions for renovation work.

The target group for these guidelines are bat experts. If the requirements of the laws covering the protection of bats in Europe are to be met in full, every single renovation project for a building that accommodates a bat roosting place will need to be monitored by experienced bat experts. These guidelines are no substitute either for scientific knowledge about the biology and ecology of bats, or for familiarity with methods of studying or dealing with bats. It is by no means the case that these guidelines will equip persons lacking specialist knowledge of bats professionally to execute renovation work on buildings accommodating bat roosts. It should also be borne in mind that renovation work on bat roosting places requires authorisation under laws covering the protection of nature – according to the legislation of the particular country in question. Persons monitoring renovation work from the point of view of the study of bats, or who enter bat roosting places in the course of such work, need authorisation under the laws governing the protection of nature. Drafting of conservation proposals must be carried out in close consultation with the appropriate nature conservation authorities.

The strong element of trans-regional co-operation involved in this Arge Alp INTERREG IIIB project gives it a sufficiently broad discussion-base. The increased number of case studies associated with

this breadth makes it possible to reach more precise conclusions about individual bat species as well as about regional differences in the ecology of the roosting places of the various species, and in construction designs and the level to which bat conservation has developed.

1.1 Project aims

The aim of the project is to provide an overall summary of current specialist knowledge and established experience as regards the renovation of buildings that accommodate bat roosting places. This will be made available to bat experts in form of guidelines.

In a helpful and concise format, these guidelines should provide bat experts with essential information about the ecology of the roosting places of the species concerned. They should also give a catalogue of examples and established experience. Finally they should provide a procedural framework for the successful renovation of buildings accommodating bat roosting places.

2 Materials and methods

2.1 Literature search

A first step was to write to all bat specialists working within the field of investigation and to request copies of their in-house reports and/or publications pertaining to renovation work for buildings with bat roosts or to bats' roosting needs.

The second step was to search the specialist literature for published articles about the subject. These were, for example, learned journals, anthologies about the bat and/or mammal fauna in the various regions, annual reports from the co-ordination centres, conference transcripts and Diploma and Doctoral theses.

2.2 Questionnaires

To provide a record of renovation projects that had not been documented in writing, a questionnaire was devised (see appendix) and sent to the appropriate professionals. In the first place, this was intended to give an indication as to which were the important factors in renovation projects. It was a means whereby reports and publications could be supplemented and/or confirmed, as the case may be.

2.3 Workshops

To tap into colleagues' wider expertise and as a way of subjecting procedures and methodologies to critical scrutiny, the authors organised the following three workshops on their field of study:

- 1st-3rd April 2005: Tuebingen, FRG; as part of the BAG Bat Conservation Conference at NABU
- 28th-29th April 2005: Trento, Italy; as part of an International Conference on “Bats and their Conservation in the Alps” (INTERREG IIIB - living space network)
- 21st-26th August 2005: Galway, Ireland; as part of the 10th European Bat Research symposium (EBRS)

The feedback from these events gave added confirmation of the subject’s topicality and the essential importance of the work. It also provided an opportunity to collect helpful comments and further information.

A. ZAHN also gave a lecture about the project in Munich on 12th March 2005, at the Bat Conservationists’ annual conference in South Bavaria.

2.4 Procedures

Using the literature search and an evaluation of the questionnaires, the roosting needs of individual species were summarised in so far as possible. Potentially critical as well as less critical factors in relation to building renovation were identified.

These "hypotheses" relating to the individual species were sent to the bat experts, with a request for constructive criticisms. After taking all proposed modifications into consideration, a last fine tuning was undertaken.

3 Data bases

The present work was able to draw upon more than 230 case studies. For the most part, they came from the alpine area: mainly from Bavaria and Switzerland but also from Austria and Italy. Further supplementary studies came particularly from England but also from other European regions.

The greatest proportion (33%) of the building renovation studies related to the roosting places of greater mouse-eared bats (*Myotis myotis)*, and mixed colonies of greater and lesser mouse-eared bats (*Myotis bythii).* For all other species fewer (and in some instances very few) documented studies were available (Tab. 3-1).

Nevertheless, in the cases of almost all the bat species in the alpine area that roost in buildings, it was possible to invoke an existing body of experience. The only exceptions were the Kuhl's pipistrelle bat (*Pipistrellus kuhlii*), the Savi's pipistrelle bat (*Hypsugo savii*) and the Nathusius' pipistrelle bat (*Pipistrellus nathusii*), for which no documented building renovation cases could be found.

Data bases for the individual bat species			
Species	**Number of questionnaires**	**Number of further case studies**	**Total**
Greater mouse-eared bat, *Myotis myotis*[1]	15	63	78
Brown long-eared bat, *Plecotus auritus*	3	19	22
Lesser horseshoe bat, *Rhinolophus hipposideros*	3	18	20
Common Pipistrelle, *Pipistrellus pipistrellus*	3	14	17
Noctule bat, *Nyctalus noctula*	1	12	13
Whiskered bat, *Myotis mystacinus*	1	11	12
Serotine bat, *Eptesicus serotinus*	1	10	11
Northern serotine bat, *Eptesicus nilssonii*	0	11	11
Grey long-eared bat, *Plecotus austriacus*	0	9	9
Natterer's bat, *Myotis nattereri*	0	8	8
Long-eared bats, *Plecotus sp.*	2	5	7
Parti-coloured bat, *Vespertilio murinus*	1	6	7
Geoffroy's bat, *Myotis emarginatus*	0	5	5
Greater horseshoe bat, *Rhinolophus ferrumequinum*	0	3	3
Daubenton´s bat, *Myotis daubentonii*	0	3	3
Alpine long-eared bat, *Plecotus macrobullaris*	0	2	2
Brandt's bat, *Myotis brandtii*	0	2	2
Barbastelle bat, *Barbastella barbastellus*	0	1	1
Total	**30**	**203**	**233**

Tab. 3-1: Number of case studies per bat species –1 = including mixed colonies of greater mouse-eared bats (Myotis myotis) and lesser mouse-eared bats (Myotis blythii)

4 Description of the individual bat species

The following guidelines for the renovation of buildings with bat roosts should serve as a basis for the successful implementation of appropriate measures. With many species, however, the body of established experience is an inadequate foundation for deducing definitive renovation guidelines for the preservation of roosting places. Besides, every individual renovation project has to be regarded as a separate case. On the basis of all the information available, it is necessary to devise and formulate a case-specific scheme for the preservation of the bat roosts.

As general principles, it can be said that renovations should ideally take place during the time when the animals are not there, and that the roost characteristics, such as the micro-climate, points of ingress and egress, hanging places as well as exit flight paths should, as far as possible, remain unchanged. As a rule observing these principles will mean that from the bats' point of view, a positive outcome can be expected.

Unfortunately practical experience shows that such optimal conditions can seldom be adhered to. So, for example, roosts of species that live in fissures are very often first discovered only during the renovation work itself. In such instances, conservation measures have to be taken spontaneously and often without sufficient familiarity with the way in which the roost is used. Other important factors occurring in practice can be economic considerations or – something that happens very often - that the work becomes liable to delays. This means that the bat expert monitoring the project is often called upon to make quick-thinking, professional decisions. These guidelines are meant to give appropriate support in such situations.

In this present work, detailed information about the completion of building work, and the design of roosts and their access points will only exceptionally be included. This is because these things depend upon many factors, such as the particular situation of each roost, regional architectural styles, or indeed financial constraints. It should be noted that discussion of these issues is already available in the following works: BLANT 1992, DIETZ & WEBER 2000, SCHULENBERG et al. 2001, FAIRON et al. 2002.

Information about the ecology of bat roosts comes in the main from the following standard works:

- Säugetiere der Schweiz (Mammals in Switzerland), HAUSSER, 1995
- The Atlas of European Mammals, MITCHELL-JONES et al., 1999
- Die Säugetierfauna Österreichs (Austrian Mammal Fauna), SPITZENBERGER, 2001
- Die Säugetiere Baden-Württembergs (Mammals in Baden-Wuerttemberg), BRAUN & DIETERLEN, 2003
- Fledermäuse in Bayern (Bats in Bavaria), MESCHEDE & RUDOLPH, 2004
- Ökologie und Schutz von Fledermäusen in Dörfern und Städten (Ecology and Conservation of Bats in Villages and Towns), SIMON et al., 2004,

Specialist publications about each particular bat species were also consulted.

To enhance reading quality, citations are not included in the text. However, all sources used are listed in the bibliography. The listing of species follows that given in MESCHEIDE & RUDOLPH (2004).

4.1 Greater horseshoe bat (*Rhinolophus ferrumequinum*)

4.1.1 Roost ecology

Roosting places

Originally a cave-dweller (in Southern Europe), the greater horseshoe bat is now an adapted species in Central Europe. Its nursery roosts are invariably located in roof spaces (fig. 4-1).

In the roosts, the animals always hang free. They seek mutual bodily contact (=clustering) only when the temperature is low; otherwise the animals hang singly.

Seasonal use of summer roosts

Migration to the nursery roosts starts from the middle to the end of April and the bats leave again from August onwards. By the end of October these roosts are for the most part deserted, but the possibility of individual animals remaining there into November cannot be entirely ruled out.

In Bavaria, given typical weather conditions, the young are born in the middle of June.

Spatial use of the roosts

Depending on the temperature, the animals move from one of several hanging places to another. However sometimes there is a 'main hanging place' (identifiable by the quantity of droppings) and this is preponderantly where clusters are formed. If it is extremely chilly or hot, the animals switch to other roosting places.

Roost characteristics and temperature requirements

The roof spaces used by greater horseshoe bats are usually very roomy and draught-free. There are no special requirements regarding light levels; the roosting places can even be fairly brightly lit.

The data show that summer roost temperatures in the south of England range from 12 to 33 °C, and in Luxembourg from 10.3 to 36.8 °C. Temperatures between 25 and 30 °C are defined as optimal from the energy point of view. Temperatures over 40 °C cause the animals heat stress and they move to cooler hanging places. During periods of bad weather with temperatures below 10 °C they move to alternative roosting places.

Access openings

Unobstructed access (both incoming and outgoing) is a basic requirement if greater horseshoe bats are to colonise a building. Anti-pigeon grids therefore make it impossible for greater horseshoe bats to establish themselves, as a rule.

Getting to the hunting areas

Greater horseshoe bats use vertical structures (such as rows of trees, or hedges) to map out flight paths from the roosting places to the hunting areas and back again.

Roost Requirements of the Greater Horseshoe Bat			
Preferred hanging places	**Access passages**	**Optimal temperatures**	**Particularly critical times**
Depending on the temperature, they use several hanging places within the roost and also alternative roosts	Unobstructed incoming and outgoing access passages are required	About 25 to 30 °C	From June to end of July (before and during the birth of the young)

Tab. 4-1: Overview of the roost requirements of the greater horseshoe bat (Rhinolophus ferrumequinum)

4.1.2 Experience and examples

Only one case study of rebuilding work on a structure accommodating greater horseshoe bats is available: the renovation of St Georgen's Church in Castrisch, Switzerland (see text box).

Reaction to disturbance

It is difficult to assess the reaction of greater horseshoe bats to the disturbances caused by various kinds of construction work. The one renovation that has been documented, in Castrisch, was carried out outside the nursery period. The few individuals remaining at the roost were in a state of lethargy and showed a relatively high level of tolerance towards the work being undertaken. However before work started, these animals had been moved to hanging places that were less seriously affected.

An indirect clue about the effects of disturbance came with the renewal of a church roof in Carinthia. The place was known from written sources as a greater horseshoe bat nursery. In the summer of 1999, when the roof was being renewed, all the remaining animals abandoned the roost. (The number of individuals originally using the roosting place in the year of the renovation work is unknown, because it was found empty when checked during the summer.)

The new roof was of the same kind (stone shingles) as the old one and therefore the climatic conditions at the roost remained the same. Nevertheless, since completion of the work, no greater horseshoe bats have been detected there to date. A colony of lesser horseshoe bats, however, stayed at the roost, both during and after the renovation period.

Changes in ventilation and temperature conditions at the roost

Inner and/or beamed roofs should be avoided where possible, since roost temperatures fall much lower, as compared with roofs without back ventilation. The negative consequences are especially significant in cooler years and so can only be expected to become apparent over an extended time period.

A change of roofing can dramatically alter the micro-climatic conditions of roosting places. In the documented case study of renovation work in Switzerland (see example) this fact was indeed taken into consideration. A building physicist compiled a record of temperature patterns in the roost and worked out suggestions for the design of the new roof accordingly.

Where a drop in roost temperatures is unavoidable after a new roof has been built, a heater can be installed in the roof space. Cases in Switzerland and England have shown that such heaters (heat bells or area heating systems) are well received by the animals. As tests in England have shown, the preferred temperature is 30 °C.

Alterations to Egress Conditions

Whether greater horseshoe bats will accept newly made openings is completely unknown.

As with other species (lesser horseshoe bats, greater mouse-eared bats) lighting in the area of egress openings can lead to the bats delaying their exit time. This results in a real reduction in their food supply, as the number of insect decreases dramatically after dawn.

In fact there was a case in Switzerland where the illumination of a church, also lit up the bats' ingress and egress openings. This apparently resulted in the small number of greater horseshoe bats that had formerly lived there abandoning the roost.

Reactions to external scaffolding

Greater horseshoe bats tolerate external scaffolding, provided the egress openings themselves are not blocked. This means that work on the exterior of buildings is possible even whilst the young are being reared. There was one instance where cats were able to enter the roosting place by means of the external scaffolding; therefore it is necessary to ensure that predators cannot climb the scaffolding.

Use of alternative roosting places

During the course of the year, and under certain temperature conditions, greater horseshoe bats will often make use of different buildings. Their required standards for these alternative and occasionally used roosting places can be relatively low. Whether alternative roosts can be used even whilst the young are being reared, may very well depend upon the quality of the alternatives. At all events, therefore, building work should definitely not be carried out whilst the young are being reared.

Renovation example

Castrisch Church (Grisons, CH)

The colony was located in the roof space of St Georgen's Church in Castrisch and consisted of about 120 individuals. Substantial renovation work was to be carried out at the church: renewal of the roof and facade, and restoration of the interior (fig. 4-1).

In order to preserve the roosting places, the Cantonal Bat Conservation Representative for Grisons was consulted from the planning stage. The outcome was that all parties involved agreed not to start with the renewal of the roof before the middle of October. In addition to this, temperatures were measured by a building physicist for a whole year. Working from this data, it was possible to arrive at a new roof design ensuring that, even after renewal, similar micro-climatic conditions would persist.

When work started, there still were 21 individuals in the roost. The roof area was divided into four sections, and each section in turn was stripped and then re-roofed. That is to say, the old metal roof and the shingle roof underneath had to be removed. The inner formwork (which served as the animals' hanging place) remained intact. In place of the earlier shingle roof, a wooden formwork was fitted. The inner face of its boards was left un-planed and untreated. On top of this, a covering was applied, with under-roof sheeting. And this was then used as the base for the new metal roof.

Before the work was executed, the greater horseshoe bats that were still at the roost (they were in daytime lethargy) were carefully removed from the roof segment in question and allowed to hang elsewhere.

After they had left the roosting place in autumn, the roof space was tidied up and a new wooden floor fitted. The roofing work was completed in December.

In spring and summer the church tower, the facade and the church interior were renovated. Because the church and its tower remained clad in scaffolding throughout this time, it was necessary to ensure

that the bats were still able to use their various egress openings. To this end, the top row of protective sheeting on the scaffolding was removed whilst work on the façade was in progress. Moreover the workers removed the ladders at the bottom of the scaffolding every evening when they had finished work, to prevent cats from gaining access to the egress openings and/or the roost.

Contrary to expectations, the greater horseshoe bats did not colonise the newly renovated loft at Castrisch in quite the way that had been hoped. Part of the colony gave birth to their young at another roost. It was only with a warm period at the beginning of July that these females returned with their young to their home roost at Castrisch. From then onwards the females remained with their young at Castrisch for the whole season.

The fact that the animals moved from one roost to another after a very chilly period in spring and then again - with their still flightless young – at the start of a significantly warmer period, gives reason to surmise that the micro-climatic conditions under the newly renovated roof at Castrisch had been altered slightly. Hopefully, the temperature measurements that are still being taken at the alternative roost and at Castrisch will provide more precise indicators.

Fig. 4-1: The nursery of the greater horseshoe bats in Castrisch Church (Grisons, CH). Photo: E. Mühlethaler

4.1.3 Guidelines for the renovation of buildings with roosting places of greater horseshoe bats

Things one needs to know

- Which hanging places are being used? Ideally, notes should be taken on a regular base during the year prior to renovation.
- What are the daily and seasonal temperature patterns at the hanging places?
- Which egress openings are in use?
- If there are hanging places in several different spaces, which access passages are in use?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Any measures implemented between the end of October and middle of April are unproblematic. At the preliminary planning stage the completion date for the work should be set no later than the end of March. Even though the animals usually appear only at the end of April, this is a precaution against possible delays. Wood preservation treatment can be carried out only between November and March (for this, see also chapter 5).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Partitioning off the hanging places

It has not yet been put to the test whether it is possible to partition off portions of the roof space using boards, screens or cloth, when dealing with roosts of greater horseshoe bats, even though this procedure has been completely successful with lesser horseshoe bats. In any case, such interventions should definitely not be attempted during critical times (see above), as greater horseshoe bats react more sensitively to disturbances.

Replacing wood at the hanging places

Re-installing wood removed from the former hanging places is something that may be done, where possible. However it is not absolutely necessary.

External scaffolding

When using external scaffolding it is necessary to ensure that any netting used around the area of the egress openings has matching holes in it, and that cats cannot gain access either to the roost or the ingress and egress openings.

Ingress and egress openings

The established openings leading to and from the spaces used by the animals also need to remain available to them during and after the renovation work.

Ventilation conditions

Areas where warm air builds up are very important for the preservation of colonies. The conditions as they exist prior to the building work need to be precisely documented and taken into consideration at the planning stage. Employing a specialist (building physicist) is recommended. The following principles should be observed:

- No ridge ventilation (if need be, use mortar for fixing ridge tiles)
- Ventilation openings only at about 1.5 m below the roof ridge
- No false or beamed ceilings

Temperature conditions

Besides external factors (exposure, etc), temperatures in the roost are determined by ventilation and by the type of roofing. If a reduction in the roost temperature cannot be avoided, a hanging place heater may be fitted.

Ideally, a new roof of the same kind as the old one will produce the same temperature conditions. Should another type of roof be used, an appropriate design has to be worked out in consultation with specialists, so that the original conditions can be maintained.

If a reduction in the roost temperature cannot be avoided, a hanging place heater may be fitted.

Overview of the renovation of buildings with roosts of greater horseshoe bats	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Change in the micro-climate → no false ceilings or ridge ventilations ▪ Loss of alternative hanging places ▪ Blocking of ingress and egress openings ▪ Frequent visits to the roost area
Less critical factors	▪ Use of external scaffolding
Advice	▪ Features of the route from the roost to the hunting grounds (hedges, tree rows, etc) should be preserved in so far as possible. ▪ No external lighting, particularly not in the area where the egress openings are. ▪ When external scaffolding is used, it must not be possible for cats and other predators climb up it.
Prior to the renovation	▪ Find out how the hanging places are used ▪ Find out what the temperature pattern at the hanging places is ▪ Ascertain which ingress and egress openings are in use ▪ Find out about (potential) alternative roosts ▪ Ascertain the flying routes between the roost and the hunting grounds
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-2: Overview of the renovation of buildings with roosts of greater horseshoe bats (Rhinolophus ferrumequinum)

4.2 Lesser horseshoe bat (*Rhinolophus hipposideros*)

4.2.1 Roost ecology

Roosting places

Originally a cave-dweller (in Southern Europe), it is now an adapted species in Central Europe. Nursery roosts are mainly located in roof spaces (e.g. lofts and towers), but also in hollow spaces in bridges and in heated subterranean rooms (e.g. basement heating rooms). In the roosts, the animals

always hang free. They seek mutual bodily contact (=clustering) only when the temperature is low; otherwise the animals hang singly.

The bulk of the known nursery roosts can be found in churches, chapels, castles, vicarages and presbyteries, and schools as well as in private buildings.

Fig. 4-2: Nursery colonies of lesser horseshoe bats, with high roost temperatures (Niederdörfl, Carinthia, A), and under chilly conditions as a cluster (Freudenberg, Carinthia, A). Photos: G. Reiter

Inward migration can occur from the end of March onwards but for the most part does not start until April. In roosts located in bridges the peak number of individuals can be found from as early as April. By contrast, colonies in roof space roosts are often not complete before the end of May (in Grisons and Salzburg not before middle/end of June).

Outward migration begins in August. By the end of September or beginning of October, the roosts are mostly deserted.

Spatial use of the roosts

Depending on the temperature, the animals move from one of several hanging places to another. However sometimes there is a 'main hanging place' (identifiable by the quantity of droppings) and this is preponderantly where clusters are formed. If it is extremely chilly or hot, hanging places below the floor beams or an inner floor are likely to be used. Some animals switch to other roosting places under such conditions. It can be assumed that the animals also use satellite roosts in the alpine area (such as those in Aschau, Upper Bavaria), even though this is much rarer than, for example, in England. Amongst other things, satellite roosts are used to reduce the distance to the hunting grounds in times when food supply is low. Their use is temperature dependent and they are never located in the same buildings as the nurseries.

Roost characteristics and temperature requirements

Buildings used by lesser horseshoe bats are very often structurally good, or even very good. They may, for example, be multi-storey or extended constructions providing spaces full of nooks and crannies. On the other hand there are no special requirements regarding light levels; some of the roosting places can even be fairly brightly lit.

The data show that the optimal summer roost temperatures range from 26 °C (Poland) to 30 °C (Wales, UK). At temperatures over 30-34 °C the animals start to move to cooler hanging places. Warmer temperatures are beneficial for the development of the young and are important especially during colder years.

Fig. 4-3: Nurseries of lesser horseshoe bats are often located in churches (St Pankraz, Salzburg, A), but also less frequently in the hollow spaces of bridges (Annabrücke, Carinthia, A). Photos: G. Reiter, E. Schober

Access openings

Unobstructed access (both incoming and outgoing) is a basic requirement if lesser horseshoe bats are to colonise a building. They prefer larger openings but sometimes even smallish ones can be sufficient (the smallest opening would have a diameter of about 10 cm). Anti-pigeon grids make it impossible for lesser horseshoe bats to establish themselves, as a rule.

Fig. 4-4: The ingress and egress openings used by lesser horseshoe bats need to be accessible to fly through at all times. Sometimes they are of a relatively small diameter (Unteramlach Church, Carinthia, A). The picture on the right shows a fire shutter that was installed as an access opening for lesser horseshoe bats (Herrenchiemsee castle, Bavaria, D). Photos: K. Frühstück, A. Zahn

Getting to the hunting areas

The distance from the egress openings to the nearest place with vegetation and to potential hunting grounds is an important matter for lesser horseshoe bats. Roosts from which trees/bushes and hunting grounds are easily accessible, allow for flying at higher light intensities. This in turn means bats can fly at earlier times, which may have an effect on an individual's fitness, at least at certain stages of its development.

Roost Requirements of the Lesser Horseshoe Bat			
Preferred hanging places	**Access passages**	**Optimal temperatures**	**Particularly critical times**
Depending on the temperature, they use several hanging places within the roost and also (in part) alternative roosts	Unobstructed incoming and outgoing access passages are required; openings in shady areas of the building are preferred	About 30 °C	From (May) June to July (before and during the birth of the young)

Tab. 4-3: Overview of the roost requirements of the lesser horseshoe bat (Rhinolophus hipposideros)

4.2.2 Experience and examples

In total this work was able to draw upon 21 case studies. They come mainly from Bavaria, Austria and Switzerland. There are also some examples from Thuringia, Wales and Ireland.

Reaction to disturbance

Tolerance of the disturbance caused by building work is comparatively high. Noise and vibration, when tiles were being fitted to the framework of boards, for instance, was tolerated in some cases.

As to minor technical jobs (e.g. wiring) resident horseshoe bats are only slightly affected by them, provided they are carried out at some distance from their hanging places, or in adjacent rooms. But in most cases the animals will fly off immediately and move to another hanging place, as soon as someone come near them. Working near to the hanging places should therefore be avoided.

In two of the case studies, the hanging places were screened off from the adjacent working areas with sheeting or cloth during the rearing period. However despite this, in both cases part of the colony moved away temporarily.

Inner and/or beamed roofs

When renovating buildings with existing roosts, neither of these sorts of roof should be fitted. This is because they would reduce the roost temperature considerably, as compared to roofs without back ventilation. Having said this, in two buildings with roosts in Austria that were newly equipped with false ceilings, no difference in population development, in comparison with other roosts nearby, has been observed so far (after at least 5 years). However the damaging effects are particularly felt in colder years and therefore can only be expected to become apparent over an extended period of time.

Reaction to external scaffolding

Lesser horseshoe bats tolerate external scaffolding, provided the egress openings themselves are not blocked. This means that work on the building's exterior, that does not directly disturb the nursery roost, is possible even whilst the young are being reared.

Note: Cats can enter roosting places using the external scaffolding and this may result in the colony being driven away.

Spatial Volume Reduction

In a case study in Wales, the volume of space available to the animals was successfully reduced to about 15 m^3. A series of accompanying measures were put in place:

- The volume of space left to them was designed so as to be very complex.
- The ingress and egress openings remained almost unchanged.
- To improve the micro-climate (=warming) the room was equipped with a hot water boiler and an area for drying clothes, with heating pipes.
- The work was done whilst the animals were away.

Altering the ingress and egress openings

In some of the case studies, newly created openings were accepted. So, for instance, in Bavaria, on Herren Island in Lake Chiem, a nursery roost was equipped with a new opening, and this was used by most of the animals after one year.

In another case, an additional opening (at a distance of 2 to 3 m from the old opening) was made during the autumn, so that the animals could become accustomed to it. Prior to the animals' arrival in the following spring, the old openings were shut. The animals still went on to use the roost, inviting the assumption that they had become used to the new opening.

Use of alternative roosts

Alternative roosts serve to optimise energy use during periods of very high or very low temperatures at the nursery roost. Accordingly they need to be characterised by steadier climatic conditions than those at the nursery roosts. Sometimes alternative roosts are located in the same building as the nurseries but at different hanging places. Very often, however, they are in other buildings in the area.

This behaviour can be an advantage when there is renovation work, because the animals can then use these buildings as alternative roosts, as is shown by the example of Aschau (Bavaria). Yet at present it is not known if such alternative roosts are available to, or are used by, all colonies.

Reaction to external lighting

Lesser horseshoe bats are highly sensitive to excessively bright lighting around the area of their outgoing openings and access ways. Their reactions range from delaying their exit time, which means a real reduction in their food supply, changing their flight paths to avoid illuminated places, or even to totally abandoning the roosting place.

Relocating colonies

So far the relocation of a small nursery colony has only been attempted once in Bavaria (for details, see RICHARZ & LIMBRUNNER, 1992). In this case, a number of lethargic animals were captured and taken to the new roosting place (in the immediate vicinity of the old building). Despite some success at the beginning – the animals seemed to accept the new roost and also reproduced - , the project had to be categorised as unsuccessful in the medium term, because reproduction stopped after a few years. The roost eventually ceased to be populated at all a few years later. However the example does show that relocated animals can remember a new roosting place and can use it as a roost after their old building had been demolished. Therefore, relocation should not be ruled out in extreme emergency cases.

There also is an English example of a new roosting place being accepted. In this instance, as a substitute for a building that was demolished, a new one was erected for the bats. The new building was located as near as possible to the old roosting place (no details were provided) and to the nearest area of woodland. Since the animals had used the old building as both their nursery and winter roosting place, an attempt was made to ensure that the new building would serve the same functions.

As early as the first autumn, the roost was used by individual animals and in the following year it also served as a nursery.

Renovation examples

Peiden Bad Church (Grisons, CH)

The roof space in the S Glieci Chapel accommodates a nursery colony, consisting of about 50 lesser horseshoe bats (fig. 4-5). The animals are mainly in the chapel's main loft. Occasionally some animals also spend the daytime in the smaller loft, above the registry. The Cantonal Bat Conservation Representative for Grisons monitored the church renovation to ensure that both the animals and the roost could be preserved.

With this in mind, the most important part of the renovation work on the roof, was not begun until September. By that point in time, the young of the lesser horseshoe bats were fully fledged so that, when the major disturbances happened, they were able to leave the roost of their own accord.

Another measure taken was the maintenance of the sheet metal roof. As the wooden shingles had been fastened with hand made nails, the new metal panels could not be fitted onto the shingle beam (requiring that the nails penetrate the panels). That would have been the best solution from the point of view of bat conservation because it would have kept the present roof construction. However, in order to change the micro-climate as little as possible, the wooden shingles were replaced by roof boarding consisting of rough hewn and untreated planks. The metal panels were fitted directly onto these (without back ventilation) (fig. 4-5). To increase the quality of the micro-climate, all the existing openings between the wings of the roof and the capstone, except the two used by the lesser horseshoe bats as incoming and outgoing access passages, were blocked off with boards. In this way, it was also possible substantially to reduce the draughtiness that used to be a feature of the roost area.

The entire colony populated the roosting place again during the following years.

Fig. 4-5: Renovation example at Peiden Bad Church (Grisons, CH). Interior space after renovation: the old wooden shingles were replaced by roof boarding consisting of untreated boards. Photos: E. Mühlethaler, M. Lutz

Power station and residential buildings in Aschau (Bavaria, D)

The nursery roost is located in the roof space of a former power station and in an adjacent hall. The complex of buildings had been sold and was being renovated as a residential development.

Whilst the roof space in the power station (the location of the animals' main hanging place) was not to be structurally changed, the one in the adjacent hall would be reconstructed. Particularly at times when temperatures were high, this roof space had been used by the animals as an alternative roost. The Co-ordination Centre for Bat Conservation in South Bavaria and the owner agreed that, firstly, part of the roof space (about 1/8 of the original volume) should remain available to the animals and, secondly, the renovation of the roof should be carried out during the winter season.

It has to be admitted, that the renovation work was subject to delays in the winter of 2002/2003. So there was no alternative to the work in the roof space continuing into the following summer. Consequently, parts of the roof space above the hall were screened off using a sheet (fig. 4-6) so that, at times of high temperatures, there was still an alternative hanging place available to the animals. In this area, the roof had been renewed before the bats returned - the renovation of the beams had taken place during the winter season. The renovation work done outside the cordoned off area in the spring and summer of 2003 involved noise and vibrations. Around 50 % of the animals stayed in a neighbouring house, which had already previously been used by the lesser horseshoe bats (specifically as alternative high temperatures roost).

In the winter of 2003/2004, contrary to the original agreement, the ingress openings were blocked off. (that is to say the ones which the animals had hitherto flown through to access the loft.) This was because the roof space was now being reconstructed for residential use. The new ingress opening in the separate "bat area" was completed only during the same winter so that the animals did not know about it. It was for this reason that another small opening was made in the spring of 2004. This one was located at a place where there had been a large opening in the roof in the summer of 2003, whilst a roof terrace being built (fig. 4-7). It was not certain if this large opening had already been used by the animals in 2003, but it could be assumed that they at least knew of its existence. Therefore it was very probable that they would seek access here, after their original ingress opening had been blocked.

At the end of the renovation in spring, finely shredded paper was installed as thermal insulation for the floor of the room where the main roost was located. This perhaps had negative repercussions, because its very fine parts were soon spread over the whole roof space. Once the insulation had been bonded with water, some animals began to return in June. In July the roost was accepted again by the whole colony. Notably, the animals used the new egress opening in the roof terrace, but not the one that had been specially made for them, which had still been blocked in 2003.

Fig. 4-6: Renovation of a power station and a residential building in Aschau (Bavaria, D.) The bat area is temporarily screened off using sheeting (picture on the left), with an open passage for incoming and outgoing access (red arrow on top) and an area open only during the night (red arrow at the bottom). The residential area to-be (picture on the right), seen from the bat area, with the future roof terrace opening (yellow arrow), and the original egress and ingress opening (green arrow). The animals' flight path towards the opening is marked by blue arrows. Photos: A. Zahn

Fig. 4-7: Renovation of a power station and a residential building in Aschau (Bavaria, D). The situation after the renovation in 2004 (rear side view of the building). Green: boundary between the residential area (left) and the bat area (right). Dashed blue line: former fight path for the ingress and egress opening. Light blue arrow: newly made opening that was not known to the animals in the previous year (2003) and which they do not use. Red arrows (large and small picture): additional opening on the roof terrace (there had been a large opening in the roof here in 2003). This which was accepted by the animals. Orange: unused space providing an access passage between the new opening on the balcony and the bat area, and skirting the residential area. Photos: A. Zahn

School in Wald in Pinzgau (Salzburg, A)

The nursery colony consisted of up to 150 lesser horseshoe bats. Because the site was a school, it was necessary that the renovation work should be done in the summer months. However, bat specialist support during the building work, was provided by the Co-ordinator of the Co-ordination Centre for Bat Conservation and Research in Austria (KFFÖ). This meant that, from early in the planning period, it was possible to arrange measures such as rescheduling the renovation of the roof and changes in the timing and sequence of the building work.

At the end of the school year in 2002 - i.e. at the very time when the young lesser horseshoe bats were being born – a start was made on the first stage of renovation, namely the roof renewal (a tiled roof on an existing metal roof). Most of the individuals that had been in the roost before building work started remained as residents there throughout the time in which the building work was being carried out. Only whilst the roof itself was being actually renovated (counter-battens were fitted to the metal roof), did the majority of the animals vanish for several days. Only about 30 animals remained. However, they returned to the roof space as soon as the roofing work was finished. The building's insulation was not fitted beneath the roof itself, but to the floor of the roof space (fig. 4-8). This work as well as the replacement of windows and the relocation of one window in the roost area was carried out between the middle and the end of August – when all the young were already able to fly.

In the second stage of renovation in 2003, there was one day a massive disturbance for the animals, because an unplanned change had to be made – sheeting had to be fitted to screen off the hanging place from the working area. There upon, the number of animals living there in 2003 decreased to 80 individuals. However it recovered again in 2004, when there were about 100 individuals. In 2005 there were more than 150 animals once more.

Whether alterations made to roosting places (different roof covering &c.) will cause medium-term changes to the population, can only be judged in subsequent years.

Fig. 4-8: Renovation example Primary School in Wald in Pinzgau (Salzburg, A). Thermal insulation was fitted on the roof space floor instead of the roof itself. The insulation boards were covered with a sheet to catch the droppings; in the background you can see the round egress opening. The external scaffolding was accepted by the animals. Photos: M. Jerabek

Altenberga Church (Thuringia, D)

In Altenberga Church in Thuringia there was a nursery colony of lesser horseshoe bats. The colony, of about 170 adult animals, used up to 5 different hanging places in the roof space. Two of the hanging places were located right up against the roof tiles. There, the horseshoe bats not only hung from the wooden laths, on which the tiles were fixed, but very often from the inner sides of the tiles themselves, particularly on the south-facing side of the roof. As part of the research for a Diploma thesis on the use of hanging places, it was observed, prior to the renovation, that these hanging places were used as a matter of preference by the horseshoe bats in the morning, so that they could take advantage of the tiles' heat radiation.

In 2001/02 the tiled roof of the church needed to be renovated, because of a number of leaks in the tiling. There was already water-damage to the laths and timber heads. To improve the visual appearance of the roof, the Department for the Preservation of Monuments and Historic Buildings suggested that the previous single roofing (of groove-joint tiles) should be replaced by double roofing (of flat beavertail tiles). However, the bat conservationists were afraid that the planned changes would have a substantial effect on the temperatures inside the roof space. It proved possible to reach an agreement with the Department for the Preservation of Monuments and Historic Buildings, to the effect that single roofing should be used in the area of the hanging places located on the southern side.

So as to compare temperatures reached under single roofing and double roofing, measurements were made at the roost of another colony of lesser horseshoe bats, which was also located in a church. There, for financial reasons, only the lower levels of the roof had been double roofed using flat tiles. On the rest of the roof, the old "single" tiles remained for the time being. Whilst the wall crown was undergoing renovation there, temperatures were recorded on the inside of the roof using data logs, at the borders of each type of tile. This showed that, in the morning, higher temperatures were reached inside "single" tiles, and that the maximum daytime temperatures were significantly higher. However night-time temperatures were slightly lower, as compared to those inside the immediately adjacent double roofing with its flat tiles. The temperature differences were particularly marked on sunny days.

Because of the different style of roofing, at least two tiles lie on top of each other with double roofing. There is always an insulating layer of air between them. Only small segments of the tiles that form the inner surface of the roof are directly exposed to the sun. In terms of the climate of the whole space, it may be surmised that a roof space with single roofing warms up faster but also cools down faster (with more marked peak temperatures). Double roofing offers a more balanced temperature profile and retains the heat for longer.

In the course of another Diploma thesis project, the lesser horseshoe bats were experimentally offered the choice between different sets of hanging place characteristics. The experimental zones were set up along a row of 3 sections of the rafters; each was about 1 square metre in size; and all were located in the area of the hanging place below the tiled roof. The characteristics offered were: new tiles with single roofing; new tiles spattered with mortar; a simulation of double roofing, made by fitting new tiles underneath the old ones; the same, but made by fitting old tiles underneath; and new tiles with a reinforcing fabric. The animals' behaviour was monitored using infrared cameras. Amongst other things it was possible to observe that the new tiles were too smooth and that the horseshoe bats could not use them (access to them was not possible). The tiles with the reinforcing fabric were not used either. In contrast, the new tiles spattered with mortar were skid-proof and could be used. It was the same with the old tiles of course (even though they were used here in the form of double roofing).

By and large, the renovation of the roof was completed in the winter season 2001/2002. Besides the single roofing on the southern side, untreated larch timber was generally used. For one summer season, a strip of the old roofing was also partially preserved, just to be on the safe side. It has since also been re-roofed. Here too, the inside of the tiles was spattered with mortar. The renovation has had no negative effects on the reproduction of the horseshoe bats in these last years (the trend is for numbers of individuals to rise).

4.2.3 Guidelines for the renovation of buildings with roosting places

Things one needs to know

- Which hanging places are being used under what climatic conditions? Ideally, notes should be taken on a regular base during the year prior to renovation. Otherwise the more important hanging places can often be identified by the quantity of droppings; attention should also be paid to hanging places located under floor boards and inserted ceilings.
- Which egress openings are in use?
- If there are hanging places in several different spaces, which access passages are in use?
- Are there any (potential) alternative roosts nearby?

When should renovations take place?

Measures implemented between the beginning of October and the end of March are unproblematic. At the preliminary planning stage, the completion date for the work should be set no later than the middle of March. Even though the animals usually appear only in April, this is a precaution against possible delays. In principle, renovation work carried out in autumn is best, since it can still be completed in time for the next spring, if there are delays.

Wood preservation treatments may be applied only between October and February (for this, see also chapter 5).

If need be, individual jobs can be started in summer before the animals have left, provided appropriate arrangements have been put in place beforehand. For example work carried at some distance from the hanging places (e.g. the eaves area, wall coverings) can perfectly well take place in summer.

As regards the hanging places, wherever possible work should not start before the last animals have left.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Partitioning off the hanging places

When it is necessary, it is possible to separate off parts of the roof space using boards, screens or cloth, as the example in Aschau (Bavaria) shows. In this case, it was even acceptable that the egress opening should not lie within the area partitioned off. Moreover, the animals had to fly through the working area every evening (see fig. 4-6). However, this level of disturbance was obviously not accepted by all individuals, as 50 % of the animals moved to the neighbouring house or to other unknown roosting places. As the whole of the colony subsequently accepted a smaller space, it can be assumed that it was the disturbance (noise, light, draught, changed access passages) and not the diminished volume of space that was the decisive factor in their leaving. Therefore, partitioning has to be regarded as an emergency expedient, which can only be implemented with the following preconditions:

- The hanging places normally used in the season in question should remain available to the animals. The same must also apply as a matter of especial importance to alternative hanging places, used when temperatures are higher or lower.
- The standard egress openings should remain accessible.

- The temperatures in the areas partitioned off must not change excessively.
- The partitioning should be implemented whilst the animals are away.

Note: when using sheeting to screen off smaller areas, it is possible that it will become too hot.

As a rule, the area that remains available to the animals should be as large as possible. However, it needs to be at least about 20 % of the space usually used by the animals. Access to the egress openings can be provided, if need be, by a tunnel of sheeting (height and width at least 2 m) leading from the “bat area” to the opening.

Replacing wood at the hanging places

Experience has shown that it is not necessary to re-install wood removed from former hanging-places.

External scaffolding

When using external scaffolding it is necessary to ensure that any netting used around the area of the egress openings has matching holes in it.

Ingress and egress openings

The established openings leading to and from the spaces used by the animals also need to remain available to them during and after the renovation work.

Relocating the openings has already been successfully accomplished (see the Aschau example) but whenever possible it should be avoided, or attempted only after an extended period of familiarisation. Leave both the old and the new openings unobstructed for at least a summer, and make sure (by observation or monitoring droppings) that the new opening is being used. Afterwards the old openings can be made to appear “unfavourable” to the animals, by making them smaller for example.

Ventilation conditions

Areas where warm air builds up are very important for the preservation of colonies. The following principles should be observed:

- No ridge ventilation (if need be, use mortar for fixing ridge tiles)
- No change in number and size of ventilation openings; in cases where the temperature conditions in the roof space alter because of the building work (e.g. because of different roofing materials, or air grilles at the roof shoulder, etc), ventilation tiles or other openings should be fitted only in the lower half of the roof.
- No false or beamed ceilings
- No draughts (be careful when new openings are created)

One possibility in the case of roofs, where tiles are attached to wooden planking and where the planks meet at the ridge, is to fit a vapour permeable sheet in the ridge area. This should ensure ventilation in the ridge area. However there is as yet no experience to draw upon about whether this works for lesser horseshoe bats.

Roost environment

Extensive renovation of a building very often leads to a reshaping of its environment too (redesigning a cemetery, a garden, a car park, etc). When a church is being renovated (putting damp courses in walls etc), very often trees positioned next to the church are removed to allow the renovation work to be effective in the long term. In such cases care needs to be taken that flight paths can still be used in the same way as before. This may mean that features that are important for the animals such as hedges, and trees whether in rows or solitary have to be preserved.

Overview of the renovation of buildings with roosts of lesser horseshoe bats	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Change in the micro-climate → no false ceilings or ridge ventilations ▪ Loss of alternative hanging places ▪ Relocation of ingress and egress openings, and the flight path ▪ New roof tiles can be too smooth on the inside to provide a foothold to the lesser horseshoe bats. They have to be abraded, e.g. by spattering with mortar ▪ As to the renovation of heating rooms located in the basement (e.g. rebuilding of heating systems) it has to be ensured that there will be the same temperatures as before.
Less critical factors	▪ Noise and vibrations brought about by work done off the hanging places ▪ Light (providing the hanging places are not directly illuminated) ▪ Entering the roost area occasionally ▪ Use of external scaffolding, provided the egress openings remain accessible
Advice	▪ Features of the route from the roost to the hunting grounds (hedges, tree rows, solitary trees etc) should be preserved in so far as possible. ▪ No external lighting, particularly not in the area where the egress openings are.
Prior to the renovation	▪ Find out how the hanging places are used ▪ Ascertain which ingress and egress openings used ▪ Preferably find out about (potential) alternative roosts ▪ Ascertain the flying routes between the roost and the hunting grounds
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-4: Overview of the renovation of buildings with roosts of lesser horseshoe bats (Rhinolophus hipposideros)

4.3 Daubenton´s bat (*Myotis daubentonii*)

4.3.1 Roost ecology

Roosting places

The Daubenton's bat's nursery roosts are found preponderantly in the hollows of trees and in nesting boxes. However instances of colonies in and on buildings are also known. Nurseries and also colonies of males can be found under bridges, for instance, and, more rarely, in roof spaces, in wall facades, and behind window shutters or the casings for roller shutters.

Roosts in bridges can be found in box sections as well as in gaps, such as expansion joints.

Fig. 4-9: The Daubenton's bat. Photo: A. Zahn

Seasonal use of roosts on buildings

Hardly any data about the period that colonies spend in residence on buildings has been published. However, one nursery colony of Daubenton's bats in Carinthia roosted in a gap in a bridge from May to September. And another small colony of males lived in a hollow box bridge from April until October.

Spatial use of the roosts

Nursery colonies living in nest boxes change their roosting places more often than colonies living in buildings. In this respect the latter are characterised by more stable living conditions.

Roost characteristics and temperature requirements

There is no data available for the characteristics of roosting places in and on buildings and bridges. The temperature data collected from a nursery roost located in a bridge in Austria showed relatively stable conditions ranging from 20 to 30 °C, with an average of about 25 °C.

Access openings

Daubenton's bats are able to access tree hollows as well as nest boxes slipping in through very small openings. This leads to the assumption that in buildings they are not dependent on the openings being big enough to fly through.

Roost Requirements of the Daubenton's Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
There is no data available about the use of hanging places in and on buildings	About 20 to 30 °C	Presumably between May and September

Tab. 4-5: Overview of the roost requirements of the Daubenton's bat (Myotis daubentonii)

4.3.2 Experience and examples

There is only little experience that can be drawn upon relating to the Daubenton's bat in the Alpine area. One renovation example came from England.

Reaction to disturbance

In a bridge-based roost in Austria, short-term work (using a pneumatic drill) directly beneath the colony was accepted.

Changes at the roost

An example from Bavaria suggests that Daubenton's bats may be quite sensitive to changes at the roost: A mixed colony consisting of whiskered bats and Daubenton's bats (about 100 animals) lived in the gap between the house wall and the overhang of the roof. Here the renovation work was carried out whilst the animals were away. Yet, it was noticed only after the work was completed that the space between the overhang of the roof and the house wall was now larger than before. The animals ceased to populate the roost and instead moved to a neighbouring building with a smaller gap.

Against this, there is an example of successful renovation work involving a roost in a boathouse roof in England. The local nursery colony was using the boathouse, which had to be completely renovated because of its dilapidated condition. The work was done whilst the bats were away, and it proved possible to preserve the most important features of the roost unchanged. The roost was subsequently repopulated by the same number of animals as before.

Alternative roosting places

In the hollow spaces of a concrete bridge there was a nursery of the Daubenton's bat. The bridge needed to be replaced for safety reasons. As the reinforced concrete structure was rusted through it was not possible to renovate it. The bridge was demolished and a new one built in April 2003.

Because the work dragged on over the whole summer of 2003, alternative roosts in the form of bat boxes were fitted on trees, in the immediate neighbourhood of the bridge. After the work was completed, six self-cleaning facade boxes for bats were fitted onto the piers of the new bridge, to provide new (disturbance free) roosting places. On the eastern pier, two boxes were fitted on each side, and on the western one, one box on each side. The alternative boxes were accepted by the animals.

External lighting

As an example from Switzerland (Freienbach Church) shows, Daubenton's bats react very sensitively to illumination of the egress openings. In a trial illumination of the tower, no animals could be detected flying out. Even after the lighting was switched off at 11 p.m., the animals did not leave the roost until half an hour later.

4.3.3 Guidelines for the renovation of buildings with roosting places

Things one needs to know

- Which hanging places are being used?
- Which ingress and egress openings are in use?
- How long do the animals stay there?

When may renovation work take place?

Because of insufficient data, it is difficult to specify what the optimal time for renovation work is. This needs to be clarified in each individual case.

At all events, between May and September the presence of nursery colonies may need to be reckoned with. Unless more complete data about the roost is available, no renovation work should be carried out during this period.

Colonies of males may be in residence for a little longer, particularly in bridges.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Alterations to the roosting places

The few case studies available indicate that this species of bat may react quite sensitively to alterations to roosts located on/in buildings. Therefore in renovation work the original situation should, in so far as possible, be preserved unchanged, or should be subsequently restored.

4.4 The Brandt's bat (*Myotis brandtii*)

4.4.1 Roost ecology

Roosting places

The Brandt's bats' nursery roosts can be found in Bavaria mostly in buildings, and only very rarely in bat boxes.

In buildings, hanging places are encountered particularly in lofts, although the animals populate the nooks and crannies (e.g. in false ceilings, gaps between beams, or between metal sheeting and wall, as well as holes in beams, see fig. 4-10).

Apart from hanging places near to the ridge, there are also (in some cases, exclusively) hanging places on the lower part of the trusses, where the differences in temperature are less. In addition, wall facades are also used as nursery roosts.

Buildings are also shared with colonies of whiskered bats, though the two species generally use different hanging places.

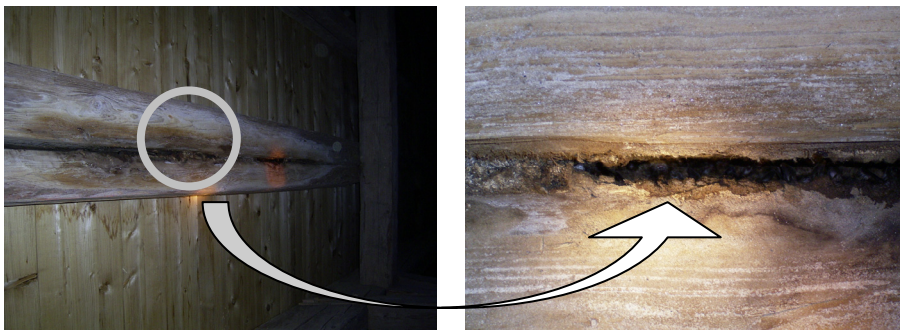


Fig. 4-10: Hanging place of the Brandt's bat at a roost located in a gap in the roof space (Burgrain, Bavaria, D). The hiding place is located in the ceiling of a multi-storey loft. Photos: A. Zahn

Seasonal use of nursery roosts

At the earliest one nursery roost in Bavaria was populated by the end of April/beginning of May and was largely deserted again by the middle of July. However, individual animals remained until the middle of August. Very often nursery colonies of Brandt's bats are resident at the roost for only a short time.

Spatial use of the roosts

Colonies, or parts of colonies, change their roosts regularly.

Roost characteristics and temperature requirements

In Bavaria, roosts' ingress and egress openings were located at a height of between 3 and 9 m (n =5), the hanging places mainly faced south and west (n=8).

No data is available for the alpine area.

Roost Requirements of the Brandt's Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Several hanging places are used, both in the same building, and usually in several other buildings. Within the roof spaces there are hanging places in areas with different temperatures.	No data available for the alpine area.	Between May and July (limited data means that this needs to be checked in each individual case)

Tab. 4-6: Overview of the roost requirements of the Brandt's bat (Myotis brandtii)

4.4.2 Experience and examples

For this species, only three case studies involving renovation work are available. One of them relates to a roost shared by both whiskered bats and Brandt's bats.

There is one documentation about the renovation of a building with a nursery roost of Brandt's bats, which took place in the Märkisch Switzerland National Park. There, important roost characteristics (e.g. ingress and egress openings, hanging places) were collected prior to the start of the renovation work. The work was done whilst the animals were away. Due to the fact that the roost situation could essentially be preserved, the colony returned in the following year in the same size.

Reaction to disturbance

Whilst monitoring a colony of Brandt's bats consisting of at least 50 animals in the church in Ulrichsried (Bavaria, D), it was noticed that renovation work was being carried out on the building. According to the workmen, they had started to remove rubble about 2 days before, with a view to working on the roof truss.

Unfortunately the actual size of the colony could not be ascertained. One of the young was seen at the hiding place, and one flying bat was observed. Therefore it can be assumed that, despite the disturbances, a few animals still used the roost whilst work was being carried out.

When inspecting the place about 4 days later, no traces of bats could be found. This gives reason to suppose that the colony moved away gradually because of the work undertaken there.

4.4.3 Guidelines for the renovation of buildings with roosting places of Brandt's bats

Things one needs to know

- Which hanging places are being used? Ideally, notes should be taken on a regular basis during the year prior to the renovation.
- Which egress openings are in use?
- Are there any other roosts in use?

When should renovation take place?

Measures implemented between the beginning of September and the end of March seem to be unproblematic. At the preliminary planning stage, the completion date for the work should be set no later than the end of March, as a precaution against possible delays. Since only a very little is known about the phenology of this species, appropriate inquiries should definitely be made prior to the renovation work.

Wood preservation treatments should only be applied between October and March (for this, see also chapter 5).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic	***Yellow*** Some work allowed	***Red*** Work in proximity to the roost not normally allowed

Potentially important factors in renovation

There is only very little data about renovation work in buildings accommodating roosts of Brandt's bats. This means that recourse has to be had to expert knowledge about whiskered bats and other

species that live in cracks and gaps. Therefore the following points should be regarded as factors that are only probably important.

It is not known if the Brandt's bat accepts droppings boards fitted below the ingress opening (compare comments about the whiskered bat).

With roosts located behind facades, the primary objective should be to attempt to preserve the original hanging places and access openings.

Possibly alternative roosting places will be accepted. When trying to establish alternative roosts the following advice may increase the chances of success.

- At least two, or where possible more, alternative roosting places should be made available. These should face in different directions(e.g. put them severally on the south and the east side of a building)
- Fit the alternative roosts next to the original roosting places
- Fit the alternative roosts as early as possible, i.e. before the original roosting places are lost. This means that the animals can explore them and can even begin populate them
- As an odour marker, use both wood taken from the original hanging places and droppings taken from the nursery

In the case of roosts located in roof spaces, the nooks and crannies that are used by whiskered bats and Brandt's bats need to be preserved, or reconstructed in the same places where they were before. If beams or boards in the area of the hanging place need to be replaced, some of the wood from the hanging place should be kept or used for the new roosts in the holes and gaps. The width of the hole or gap must match that of the original hiding place (holes and gaps must not be too wide!). The access point for the new hiding place should be adjacent to the original one. Roosts in holes and gaps that are located under a surface that warms rapidly (such as roof sheeting) have to be rebuilt in such a way that the temperature conditions remain the same.

In addition, fitting bat boards and flat boxes should be considered (see appendix) at a number of sites in order to optimise the range of hanging places.

4.5 Whiskered bat (*Myotis mystacinus*)

4.5.1 Roost ecology

Roosting places

Originally the whiskered bat used tree hollows or the loose barks of trees for their nurseries. Today, by contrast they almost exclusively use buildings; nest boxes (flat boxes, bat boards) are relatively uncommon.

The buildings used for nursery roosts are very often residential properties or others, such as alpine huts, transformer housings, garages, barns and the like. The roosts are mostly located on the outside of buildings but sometimes also hiding places in roof spaces or barns are populated.

More than half of all roosts in Bavaria and western Austria are located behind vertical outer wall coverings, significantly fewer behind shutters, soffits, or signposts. Other roosts can be found in chinks

of walls or in plaster and in roller shutter casings. However, when the roost is located in a loft, the hanging place can also be in cracks.

In Bavaria it was also possible to establish that, as compared with colonies located behind outer wall coverings, colonies resident behind shutters usually consisted of fewer individuals (< 30 individuals).

There are known examples of groups of non-reproducing females living behind outer wall coverings in Bavaria. So there is need to clarify in any individual case, whether or not it is a nursery.

Fig. 4-11: A hanging place of whiskered bats, located in the gap between a metal roof and the wood. Photo: A. Zahn

Seasonal use of nursery roosts

Usually the nursery roosts begin to be populated at the beginning of May and, in rare cases, as early as April. The young are born in June, and some of them are fully fledged by as early as July. Usually the nursery group disperses again in July (though sometimes not before August). However, a few individual animals may not depart before the end of September/beginning of October.

Spatial use of the roosts

Usually one colony uses several roosting places during the course of the summer. These roosts can be located at different places in one building, as well as in separate buildings. Temperature conditions may account for their movement from one roost to another, but disturbances may be a factor too. Particularly in the case of dark, south-facing outer wall covering, there appears to be a danger of over-heating.

Roost characteristics and temperature requirements

During the course of an “E+E” project it was possible to establish that in Hesse the nursery roosts of whiskered bats are mostly in south, south west, or south east facing locations. In the case of Switzerland, it is reported that egress openings are located by preference between the north east and the south east, and in Bavaria, that the roosts face eastwards, or to the south, or west. In Bavaria, the ingress and egress openings can be found at a height of up to 15 m, but they are mainly between 3-9 m. from the ground.

Detailed data is available covering the temperature requirements for nursery roosts located in flat boxes. They are characterised by large fluctuations, and periodically by some very high temperatures. Some animals will still remain in the boxes even when the temperature is over 40° C.

Also during the E+E project, temperatures over 40° C were reportedly measured at a roost in Hesse, that was located in south-facing wooden cladding

Roost Requirements of the Whiskered Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Depending on temperature, several hanging places are used in one or more buildings	Probably between 30 and 35 °C	Between May and the end of July (however individual animals may still be in residence later)

Tab. 4-7: Overview of the roost requirements of the whiskered bat (Myotis mystacinus)

4.5.2 Experience and examples

In total, this work was able to draw upon 12 case studies, mainly from Bavaria and Switzerland.

Changes in the roost characteristics

As an example in Bavaria highlights, whiskered bats may react negatively to the slightest changes in the roost characteristics. A colony abandoned the roost, because after renovation the gap between the over-hanging roof and the house wall turned out to be wider than it had been previously.

Ingress and egress openings

The loss of individual ingress and egress openings seems to be justifiable. However, this is provided that other, already familiar openings are preserved and that access to hanging places that are periodically essential to the colony (e.g. for temperature reasons) is not blocked.

Use of alternative roosts

There are known cases where whiskered bats have successfully been induced to accept alternative roosts. So, to take one example, after the loss of an original roost behind wall facade cladding, a new alternative roost in the gable area was accepted. It took the form of a bat board with double wood cladding. The outside of the alternative roost was painted in a dark colour and it was oriented towards the south east.

Yet, there are also other case studies, where alternative roosts were not accepted.

Renovation examples

Private house, Lindenbühel (Bavaria, D)

The forester's house accommodated a very large colony of whiskered bats and was in need of renovation. Consequently, the work was monitored by bat experts.

The nursery colony occupied the overhanging portion of the roof and was present only during the summer months. After the animals had left the roost in autumn, the roof tiles were removed, the beams were extended and new battens were fitted. In spring inner floors with small spaces (3cms high) between the boards were constructed to re-establish something like the original conditions.

Preserving two of the four ingress and egress openings that the animals were already accustomed to, proved to be important.

The animals used the roost again in undiminished numbers, after the work had been completed.

Factory canteen, Murnauer Moos (Bavaria, D)

The building had to be demolished. There was a colony of whiskered bats, consisting of about 90 nursery animals, living behind soffits on the east and west side, as well as behind shutters to the south (in much smaller numbers). To avoid disturbing the animals, demolition of the canteen was not carried out before the end of September 2001. The eastern part of the building, where the soffit was located, was retained, in order to preserve the roost. To improve the roost's situation and to create new hiding places, wood panelling was fitted on the south, east and west sides (gap widths: between 1.5 and 3 cm, ingress openings at a height of between 2.5 and 3 m), as well as a second soffit on the west side (fig. 4-12).

The alternative roosts were scarcely accepted. A few individuals were found only behind the panelling on the south and west sides. However there was a draught behind the new soffit, and in part also behind the new panelling. Moreover, the new roosts probably did not warm up in the same way as the old ones because the wood had not been painted. The colony now almost exclusively uses the preserved soffit on the east side. In 2005, over 270 adult animals were counted.

Fig. 4-12: Factory canteen, Murnauer Moos (Bavaria,D). Between the windows bat boards were fitted. So far they have been accepted only by a few individual animals. The colony still resides behind the soffit, as before. Photo: B. Wimmer

Residential house, Hirschberg (Bavaria, D)

A whiskered bat nursery consisting of 80 animals lived under wooden cladding, on the southern side of the house. Individual animals, as well as long-eared bats, also used the other sides of the house.

The old wooden boarding was to be renewed. The residents were no longer prepared to accept the bats around the patio. This was because of the considerable soiling and because the animals' ingress and egress openings were located directly above the patio. However the bats definitely were welcome next to the patio, as well as on all the other sides of the house.

The various openings in the boarding were either left alone or were blocked, accordingly. The renovation work was carried out whilst the bats were away. The new work above the patio and the closing of the roost were not a complete success. The animals were able to slip back into the renovated area above the patio. They again settled in the old roost, where they successfully reared their young. After the animals had left, this new access was also blocked off.

According to the residents, in the following year the returning bats were swarming around the roost for days and weeks, trying to get in again. Eventually the bats abandoned the house almost completely,

with only individual animals remaining in the old places. They probably went and joined another nursery in the neighbourhood that consisted of about 90 animals.

Private house, Schwarzbach (Thuringia, D)

The building had accommodated a mixed colony of whiskered bats and Brandt's bats since at least 1970. They had been studied in detail by the Meiningen Bat Research Association since 1991. Because of their dilapidated condition, both the building and its wall covering ('top and bottom cladding') accommodating the hanging places, were to be renovated in 1999.

The renovation work was carried out in late summer, immediately after the bats had left the roost. In the process, the essential roost structures were preserved. However the house was also fitted with thermal insulation. The construction of the new facade also included a layer of boards, on which the new 'top and bottom cladding' was fitted, with the 'top' boards at intervals of 1 to 4 cms (see drawing, fig. 4-13). This was in addition to the thermal insulation.

To encourage acceptance of the roost, wood pulled out during the course of the renovation, was used particularly at the old hanging places. The surfaces were brushed in places with moistened bat droppings, or were covered with a thin layer of clay.

On numerous occasions, the bats flew up to the façade, even in the same year. In 2002 it was possible to verify that the building had been accepted once more as a nursery roost.

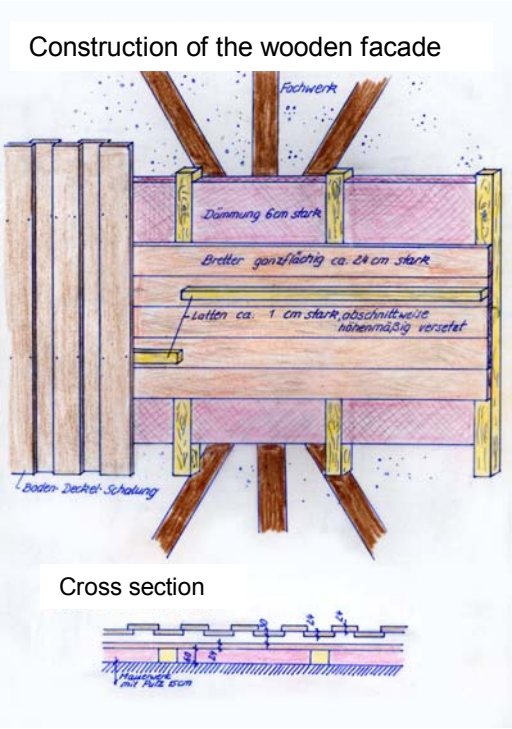


Fig. 4-13: Renovation example: forester's house in Schwarzbach (Thuringia, D). Photo: K.-P. Welsch; drawings: B. Ehrsam

4.5.3 Guidelines for the renovation of buildings with roosts of the whiskered bat

Things one needs to know

- Which hanging places are being used? Ideally, notes should be taken on a regular basis during the year prior to renovation.
- Which egress openings are in use?
- Are other roosts being used as well?

When may renovation work take place?

Any measure implemented between the beginning of October and the end of March is unproblematic. At the preliminary planning stage the completion date for the work should be set no later than the end of March. This is a precaution against possible delays. It should also be borne in mind that individual animals can be in residence in April and September.

Wood preservative treatments should be applied only between October and February (for this, see also chapter 5).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Ingress and egress openings

It appears to be important to keep at least one incoming and/or outgoing access passage that has previously been used. This applies even when the incoming and outgoing access passages of accepted alternative roosts are not always positioned in the same way as at the original hanging places.

Use of droppings boards

Should bat droppings under the roost openings become a nuisance, a " bat board" may be fitted under the ingress opening, once the young are fully fledged (fig. 4-14). It should be up to about 15 cm wide and should be fitted at least 40 cm below the ingress opening. However it is necessary to check whether the animals still use the roost after the board has been fitted. If the number of animals flying out should decrease during the following days, the board needs to be removed again. Take care that the board cannot be accessed by cats, as they can sometimes catch bats as they fly out.

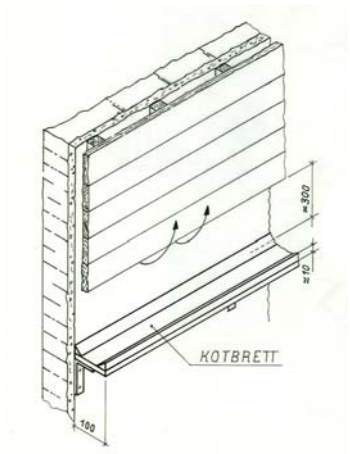


Fig. 4-14: Fitting a droppings board under the ingress opening (measurements in mm)

Using wood taken from former roosts and droppings, as odour markers

As part of the successful renovation of a building in Franconia that accommodated whiskered bats and Brandt's bats, wood taken from the former hanging places as well as droppings were used as odour markers at the new roost. It does not follow that the successful repopulation of the roost, can be attributed to the effect of these measures. Even so, it may be worth considering them, seeing that they require only a minimal effort.

Tips for alternative roosts

In principle every effort should be made to preserve existing roosts. If this is not possible, the following tips may increase chances of success in establishing alternative roosts:

- Ensure that temperatures at the alternative roost are appropriately high. For instance, position it in a place where it faces a direction between the south-west and the south-east. Or, choose a dark colour for its outer surface.
- To avoid overheating in times of high outdoor temperatures, make cooler areas available in the roost too. For instance, divide the roost into different chambers (see the model box in the appendix). Or make alternative roosts available with cooler hanging places. Generally, providing at least two roosts with different orientations is recommended (e.g. on the south and east sides of a building).
- Establish the alternative roosts immediately next to the original ones.
- Fit alternative roosts at an early stage, i.e. before the old roosts are removed, so that the animals get the chance to visit them.
- Use wood taken from the old hanging places as well as droppings from the nursery as odour markers.

When renovating roof spaces with crevice roosts of whiskered bats, the crevices/gaps used by them must either be preserved or re-created in the same places as the old ones. If beams and boards have to be renewed in the area of the hanging place, at least portions of the old wood should be retained or used in the fashioning of new crevice roosts. The width of the crevice/gap needs to match that of the original hiding place (gaps must not be too wide!). The openings through which the bats slip into the new hiding places should be next to the original openings. Crevice roosts located under surfaces that warm up rapidly (such as roof sheeting) need to be rebuilt in such a way that temperature conditions remain the same.

To optimise the range of hanging places, it may also be worth considering the introduction of bat boards (see appendix) or fitting flat boxes here and there.

Overview of the renovation of buildings with roosts of whiskered bats	
Critical factors	▪ Unsuitable wood preservatives or paint in the vicinity of the hanging place (only treat external surfaces and only whilst the animals are away) ▪ Changes in the micro-climate (temperatures that are too low) ▪ Relocation of egress openings ▪ Keeping a variety of hanging places with different temperature conditions
Less critical factors	▪ Light conditions ▪ Volume of the roost space, provided several roosts with different temperature conditions are available
Prior to the renovation	▪ Find out how the hanging places in the building are used ▪ Identify the ingress and egress openings that are used ▪ Preferably find out about (potential) alternative roosts in the neighbourhood
During the renovation	▪ No work in the roost area whilst the colony is present ▪ Egress openings (at least one already established opening per hanging place) must remain accessible. ▪ Hanging places should be preserved. If this is not possible, alternative roosts should be created in the immediate neighbourhood.
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-8: Overview of the renovation of buildings with roosts of whiskered bats (Myotis mystacinus)

4.6 Geoffroy's bat (*Myotis emarginatus)*

4.6.1 Roost ecology

Roosting places

Originally a cave dweller (living in Southern Europe), it is now an adapted species in Central Europe. In the alpine area nursery roosts are mainly located in roof spaces (e.g. lofts and farm haylofts). In the roosts, the animals mostly hang free, or more rarely in little hollows, such as in mortise joints for example. Even at times of high temperatures Geoffroy's bats nearly always seek mutual bodily contact (=clustering). The animals only hang singly after disturbances. Roosts of males are less commonly found (mostly in roof spaces, but sometimes also in wall facades, below overhanging roofs, and in tree hollows).

Fig. 4-15: Geoffroy's bats at the hanging place, and a typical hanging place situation in Maxelrain (Bavaria, D). The characteristic discoloration of the beams with urine and droppings is noticeable. Photos: A. Zahn

Seasonal use of summer roosts

Inward migration starts from the beginning of May (in Baden-Wurttemberg from as early as the middle of April). Most of the adult females are at the nursery by the beginning of June. In spring part of the colony may congregate at temporary roosts before moving to the main roost. The young are born in June, when the new arrivals appear over a period of several days.

The bats leave again from August onwards (in the warmer years from as early as the middle of July onwards). By some time between the middle and end of August most of the animals will have left. In colder years smaller groups of animals may remain at the roost into the middle of October.

Spatial use of the roosts

It is very rare for the animals to hang right at the ridge. When it is a multi-layered roof space, most often it is the lower levels that are used. Before giving birth and after the young are fully fledged, they characteristically move from one hanging place to another, depending on the temperature. However, the colony can also be spread over several hanging places. Whilst the young are not yet fledged, the animals mostly make use of only one hanging place with moderately high temperatures. Whereas smaller colonies (< 40 animals) like to retreat into nooks and crannies, larger groups mostly hang free from beams or boards.

In some cases it has been shown that one colony may be spread across several lofts (e.g. in Freiburg in Breisgau/Baden-Wurttemberg D, across three lofts) within a few hundred metres of each other. Moving from one roost to another is obviously routine in such instances.

Roost characteristics and temperature requirements

Spaces used by Geoffroy's bats are often comparatively light and only moderately warm. Many spaces are well structured, for example by having several different levels. Very often spacey lofts are used, some of which may be multi-storey. Places that are characterised by big shifts in temperature, such as towers, are used more rarely and at best only temporarily.

Studies in Bavaria have shown that Geoffroy's bats use either spaces that rarely have a temperature of more than 30 °C or at least that they use hanging places where the temperature is lower than that. Given the choice, the animals used hanging places with a temperature of at least 25 °C. This appears

to show that the animals prefer temperatures of between 25 and 30 °C. Temperatures over 33 °C are obviously avoided.

Ingress and egress openings

Free incoming and outgoing access passages appear to be important for Geoffroy's bats. There is no unequivocally documented case in the alpine area of a colony using as its principal egress opening one that would require them to land and crawl through. On the other hand, the animals are able to fly through relatively small openings and even, it seems, through the gaps in very wide-meshed gratings (cp. fig. 4-16).

The ingress and egress openings in five colonies in Slovenia, however, were located at a height of only between 1.5 and 3 cm from the ground (for example gaps between a grating and a wall). This makes it probable that the animals are not able to fly through them. (fig. 4-16).

Fig. 4-16: Ingress and egress openings of roosts of Geoffroy's bats in Bavaria (left) and Slovenia (right). Photos: A. Zahn, K Jazbec

Access to hunting grounds

To get to the hunting grounds, Geoffroy's bats predominantly fly along linear features of the landscape (such as hedges, rows of trees, wood fringes) or through woods and forests. Even in the immediate vicinity of the roost, the animals like a flying route that is sheltered by woodland. This means that during renovation the relevant structures need to be preserved, in so far as possible.

Roost Requirements of the Geoffroy's Bat			
Preferred hanging places	**Access passages**	**Optimal temperatures**	**Particularly critical times**
Depending on the temperature, they use several hanging places, which are often relatively light and only moderately warm. In multi-storey buildings, they do not usually select places immediately under the roof.	Very often these are passages that can be flown through. However, examples are also known of animals using very small openings through which they crawl.	About 25 to 30 °C	From May to July (before and during the birth of the young)

Tab. 4-9: Overview of the roost requirements of the Geoffroy's bat (Myotis emarginatus)

4.6.2 Experience and examples

Because of the small number of colonies that are known, there are also only very few renovation case studies for this species. From Bavaria there are three available examples, where substantial renovation or rebuilding work was carried out involving buildings with roosts, during the summer season. Two of these cases were monitored by bat specialists, but they were only called in at a point when the work had already reached an advanced stage. Further information comes from Salzburg and Baden-Wurttemberg.

Reaction to disturbance

Geoffroy's bats will fly off from the roost at even slight disturbances (such as noise, light, or vibrations). Very often on these occasions, the whole colony leaves the hanging place almost at the same moment, excreting droppings and urine. However, there are significant differences between colonies. Smaller groups and those whose hanging places are in rooms that are frequently entered or that are very high up, are less prone to fly off in a hurry. In general colonies react less strongly, as long as the young are not yet fledged.

Geoffroy's bats' tolerance of disturbances resulting from building work must be rated as comparatively low. In one of the examples from Bavaria, noise and vibration caused by work done on the roof and by the plaster being removed from the outer wall, led to the bulk of the colony moving out.

Even with minor technical work (e.g. wiring) carried out during the nursery period, negative effects cannot be ruled out. Yet, colonies living in rooms that are frequently entered are apparently more tolerant towards this kind of work. What the little experience that we have to draw upon shows is that it is at least likely that the animals will temporarily leave because of noise and vibration caused by renovation work. Therefore, this kind of work should be avoided during the periods when the nursery roosts are forming and whilst the young are being reared.

Reaction to external scaffolding

Geoffroy's bats seem to tolerate external scaffolding, provided the egress openings are not directly obstructed. This means that outdoor work that does not involve vibration or noise can be carried out even during the nursery period. However, it must be ensured that any netting used in the area of the egress openings has corresponding gaps in it (fig. 4-17).

Reaction to external lighting

When there is very bright external lighting, delays in leaving the roost and/or a change to the flight path can be expected. And indeed this was actually observed in an Austrian example. The animals did not fly out until the lighting was switched off, and that was about one hour after the usual exit time.

Examples from Belgium confirm this observation. There the lighting also represented a higher amount of risk to the bats to be caught by diurnal birds of prey.

Renovation examples

Zaisering Church (Bavaria, D)

The colony consisted of around 20 animals living in the loft of the village church, together with a small nursery of lesser mouse-eared bats. The hanging places could be found in the upper third of the loft, on beams and rafters. The roof was slated-covered, with boarding underneath. When the colony was being checked on 26th May 2003, it was ascertained that the north side of the roof had been given a

new covering. Work on the south side was just taking place. Both colonies were resident and were their usual size. This implied that the Geoffroy's bats had tolerated the work whilst the colony was in the process of forming. Because of the advanced stage of the work it was agreed that the roofing should be completed. On 7th July all mouse-eared bats but only five Geoffroy's bats were in the roof. The work was largely completed. Obviously the Geoffroy's bats had moved away much earlier than usual. Because of the warm summer, the young had already been fully fledged by that time; so it can be assumed that they had been reared successfully. With this species the nurseries start to break up immediately after the young have become fully fledged. Therefore the early migration need not necessarily have been a consequence of the building work, because the young were born early in the summer of 2003 and developed rapidly because of the extremely high temperatures. In the summer of 2004, the colony was back again with its usual numbers.

Maxlrain brewery (Bavaria, D)

The nursery roost was located on the second and third floor of a brewery, in spaces that are used only for storage. The egress openings were located on the top floor (4th floor). The colony consisted of about 250 animals.

Spring 2005 saw the start of improvement work on the roof. On 18th May the work being carried out on the roof was in full progress. In front of the egress openings there was scaffolding covered with a protective screen.

The architect, who was present on the scaffolding at the animals' exit time, stated that they were able to fly out through the gaps in the scaffolding covering without any problems. Nevertheless, the protective screen was removed around the area of the egress openings at the end of May. A first count at the hanging place (on the two floors below where the work was being done) found about the same number present as in the previous year (270 adult animals). The noise and vibrations caused by the work on the roof did not, apparently, disturb the animals. Yet, when a subsequent count was made, on 16th June only about 140 animals were present. They had spread to several different, and in some cases unusual, hanging places. Also some solitary individuals were found. This picture suggested that there must have been some antecedent disturbance. An inquiry into the matter showed that in the course of work on the facade plaster had also been partly removed. This may have resulted in noise and vibration from the outer walls of the floors inhabited by the animals. The work being carried out on the roof was also causing vibrations. These were clearly noticeable when the hanging places were being checked. Since the work was nearly completed, it was allowed to proceed.

In July, after the work had been finished, the colony was in residence again with its usual numbers; so the migration had only been temporary.

Pertenstein Castle (Bavaria, D)

The animals lived in the castle's roof space, which was used for storage and intermittently also for performances. The work and the rebuilding (fitting out a performance space) was carried out unmonitored and over an extended period of time. This was partly whilst the animals were present, although there was no knowing disturbance of the Geoffroy's bats. The colony had grown from about 8 animals (in 1995) to 50 (in 2005). The sporadic disturbances evidently did not lead to the animals being permanently frightened off.

Bergheim Church (Salzburg, A)

A colony of 15 to 20 animals lived in the church attic, using the towers as egress passages. In 2003 and 2004, the church underwent renovation. In the first year the whole roof was renewed. The asbestos cement shingles were removed and replaced with a sheet copper roof. However, neither the old wooden slats, used as hanging places inside the loft by the Geoffroy's bats, nor the paste-boarding in the roof were renewed. In 2003 the towers were also renovated (this involved scaffolding), and both a new copper roof and a slatted window were fitted. Due to unfavourable weather conditions the renovation work was delayed and done when the Geoffroy's bats were there already (May). However, the work carried out on the roof and the towers was not done from inside the loft but from the outside only. Despite the disturbance during the period when the nursery was establishing itself (May), 18

animals were counted in the course of a roost check on 22nd June 2003. In 2004 the three remaining outer sides of the building were renovated. During this year, only a maximum of four animals were observed in counts of animals flying out. Again, in 2005, only a few animals were observed during the course of such counts. But a roost check on 16th June 2005 showed that 15 animals were present. Counts during the following days made it clear that the animals had in fact changed their flight path. This may, on the one hand, be attributable to the renovation work of 2003 and 2004 or, on the other hand, it may reflect changes in the roost's environment (such as the ground clearing work in the neighbourhood of the church).

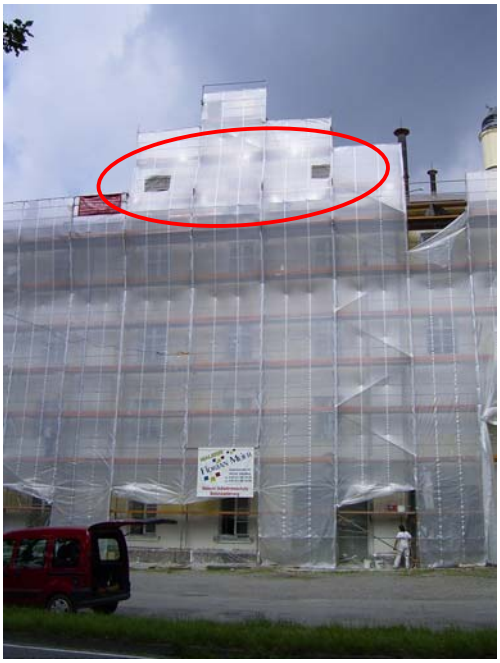


Fig. 4-17: The egress openings of the colony of Geoffroy's bats, consisting of about 250 animals, is located on the top floor of the attic. In 2005 the facade was renovated. Photo: A. Zahn

4.6.3 Guidelines for the renovation of buildings with roosting places of the Geoffroy's bat

Things one needs to know

- Which hanging places are being used? Ideally, notes should be taken on a regular basis during the year prior to renovation. Otherwise usage needs to be estimated from the quantity of droppings. It is particularly important to know which hanging place is used for rearing the young.
- Which ingress and egress openings are in use?
- If there are hanging places in more than one space, which access passages are in use?
- Are any potential alternative roosts available in the neighbourhood?

When may renovation work take place?

The current state of knowledge suggests that no work involving noise, vibration or increased frequentation of the roosting places should be carried out between the beginning of May and the end of July. This is because the animals are vulnerable to disturbance at these times. Measures implemented between the middle of October and the beginning of April are unproblematic. There are many years when the colonies have already dispersed by middle of August. As soon as that has happened the renovation work can start, if need be (but one needs to check). At the preliminary planning stage, the completion date for the work should be set no later than the end of March. Even though the animals usually appear only in the middle of April, this is a precaution against possible delays.

Wood preservative treatments should be applied only between October and the middle of March (for this, see also chapter 5).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Provided the appropriate precautions have been taken, a start can be made with the work if necessary during the period of the animals' migration in the middle of August. For example work away from the hanging places (such as the eaves area, facades) can already been carried out during this time, provided the colony is already on the point of migrating (i.e. if the reduction in numbers is already > 50 %). Work near the hanging places must not start before the last animals have migrated.

Partitioning off the hanging places

To date there are no precedents for the use of screens or cloth to partition off the hanging places from adjacent working areas, whilst the young are being reared. Because of their sensitive reaction to noise and vibration (even when it is not in the same room as the hanging places) partitioning areas off in order to undertake substantial renovation work in the adjacent areas should be avoided.

Replacing wood at the hanging places

Re-installing wood removed from the former hanging places is something that should be done, as a precaution, since there is no expert knowledge available about the acceptance of new wood.

Ingress and egress openings

The established openings leading to and from the spaces used by the animals also need to remain available to them during and after the renovation work. To date, acceptance of relocated openings has never been tested.

Ventilation conditions

It is very important for the preservation of colonies that there should be areas with different temperatures. Since no data is available about reactions to changed ventilation conditions, anything that would cause changes of temperature at the hanging places should be avoided (there should for example be no ridge ventilation, and no new openings at the same height as the hanging places, which are sometimes quite low down).

Overview of the renovation of buildings with roosts of the Geoffroy's Bat	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Changes in the micro-climate ▪ Loss of alternative hanging places ▪ Relocation of ingress and egress openings ▪ Noise and vibrations ▪ Increased frequentation of the roosting place
Less critical factors	▪ Work carried out on the exterior, provided no vibrations or noise are involved
Advice	▪ External lighting should not directly illuminate the area of the animals' egress openings ▪ During external work, entering the roost area should be avoided (i.e. access to the roof should be by means of external scaffolding etc) ▪ To date there is only little experience to draw upon. This means that it is difficult to evaluate the animals' reaction to various effects and to changes made to the hanging places.
Prior to the renovation	▪ Find out how the hanging places are used. ▪ Ascertain which ingress and egress openings are used. ▪ (If possible) also check on temperature conditions at the hanging places. ▪ (If possible) also ascertain flight paths. This is for cases where building work is planned in the vicinity, or involving illumination of the building site &c.
During the renovation	▪ No work in the roost area during critical times. ▪ Egress openings and hanging places must remain accessible. ▪ Connecting features between the roost and the hunting grounds (hedges, rows of trees etc) should be preserved, if possible.
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends.

Tab. 4-10: Overview of the renovation of buildings with roosts of Geoffroy's bats (Myotis emarginatus)

4.7 Natterer's bat (*Myotis nattereri)*

4.7.1 Roost ecology

Roosting places

Natterer's bat nurseries can be found in buildings as well as in nest boxes for bats and birds. The natural nursery roosts are located in tree hollows, and consequently there is no data available about them for the alpine area.

Roosts in buildings can be found either in wall cavities (e.g. in openings in the stonework) and in the roof area (e.g. in tenon holes or gaps in the frames). It is very rare for Natterer's bats to be found behind shutters or in wall facades.

A special feature of the Natterer's bat is that their nurseries are often found in cowsheds and machine shops in the region. The roosts are usually located in the openings in the stonework of the shed roofs or the walls. Originally a species that lived in tree hollows, the Natterer's bat is adjusted to having to find new roosts time and again.

Fig. 4-18: Hanging places of Natterer's bats in a shed, between a beam and a wall (Westerndorf, Bavaria, left), and in a cavity in the stonework at a machine shop (Kehrham, Bavaria, D). Photos: A. Zahn

Seasonal use of roosts in buildings

Relatively little data is available about the time of residence in nursery colonies. In the cases of six Bavarian nurseries, it was documented that all of the colonies were present in the months of June, July and August. One colony was present from April to September.

One nursery in a stable in Hesse was occupied from the end of April to the end of June. One colony was resident in a church loft from the end of March/beginning of April to November.

Often roosts of the Natterer's bat are only sporadically populated.

In bat boxes the last animals from nursery communities have been found until well into October. It is also possible to find smaller groups in buildings at this time. The possibility that individual animals also over-winter at some roosts cannot be excluded.

Spatial use of the roosts

In contrast to nursery colonies in nest boxes, which are characterised by high rates of roost changes, colonies in buildings apparently reside at their roosts for a longer time. So it is that sub-colonies can be sometimes found within one building. In cases where the animals live in gaps in the stonework, several gaps located on different sides of the house may be populated. Changes of roosts are probably attributable to temperature.

Egress openings

Since Natterer's bats readily slip through small openings (e.g. into damaged hollow blocks), when it comes to egress from the building itself, they may not depend on openings large enough to fly through.

Temperature requirements

Temperatures taken in a nursery roost in Hesse, which was located in the breeze block roofing of a cowshed, showed relatively constant temperatures of between 16 and 28 °C. However, this type of roost has to be differentiated from those located in lofts, where there are significantly higher fluctuations according to the time of the day.

In Bavaria, measurements taken in a gap in the stonework populated by a nursery showed major temperature fluctuations during the course of a day (maximum fluctuation 28 °C; average 14 °C), so that there might routinely be temperatures above 30 °C (maximum: about 39 °C). Animals changing roosts because of the high temperature was something that was not observed. Because of the animals' body heat, the temperatures in a hollow block could rise by about 10 °C, and reached nearly 30 °C during the night, after the animals had returned from the hunting grounds.

Roost Requirements of the Natterer's Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Even in buildings several hanging places are used, preferably in hollows and cracks.	Probably 30 to 33 °C	Probably between April and August, but this may vary from one colony to another

Tab. 4-11: Overview of the roost requirements of the Natterer's bat (Myotis nattereri)

Experience and examples

There are only a few case studies relating to the Natterer's bat in the alpine area. More substantial numbers of renovation examples came from England.

Reaction to disturbance

In Allgaeu (Bavaria) there are two documented cases where Natterer's bats flew off, abandoning their young because of sudden alterations to the roost. (Window shutters were closed and/or removed in the course of work on the wall façade). In each case, the young (7 and 23 animals, respectively) were on the same day housed in a flat bat box, fitted at the site of the former roost. During the following night all 7 young, in the one case, and 16 out of 23, in the other, were picked up by their mothers.

In one instance, the shutters were populated again in the following year (the boxes were not a suitable long-term replacement). In the same area it was observed that, after the erection of scaffolding, a colony of Natterer's bats that lived in a false ceiling stayed away for a whole year. (They probably moved to a house in the neighbourhood). However, they subsequently moved back again. Whether the scaffolding (without covering) in front of the egress opening, or the work done (painting the wall and beams) was the reason for their migration, is not completely clear.

Alterations at loft roosts

A study in England has shown that it is very important to colonies living in lofts that an extensive number or roosting places within the loft are available to them.

Moreover, it appears that the animals require their loft space to be of some considerable size. This is because the animals display a substantial amount of flying activity inside the loft (such as swarming behaviour in front of crevice roosts).

Alterations to the ingress and egress openings

Indicators from England lead to the speculative conclusion that Natterer's bats to not readily accept new ingress and/or egress openings, unless they conform to the original ones in both location and size.

In England the relocation of ingress and egress opening in the course of renovation work carried out on a church resulted in the colony staying away. When the old opening was cleared again a year later, this was enough to ensure that the colony populated the roost again in the following year.

This example suggests that the animals had been checking the roost for an improvement in its conditions, probably over an extended period of time.

Substitute roosts at the same location

In some cases in barn lofts in England, supplying wood and concrete boxes was attempted (the designs were not specified). However, as replacements for lost roosts that had formerly been located in the gaps and hollows of the rafters, they were not successful. In one case however the Schwegler 1FF model (=flat box) was accepted.

In the Czech Republic Natterer's bats were offered bat boards as an alternative to the original roosts located behind window shutters. In the first place, they were fitted on the shutters and then they were moved little by little. The inhabitants found this acceptable.

External lighting

In cases where the ingress and/or egress openings are directly illuminated, external lighting seems to have a negative effect on the use of the building by Natterer's bats.

4.7.2 Guidelines for the renovation of buildings with roosting places of Natterer's bats

Things one needs to know

- Which hanging places are being used?
- Which ingress and/or egress openings are in use?
- Are there any alternative roosts nearby?

When should renovations take place?

Because there is only little data available, it is difficult to be specific about which periods would be best for renovation work. Each case needs to be judged on its own terms.

In any case, it must be borne in mind that there will be nursery colonies between April and September. No work should be carried out during this period, unless better information is available. Moreover the presence of individual animals during the winter months cannot be ruled out, and this too has to be taken into consideration.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Potentially significant factors in respect of renovation work

The data about the renovation of buildings with roosts of Natterer's bats collected so far does not constitute an adequate basis for guidelines. Nevertheless, judging from the few case studies and from the species' ecology, factors that may be important are as follows:

- Preserve and/or make available a range of hiding places in crevices at various temperatures
- Do not relocate ingress openings
- With colonies in lofts, the dimensions of the space should not be greatly reduced

With roosts in roof spaces, the crevices used by Natterer's bats must be preserved or reproduced in the same places. In cases where beams and boards in the hanging area need to be renewed, portions of the wood from the hanging place should be retained. At least in places it should be used for the newly fashioned crevice roosts. The width of the gap has to conform with that of the original hiding place, and the opening through which the animals slip into the new hiding place should be adjacent to the original one. Crevice roosts that are located under surfaces that warm up rapidly (such as roof sheeting) have to be designed in such a way that the temperature conditions remain the same as before.

To optimise the range of hanging places, fitting bat boards or flat boxes (see appendix) at a number of points, may also be worth considering.

4.8 Greater mouse-eared bat (*Myotis myotis*) and lesser mouse-eared bat (*Myotis bythii*)

Nearly all the observations and case studies that have been made available relate to the greater mouse-eared bat. A few cases deal with mixed colonies of both mouse-eared bat species. It is reasonable to assume that in many respects the lesser mouse-eared bat has similar requirements to those of the greater and that it has similar behaviour and reacts similarly to changes at the roost. However, there are no comparative observations to draw upon nor any accounts of renovation work that focus on the behaviour of lesser mouse-eared bats.

The following data applies safely only to greater mouse-eared bats. All the photos show greater mouse-eared bats and/or their roosts.

4.8.1 Roost ecology

Roosts

Originally a cave dweller (living in Southern Europe), it is now an adapted species in Central Europe. Nursery roosts are located in roof spaces (such as lofts and towers), and more rarely also in bridges and (heated) subterranean spaces. The nursery communities mostly hang free in the roosts and often

seek mutual physical contact. They retreat to the crevices only at times of high or low temperatures. It is very rare for nurseries to reside in crevice roosts (such as false ceilings) or other spaces of small volumes. Individual animals or mating groups hang free or in the gaps in roofs. Additionally, they also use alternative crevice roosts in buildings, tree hollows and nesting boxes. Caves and rock crevices too can serve as daytime roosts.

Fig. 4-19: Mouse-eared bats at a hanging place under the ridge of a roof (left) and one on a wall used at times of high temperatures (right). Note the brown discoloration around the hanging places, the boards of a lighter colouring because of the minerals in the dried urine, and in the foreground of the right-hand picture, droppings on supporting beams. Photos: A. Zahn

Seasonal use of summer roosts

In warm years inward migration starts from the end of March onwards, more usually however not before April. By the middle of May, or at the latest the beginning of June, the colonies are fully populated.

Outward migration starts at the end of July/beginning of August. The young remain at the roosts until September/beginning of October. In cold years, smaller groups or individual animals sometimes stay well into November or even try to over-winter at the roost.

Roosts of male bats are occupied from May onwards, though often only from June/July to September/October. From the end of July onwards female bats migrate to the male bats' hanging places (for mating).

Spatial use of the roosts

In most cases colonies will switch from one hanging places to another, often doing so in a set order (e.g. in spring the church tower, in summer the church roof). In all roosts located in lofts, sites where warm air piles up (such as the ridge, or tower) are used for hanging places, and they are usually the most frequented ones. In summer mouse-eared bats move to cooler hanging places: on walls (such as wall crevices), down to the lower floors of buildings, or even under the floor boards of church lofts.

At these times, draughty places that would otherwise be avoided are also used (such as damaged areas of the ridge, or walls near to a window). In autumn greater mouse-eared bats can quite often be found hidden in crevices.

Tip: Hanging places can be identified by means of the droppings below and of a black-brown discoloration of boards and walls.

Fig. 4-20: Brown discoloration of wood, brick and wall at a hanging place of male mouse-eared bats. Photo: A. Zahn

Roost characteristics and temperature requirements

Colonies of mouse-eared bats populate both narrow towers and spacious lofts. A decisive factor in this is the range of hanging places with different temperatures. The mother does not take her more mature, but not yet fully fledged, young with her, when she switches to other hanging places. So it is advantageous if these animals can move to places with different temperatures by climbing (rough walls/beams are necessary for this).

In nurseries located under the ridge, hanging places quickly reach temperatures of between 25 and 30 °C, when the sun is shining, and they routinely climb to more than 35° C. From about 30 °C and upwards, however, the animals gradually move to cooler hanging places. In general, warm roosts promote the development of the young, but in periods of bad weather they can probably also be disadvantageous. This is because in periods of cool weather, when there is often a shortage of food, the danger of mortality amongst the young is greater at roosts with comparatively high temperatures. In such roosts the young cannot reduce their body temperature sufficiently to save energy and thus survive the period of food shortage. Warm roosts without cooler alternative hanging places (e.g. in towers) can become so hot in some years that the animals migrate.

Nurseries of mouse-eared bats are mostly dark.

Large colonies of mouse-eared bats readily attract predators such as martens or owls. They must not be able to gain access to the roost.

Ingress and/or egress openings

In some cases the animals fly in through open windows. Alternatively, they land and then have to crawl through narrow openings. Such openings (with a minimum width of about 3 cm) are for example gaps at the bottom of the roof, holes in walls or around windows, between the frame and the window opening. Gaps between the roof tiles are also used (particularly in the ridge area). In cases where free ingress openings as well as smaller gaps are available, the openings that can be flown through are usually preferred. Observations show that where there are coarsely meshed grilles that they could easily be traversed on the wing, the animals prefer to land and to climb through.

Large colonies (> 300 animals) tend to use the larger openings. Small gaps that only few animals can use at the same time are likely to be found at smaller colonies (although there are exceptions).

Tip: The transit and egress openings that can be used in free flight may only be identifiable by means of the droppings on the floor and on the wall, in the environs of the egress opening. (Note that these may be inconspicuous with small colonies.) Smaller gaps that are used can be identified by the brown discoloration of the landing place in front of the opening and on the surfaces over which the animals climb. Usually it is easier to spot them in the roost than it is from the outside. However sometimes it is also possible to identify them from there (remember to take your binoculars!).

Fig. 4-21: Gaps through which the animals can slip into and out of the roost: between a door and a wall (left) and at the base of the roof (from the outside the animals appear under the eaves gutter). The place where the mouse-eared bats land on the wall and beam is discoloured brown. Photos: A. Zahn

Fig. 4-22: Ingress passage below the guttering, identifiable by the dark discoloration of the wall (left), and ingress passage through diagonal window slats (right). Photos: A. Zahn

Roost Requirements of greater mouse-eared bats (incl. mixed colonies with lesser mouse-eared bats)			
Preferred hanging places	**Access passages**	**Optimal temperatures**	**Particularly critical times**
Typically in the ridge area, but also in gaps and cracks in the wood and brickwork	Spacious lofts are preferred because they offer a wide range of hanging places	Between 25 and 33 °C	May, June, July, August (pregnancy and rearing of the young)

Tab. 4-12: Overview of the roost requirements of greater mouse-eared bats (Myotis myotis) and mixed colonies of greater and lesser mouse-eared bats (Myotis blythii)

4.8.2 Experience and examples

By far the largest number of renovation case studies refer to this species (a total of 78 of them). The documentation of the cases is generally more substantial and more detailed than it is for most of the other bat species.

Reaction to disturbance

Mouse-eared bats have proved to be comparatively tolerant towards disturbances caused by building work. If the disturbances are kept within limits, the colony will usually remain in the building. If a migration does take place, then it is only temporary or just involves part of the colony. Generally when animals move, it is to other mouse-eared colonies in the neighbourhood.

In the documented case studies, the animals showed no behavioural changes as a reaction to noise. In cases where the hanging places were illuminated however, the animals left the illuminated places after some time. Vibrations (e.g. caused by work carried out on a roof) were in several cases extremely well tolerated. But it must be supposed that, in conjunction with other factors, vibrations can sometimes cause the colony to migrate.

Minor technical work (such as wiring) was carried out in several instances, without noticeable effect on the animals. Even where more substantial work was done on the larger roof rafters, colonies did not

abandon the roost. However, in some cases part of the colony migrated because of the work, particularly when it was carried out in the immediate vicinity of the hanging places.

During renovation work, on several occasions the hanging places were partitioned off from the adjacent working area with sheeting or cloth (hung horizontally and/or vertically) during the time when the young were being reared. In such cases, the whole colony, or at least the majority of the animals, remained at the roost. This meant that a reduction in the space occupied by the animals (sometimes of up to 90 %) was tolerated.

There are indications that migration in response to disturbances is more likely in spring (i.e. before giving birth) than it is after the young are born.

Reaction to external scaffolding

Any changes made to the egress openings during renovation work on the outside of a building are problematic: e.g. protective mesh or tarpaulins on scaffoldings. When direct flight to the openings is made difficult, there is the risk that the colony will migrate. When the scaffolding covering has an extensive gap in it, in front of the egress opening, this access is accepted by the mouse-eared bats.

In an instance in Switzerland renovation work was carried out at a building accommodating over 400 greater mouse-eared bats and lesser mouse-eared bats. By means of the scaffolding, cats were able to gain access to the ingress opening and the inside of the roost. As a consequence the mouse-eared bats deferred flying out for some considerable time.

Fig. 4-23: Partitioning off the hanging places with dark sheeting, at Kläham (Bavaria, D). Photo: A. Zahn

Alterations to egress conditions

Mouse-eared bats behave rather predictably as far as their ingress and egress openings are concerned. New openings are usually accepted only reluctantly, or not at all (sometimes the young test new or less appropriate openings). In many cases, closing the established opening in favour of a new alternative one was the most important reason for a colony's migration.

In instances where animals use several different spaces, flight paths need to be preserved. This can present difficulties from the point of view of fire prevention regulations. One option is to fit a fire retarding flap that is still suitable for flying through (fig. 4-26).

If floodlights are directed at the egress openings, flying out times can be significantly delayed (> 2 hours). Sometimes the animals do not emerge until the lighting has been switched off. In some cases open illuminated windows will not be used. Instead the animals prefer an egress opening in an unlit area, even though they have to crawl out. In one case it was possible to alter significantly a nursery's behaviour by partial screening of the floodlights: the animals once more emerged at a much earlier time. In some cases a reduction in colony size may be linked to exterior lighting. In Rheinfelden (Switzerland) it was suspected that there was a connection between lighting and increased mortality amongst the young. When egress is delayed, hunting during the first night time hours drops off. But it is precisely then that the still relatively high temperatures favour insect activity.

Alterations to ventilation conditions at the roosts

Alteration to climatic conditions in the course of renovation work is one of the principal reasons why colonies of mouse-eared bats are lost. A reduction in the warm air piling up below the ridge because of ridge ventilation, the creation of ventilation openings near the ridge (with ventilation bricks), a general decrease in the roost temperature because of too many ventilation openings: these are all reasons why roosts may be abandoned. In small spaces, even a wide ventilation gap at the base of the roof (between the roof and the house wall) can probably cause temperatures to decline too much.

Renovation examples

The effects of noise and vibration

Taching Church (Bavaria, D)

The church underwent re-roofing whilst the young were being reared. The animals hung from the roof's boarding, and light and draughts could now enter between the boards. It is not known whether the animals preferred to move to the roof segments where the old roof had not yet been stripped, or the ones that had already been re-roofed. No reduction in the colony's numbers (about 200 female bats and young) was observed.

Partitioning off of hanging places

Triesen Parish Church (St Gallen, CH)

Prior to renovation work, the roost of greater and lesser mouse-eared bats, numbering about 160 individuals, was located in a small roof space, above the choir. Hanging place marks and traces of droppings showed that the main roof frame above the nave were occasionally used too. During rebuilding work, carried out from 1991 to 1993, it was essential that the mouse-eared bats could freely use the smaller frame of their roof space. Therefore no building work was done in the roost area between 1st April and 30th September. As the animals' egress opening was located on the other side of the building (in the main roof frame), they had to cross the whole roof space above the nave in order to be able to get to the opening. Had the main roof frame partially been left open at the side during the rebuilding of the nave, this would have caused a strong draught, adversely affecting the micro-climate. Before the animals arrived in the spring of 1992, a passage about 3 m high, made of plastic sheeting was made. It completely closed off the sides of the nave that had already been opened up in parts. The bats were thus provided with draught-free conditions in the small roof space, as well as the ability to access their egress opening freely. The previously unobstructed opening between the hanging place area and the main roof frame was temporarily closed off in order to guarantee that temperatures would be sufficiently high for the hanging place (because of warm air

piling up). Using a small slit, the animals were able to access the sheeting tunnel, and through it the egress opening. Thanks to this flight corridor that was closed to the sides, the bats were not disturbed by the ongoing building work on the nave and the noise it involved. They appeared on schedule in April, and did not migrate until September. They used the tunnel without any problems. In October 1992 the plastic flying corridor was taken down, and work on the roof area above the choir was started. In places new support beams had to be fitted in the area that up until now had been the hanging place. However, the beams and laths marked by the animals' scent secretion were preserved in so far as possible. When the cement asbestos sub-roof was renewed, the old tile battens were used again. However in the spring of 1993, the choir roof was temporarily closed up again with plastic sheeting and additionally covered with form-work panels, to preserve the micro-climate in the roost area.

The first mouse-eared bats appeared at Easter but they moved to the rafters in the main body of the church. (This was despite the fact that the base of the roof was open and only temporarily closed off with sheeting.) The colony spent the whole summer there. It is unclear, if the temporary, and possibly inadequate, provisions in respect of the smaller roof frame were the reason for this. Although their new hanging place had sometimes been used before, the space normally used, at least during the previous years, was the one above the choir. In subsequent years too the mouse-eared bats preferred their new hanging place located in the rafters of the main body of the church (where the renovation work had been meanwhile completed) to their old one. Negative effects on the size of the colony were not observed.

Partitioning off the hanging places under less than optimal conditions

Oberflossing Church (Bavaria, D)

The colony (of around 130 to 200 female bats and young) was found in the roof frame of a small sacristy, when tiles had already been removed from half of the roof. The young were not yet fully fledged. The roof was temporarily closed in again by means of black sheeting. The animals successfully completed the rearing of the young. However in the following years they avoided the roost in the sacristy roof frame, and took up residence in the tower instead. The ingress openings at the sacristy had been preserved, but the roost had presumably become cooler than before, because of better ventilation at the base of the roof.

Kläham Church (Bavaria, D)

In the summer of 1998, the church roof frame underwent renovation church. Before work began, about half of the timber frame, namely the portion above the lower cross beams, was partitioned off by means of black sheeting. That the animals were still able to fly out through a window in the tower was verified. From June onwards, renovation work was carried out below the cordoned off portion as well as in the free area above the apse (fig. 4-23). The partitioned area was renovated only after the young had been reared. However, one of the colony's main hanging places was located outside the partitioned area, and in April 1998 the first animals gathered at that hanging place. By the beginning of May the roughly 25 animals present had retreated to the partitioned area (so the size of the colony was slightly smaller than the year before). During the summer, the animals only stayed there from time to time, probably because the temperatures rose too high in the partitioned area, when the sun was shining (over 40 °C). The tower was chosen as the alternative hanging place, because the animals had already stayed there occasionally in the previous year. In subsequent years the colony used the roof again. However, and for no obvious reason, the number of animals gradually decreased.

Alterations to climatic conditions at the roost

Frichlkofen Church (Bavaria, D)

The church underwent renovation in the summer of 2000. However, work on the space in which the nursery's hanging place was located was not carried out, until after the young had been reared. The

egress openings were left without their gratings. In order to provide warm hanging places despite the improved ventilation, two areas of rafters were boarded over at the ridge (fig. 4-24). The work was completed by the beginning of April 2001. However the improved ventilation meant that the space warmed up significantly less. In May the few animals that had appeared did not roost at the usual hanging place but in the tower. However, 170 female bats and young bats were observed back at the usual hanging place once more, at the beginning of August. This was after the ridge area had been to a large extent sealed and the boarding at the hanging places had been optimised. The colony size was equal to nearly two thirds of what had been observed prior to the renovation. (Two years later this had risen to three quarters.)

Röhrnbach Church (Bavaria, D)

Renovation of the church tower (roof and tower shell of the onion dome) was carried out outside the nursery period. Ventilation bricks were fitted around the base of the onion dome. Subsequently only about 20 out of the previous 90 animals were counted. After the ventilation bricks were sealed, the colony numbers rose again between 1993 and 2005 to 180 animals.

Alterations to airborne access conditions

Hohenwart Church (Bavaria, D)

The example of the colony in this church shows how the animals react to wire mesh. Essentially the animals (at that time about 250 female bats and their young) always flew out through the acoustic windows in the tower. About 90 % of them used the north window, where there was a gap of about 20 cm because of a missing wooden slat. Before the bats arrived in 1997, all the tower windows were grated over using coarse mesh wire netting, to keep the pigeons out. To ensure that the mouse-eared bats could still fly in, the wooden frames on which the wire mesh was mounted were fitted in such a way that open slits about 5 cm wide were left between the frames and the wall, above the acoustic windows and at their sides. Subsequently, in June 1997, a hole about 8 cm high was cut in the north window mesh, at the height of the missing wooden slat. In May 1997 the complete colony returned. However, they now mostly edged through the slits between the mesh's wooden frame and the wall, on the southern and eastern windows. Only very few animals still used the hole that had subsequently been made in the northern window's mesh, at the site of the former ingress opening. Compared to previous years, the time at which the animals began flying out was not delayed, in so far as could be ascertained. However, in the following years the size of the colony decreased.

Fig. 4-24: Boards fitted at the ridge of Frichlkofen Church (Bavaria, D). The seamless rabbet and feather joints (tightly sealed at the ridge), enable warm air to build up. From as early as the first year, the animals hung from the new boards. Photo: A. Zahn

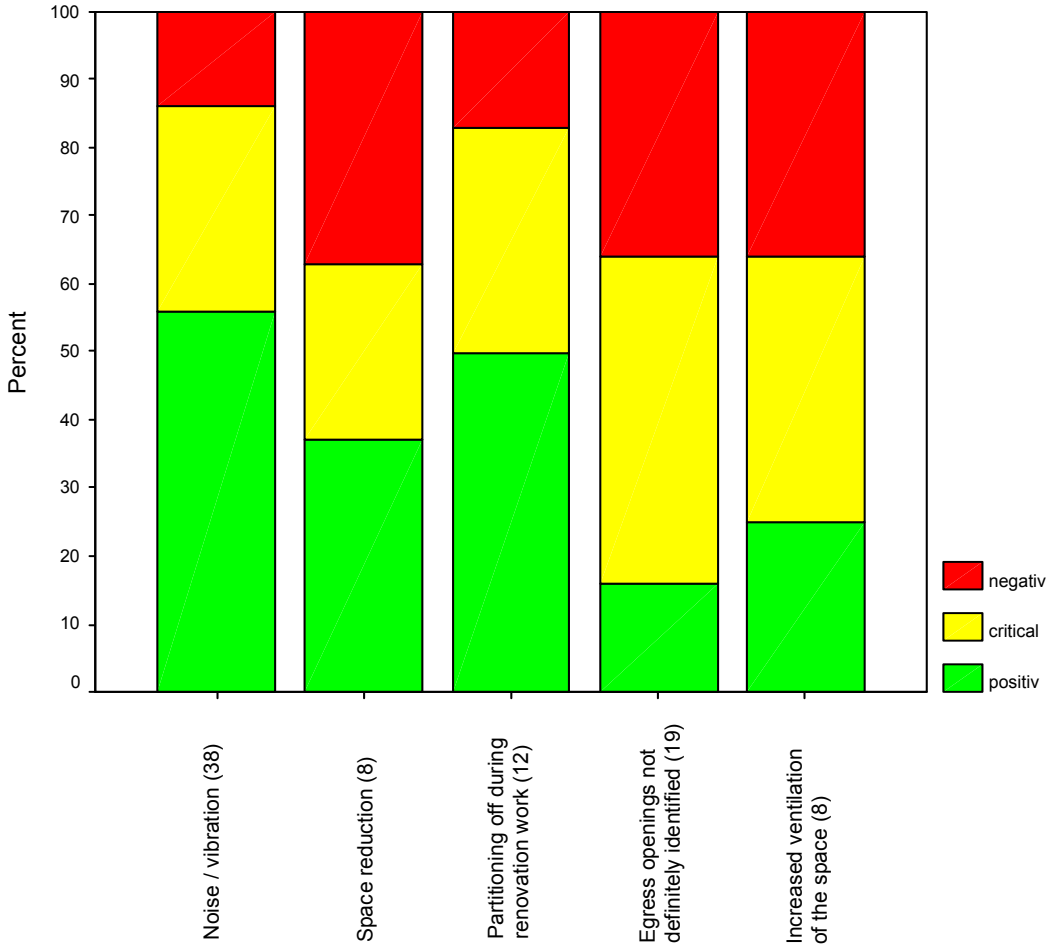


Fig. 4-25: Critical factors when renovating buildings with roosts of mouse-eared bats, and their effects on the colony. Those factors that could potentially have a negative effect on a colony are specified, and, in brackets, the number of cases where data relating to the factor in question was available. Cases were evaluated as "positive" if colony populated the roosts again in the following years, without any significant drop in numbers. "Critical" cases were renovations that resulted in population declining by about 25 % or more. "Negative" cases refers to instances where colonies migrated permanently, or moved into a completely different part of the building. In almost all cases renovation work involves several different kinds of disturbance. This makes it unclear which factor was decisive in any eventual failures. Yet, it can be stated that cases where egress openings were unknown (and so were often altered) and cases in which there was an increase in ventilation at the roost area, very rarely ended positively. Noise and vibration were mostly tolerated, provided no other negative changes occurred.

4.8.3 Guidelines for the renovation of buildings with roosts of the greater and the lesser mouse-eared bat

Things one needs to know

- Which hanging places are in use and at which times (ideal: notes should be taken on a regular basis during the year prior to renovation; if need be: expert evaluation identifying traces of droppings and hanging places)?
- Which egress openings are being used by the colony (ideal: which openings are used by which parts of the colony)?

- When there are hanging places in several different spaces: which access passages are used?

When may renovation work take place?

Despite their comparatively high tolerance of disturbance, work should basically be avoided whilst the mouse-eared bats are present. Work carried out between the middle of October and the middle of March is unproblematic. At the preliminary planning stage, the completion date for work should be set no later than the middle of March. Even though the animals usually appear only in April, this is a precaution against possible delays. Treatment with wood preservatives containing toxins may only be implemented between November and February (for this, see also chapter 5). Treatment using hot air and CO_2 gas may also be carried out in October and March, when the presence of the animals can be ruled out.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Work at the hanging places should not be carried out before the last animals have left (September/October). If need be, the migration of any remaining young can be hastened by, for example, altering the temperature conditions (by opening up the roof near to the hanging places). (It is not known, if these animals will return in the following spring).

Work carried out further away from the hanging places (such as re-roofing, replacing beams etc) may be carried out during the summer too, provided the hanging places have been partitioned off. In each individual case of this kind the experts need to decide the following: what distance must be kept between the bats' hanging places and the working area, which kinds of work are allowed in the first place, and what safety precautions should be taken. Partitioning must be regarded as a temporary measure, anyway. This is because a migration of parts of the colony has already been seen on more than one occasion in such cases. If the spaces used by the animals are small (such as church towers, or small churches), the work should in any case be postponed to autumn.

Work carried out on parts of the building away from the roost area (such as facade renovation and work on towers - provided the colony lives in the loft, etc) are usually unproblematic even in summer (keep an eye on the relevant egress openings, if need be!).

Partitioning off the hanging places

In cases where renovation work done on larger buildings takes an extended period of time, the mouse-eared bat hanging places can be partitioned off by means of boarding, screens or cloth. This makes it possible to carry out work in adjacent areas. The pre-conditions for doing this are:

- The partitioning off is to be done in winter/spring, prior to the animals' appearance
- Hanging places used by the animals at different seasons are to remain accessible (that is are located in the "bat area"). This applies particularly to alternative hanging places which are used at times of high or low temperatures. If important hanging places are not accessible, this may result in a migration of at least parts of the colony. The range of temperatures at the hanging places in the partitioned off area is probably the decisive factor in determining whether mouse-eared bats will accept it. Provided temperature requirements are met, the animals accept the partitioning even if not all their hanging places are available to them.

- The customary egress openings are to remain usable (unobstructed access!).
- Temperature patterns in the partitioned off area are not to change too much (when smaller areas are partitioned with a screen, it is possible for temperatures to rise too high).
- As a basic rule, as large an area as possible is to remain available to the animals. The minimum figure is about 20 % of the space normally used by them. If need be, access to the egress openings can be ensured by means of a tunnel of sheeting (at least 2 m high and wide) linking the "bat area" to the opening.

Replacing wood at the hanging places

After renovation work has been carried out, mouse-eared bats initially like to use the remaining "old" boards and beams, with their characteristic odour (they are identifiable by the dark discolorations). In cases where the hanging places have been completely or almost completely refurbished, a few old and discoloured boards and beams should be preserved and re-installed at the hanging places once the renovation work has been completed (without a load-bearing function). Fitting just a few segments of old wood (with a total length of about 3 to 6 m, distributed around the hanging places) will be sufficient, as the animals will very soon hang from the new wood too.

Ingress and egress openings

Customary ingress and egress openings at the space used by the animals should remain available even during the renovation. Temporary or permanent relocation of the openings would very probably lead to the colony migrating for good. At best, the animals will use new openings only after they have become used to them over a period of several years. Therefore, any new openings should always be fitted next to the old ones (< 1m away) and should be as big as possible, so that the animals can easily find them.

Openings that are altered, for instance to keep pigeons out, are generally accepted by the bats, provided they remain usable. Yet, in such cases, the opening may be divided (by means of a slatted window, or horizontal bars), but it may not be made smaller or fitted with fine mesh grills. As regards slatted windows (acoustic vents) with diagonal slats, the distance between the slats should be at least 7 cm to ensure that the bats can fly through. In cases where the distance between the slats is smaller (3 to 6 cm) the wood needs to be rough so that the animals can land. If, instead of slats, horizontal wooden bars are fitted to keep the pigeons out, the bats can still fly through the opening, provided the distance between the bars is between 5 and 6 cm. Grills (e.g. wire netting) with a mesh width of about 6 x 6 cm can be traversed, however it seems the animals do not like it. Therefore, the grating should be holed with several slits at least 6 x 40 cm large, to ensure that the animals can fly through without obstruction. (Pigeons can be prevented from entering by means of a roller bar). As a precaution, a gap of at least 3 cm should be left between the edge of the grating frame and wall, so that the mouse-eared bats can land if necessary, and climb round the frame.

Tip: A danger with smaller meshes is that the animals may get caught in them. Therefore they must not be used (this also applies in relation to other bat species).

Ingress and egress openings must remain open at all times and, where applicable, rebuilt in an appropriate fashion, so that it is impossible for a colony to be shut out or in by mistake (e.g. by fitting a skylight).

Use of alternative roosts

Even if mouse-eared bats migrate because of renovation work, or because the openings they use have been blocked, it is still possible that some or all of the animals will return after several years. Therefore it is worthwhile preserving appropriate roost conditions or subsequently restoring them. In most cases however the nursery remains permanently abandoned after the animals have been driven away. There are instances on record, however, where the animals' eventual return has been made more unlikely, because of unsuitable or blocked openings and/or unfavourable hanging place conditions (such as ventilation).

Ventilation conditions

A crucial factor in determining whether a colony remains is whether there are ridge areas where warm air can build up. This means that ridge ventilation has to be avoided. Ridge tiles need to be cemented in place. In the case of roofs with wooden boarding beneath the tiles, ridge ventilation (in the form of ventilation tiles) can be tolerated, if need be. But this is only on the proviso that the boards meet at the ridge (without gaps!) and that vapour-permeable sheeting is fitted in the ridge area, between the boarding and the tiles (fig. 4-26).

The number and location of the ventilation tiles located below the ridge needs to be adjusted so as to ensure the build up of warm air is maintained (or in some cases improved). In principle, it should be possible to plan this out before the renovation begins. In cases where ventilation conditions are altered as a result of renovation (e.g. by improved ventilation at the base of the roof), ventilation tiles should not be fitted in the upper half of the roof. Larger ventilation openings should only be introduced in the lowest third of the roof. It is preferable not to fit ventilation tiles in sub-sections of the roof frame, e.g. the side wings.

At least in one case, a moderation of temperature fluctuations (because of thermal insulation) was the probable reason for a colony migrating. It should therefore be avoided.

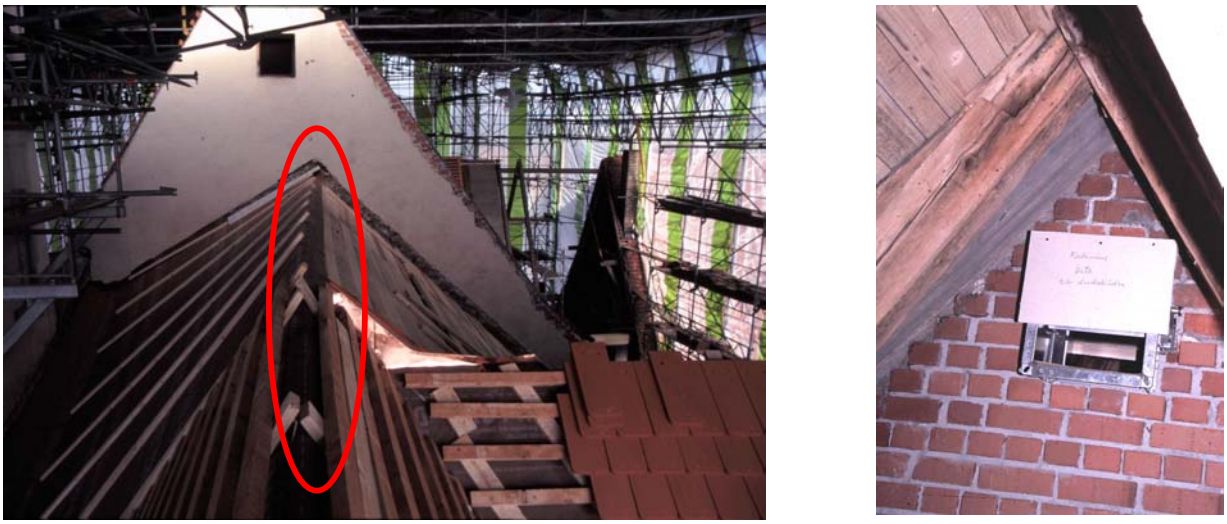


Fig. 4-26: In Beyharting (Bavaria, D) a vapour-permeable sheet was fitted along the ridge, making it possible for a certain amount of warm air to build up. Under the sheet there is boarding, from which the animals hang in summer, just as they did before renovation. If it is cold however (in spring), the animals roost in an adjacent roof frame with higher temperatures, which is also as it was in previous years. For this purpose they fly through a fire retarding flap (small picture), which was fitted about 70 cm below the former transit passage (a hole in the wall). Photos: A. Zahn

Protection of load-bearing beams from the effects of droppings and urine

Larger colonies of mouse-eared bats produce considerable quantities of droppings and urine. In some cases moist deposits on load-bearing beams are the result. Whilst dry droppings do not harm the wood, building specialists suspect that extensive quantities of urine may do damage. In the course of renovation and from the point of view of bat conservation it is therefore important to make provisions for facilitating the removal of droppings, and for protecting the load bearing beams. Generally the existing droppings will show upon which parts of the wooden structure droppings will accumulate in appreciable quantities.

Load-bearing beams can be protected against droppings and urine by being covered with “waste boards” made of untreated wood. If the beams are located in the hanging place area, the boards need to be “coarse-sawn”, or furnished with grooves (at an interval of about 3 cm) so that the animals can find a foothold. If this covering is back ventilated, the ventilation gap should not be wider than 1 cm so that the mouse-eared bats (the young!) cannot crawl into it (fig. 4-27).

For horizontal beams on which droppings collect, smooth sloping boards, pieces of sheet metal or roofing felt can be used to drain off the droppings and urine. To facilitate disposal of the droppings, the floor of the room should designed in such a way that sheeting can be laid out to collect them.

Fig. 4-27: In Au (Bavaria, D) load-bearing beams at the hanging places were covered with waste boards as a protection against droppings and urine. The animals were already hanging from the new boards in the first year, even though they preferred the hanging places located on the old roof laths. Photo: Andreas Zahn

External scaffolding

Immediately in front of the egress opening there should be a gap of at least 1 x 1 m in any meshing or tarpaulins. If the egress opening itself is bigger (e.g. a tower window), the opening in the coverings should match the size of the egress opening.

Overview of the renovation of buildings with roosts of greater mouse-eared bats	
Critical factors	▪ Unsuitable wood preservatives in the hanging place areas ▪ Alterations in the micro-climate ▪ Loss of alternative hanging places ▪ Relocation/reduction in size of egress openings and access openings
Less critical factors	▪ Noise and vibration ▪ Occasional visits to the roost area ▪ Reduction of the space available ▪ Partitioning off the hanging places
Advice	▪ No change in the temperature conditions at the hanging place → no false ceilings or ridge ventilation, ensure that warm air builds up. ▪ No external lighting in the area of the egress opening or the animals' flight paths ▪ Use coverings to protect load-bearing beams against droppings and urine ▪ When openings are relocated, the animals take a few years to get used to them (in such cases, their flying behaviour has to be thoroughly studied). Therefore, the openings to which they are accustomed should be relocated only in exceptional cases, and after consultations with bat specialists. ▪ Take care that external scaffolding is positioned so as not to interfere with the animals' flying behaviour.
Prior to the renovation	▪ Find out how the hanging places are used ▪ In cases where altered ventilation conditions cannot be ruled out, find out what the temperatures are at the hanging places, under different weather conditions (and compare with outside temperatures). ▪ Ascertain which egress openings and transit passages are in use. ▪ If need be, partition off the hanging places prior to the animals' appearance.
During the renovation	▪ No work in the hanging place area during critical times (from April to August) ▪ Continuous consultation with specialists, if exceptionally work needs to be carried out in spaces used by the animals (partition off the colony's hanging paces!). ▪ Egress openings and hanging places must remain accessible. ▪ When the animals are present, continuously monitor their behaviour; do they accept the disturbances?
Result checking after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends ▪ In cases where changed ventilation conditions are probable, find out what the temperatures are at the hanging places, under different weather conditions (and compare with outside temperatures).

Tab. 4-13: Overview of the renovation of buildings with roosts of greater mouse-eared bats and mixed colonies with lesser mouse-eared bats

4.9 Noctule bat (*Nyctalus noctula*)

4.9.1 Roost ecology

Roosting places

Originally it would inhabit tree hollows and occasionally also rock crevices. In Central Europe there are very often roosts in cracks in buildings, for instance in wooden panelling or asbestos cement, damaged hollow concrete blocks, roller shutter casing, or wall crevices, as well as in bat and/or bird nesting boxes.

Colonies do not usually reproduce in the alpine area so that roosts do not serve as nurseries. There hollows and nest boxes are mainly used as mating roosts. At the roosts the animals usually hang in groups, with mutual bodily contact.

Fig. 4-28: Roosts of noctule bats behind wooden panelling (Wasserburg, Bavaria, D, left), and asbestos cement panelling (Waldkraiburg, Bavaria, D, right) at the edge of flat roofs. Photos: A. Zahn

Seasonal use of the roosts at buildings

Crevice roosts on buildings are used by noctule bats all year round. Within a radius of several hundred metres, they often populate roosts that are located in several buildings and/or on the sides of houses. They continuously switch from one hanging place and/or buildings to another (often in a set seasonal order).

In May however nearly all the females and some males leave the alpine area and move to the nursery areas to the north-east. In June and July the roosts in buildings are mainly populated by smaller groups of males. From August onwards the noctule bats return, first mainly the young, then in late autumn also adult bats appear at the roosts in buildings. (Before their return they had frequented

mating roosts located in tree hollows and boxes). Switching from one roost to another can also take place in the winter season.

Spatial use of the roosts

Switching from one hanging place to another (often in different buildings) as a response to temperature or seasonal changes is a known phenomenon. In winter roosts exposed to the south are more often populated than in summer. When it is needed a temperature gradient is employed at the roost. When temperatures are too high, the animals will for instance hang behind panelling (e.g. in winter) near the opening through which they slip in.

Roost characteristics and temperature requirements

Roosts at buildings used by noctule bats can be both ordinary gaps behind cladding and complex hollow spaces in false ceilings and rooflines. Complex hollow spaces that allow for different group densities, and/or the creation of multi-layered groups for example, are probably advantageous from the point of view of thermal regulation. Higher buildings are preferred (with ingress usually at a height of more than 5 m). Although all sides of houses are populated, on the whole roosts facing somewhere between the northeast and the southeast are preferred.

Typical roosts can be found in hollow spaces behind the wooden or asbestos cement cladding that is fitted for wall surfacing, or as a dressing for the edges of flat roofs. Such spaces will be between 2 and 4 cm wide and more than 30 cm deep. In some cases the animals are able to get as far as the false ceiling. There they fashion hiding places above or underneath insulation layers (e.g. mineral wool). Sometimes gaps are even accepted, when the noctule bats are not able to hang but have to take up a horizontal position. In rare cases the noctule bats also hang more or less freely on the walls of internal roof spaces, provided they can change to the inside by means of crevices in hiding places located at the exterior of a building.

In some crevice roosts, particularly those behind the smooth asbestos cement cladding on walls, the animals can only get a foothold on the side of the house (and not on the inside of the panelling as well). This makes the creation of multi-layered groups difficult. In cold spells, it also results in disadvantages from the point of view of thermal regulation.

Gaps behind thin wall cladding that are populated by noctule bats are very often exposed to large variations in temperature. Measurements in summer routinely show temperatures of over 35 °C. In winter there are temperatures of over 20 °C when the sun is shining and minus 10 °C during cold spells. It can be assumed that such conditions demand an increased use of energy from the animals. Therefore hard winters can lead to increased mortality. Yet in natural roosts (such as tree hollows) there are obviously comparable conditions (and there too cases of high mortality are known). Sometimes in roosts in buildings, noctule bats probably make use of the escaping waste heat, and counteract variations in temperature by keeping closer to the building's wall.

As shown by studies in South Bavaria, in winter the animals move to cooler hiding places, as soon as roost temperatures rise to more than 15 °C. They obviously prefer the cooler conditions. If there are sub-zero temperatures at the roost, the animals form close groups and can thus survive periods of frost. On the other hand changes of roost have also been observed under such conditions. It may be presumed that both the volume of the roost and the size of the group have a role to play in this, as well as the insulating properties of the roost wall. In principle hanging places with temperatures of between 0 and 10 °C in winter might be appropriate for over-wintering noctule bats. But so far preference for roosts within this range of temperatures has not been discernible. In summer areas of roosts should have cooler hanging places (< 30 °C) available as alternatives.

On the whole, it seems to be important that there should be roosts with different temperatures in the overall spatial envelope and/or that hanging places with different temperatures within the roost should be available.

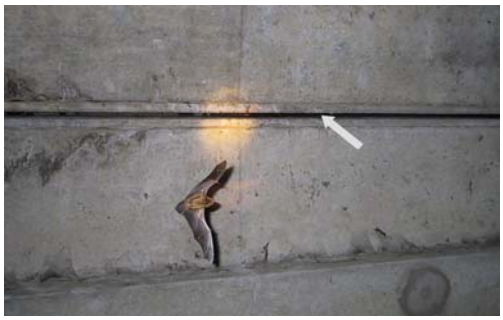


Fig. 4-29: A greater noctule bat and a colony's hanging place in the expansion joint of a bridge (Klagenfurt, Carinthia, A). Photos: P. Angeli, C. Hebein

Egress openings

Often the gaps in which the animals roost do not taper towards the bottom and are open along the whole of their length. This prevents the deposition of larger amounts of droppings at the roost. However, often in winter individuals that have fallen down are found below such roosting places. Especially if the animals can get a foothold only on one side only (as they can behind smooth cladding), lethargic animals can easily be dislodged by their more active fellows. Where the animals slip into the roost through narrower openings and/or these openings are located on top, or at the side, a lot of droppings often collect. This can make it difficult for the animals to fly out as well as causing an unpleasant smell for the residents. There also is the danger that dead animals (in view of the mortality during over-wintering!) may block the opening.

The problems mentioned seem to be least pressing under these conditions: when nearly the whole length of the roost is open at the bottom; when the gap through which the animals slip into the roost is slightly narrower (2 to 2.5 cm); and when the animals within the roost can get a foothold on each side.

Noctule bats prefer an unobstructed approach, without any troublesome trees in the area around the ingress opening.

Roost Requirements of the Noctule Bat			
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**	**Comments**
Depending on the temperature, they use several hanging places, sometimes in several buildings	In summer probably about 30 °C, in winter probably 0-10 °C	From October to March (over-wintering)	So far there is little expert knowledge about preferred temperatures and critical disturbances

Tab. 4-14: Overview of the roost requirements of the noctule bats (Nyctalus noctula)

4.9.2 Experience and examples

For building renovations and/or alterations where colonies of noctule bats were involved, there are 13 case studies to draw upon. They come from Bavaria, Switzerland and Austria. All of them were monitored by bat specialists.

In nine cases roosts were lost because of rebuilding or thermal insulation work, or the animals were deliberately relocated and/or excluded from certain roosting places. In one case (a hollow bridge pier), a roost that had formerly represented a trap for noctule bats was improved.

Reaction to disturbance

On several occasions noctule bats were discovered in winter during the course of demolition or renovation work. In such cases they obviously do not react to the disturbance quickly enough (on account of hibernation), so that roosts can easily be missed and animals can unintentionally be killed.

Reaction to external scaffolding

In a summer instance it was observed that noctule bats abandoned a roost, located behind a cladding facade, as soon as the scaffolding was erected. This evidently shows that their aptitude to migrate to other roosts when disturbed is very high. Since they are not as good at manoeuvring in confined spaces as, for example, horse-shoe bats, scaffoldings (even without netting) is of itself probably an obstacle for them as they fly into and out from the roost.

Reaction to external lighting

In Austria external lighting fitted below a colony of noctule bats, inhabiting the expansion joint of a bridge (fig. 4-29), caused them to abandon the roost. Because of the location it was not possible for the animals to seek out other hanging places. Once the lighting had been removed the roost was repopulated.

Alterations to roosts and provision of alternative roosts at the same location

Experience gained to date is inconsistent. On the one hand, when roosts were closed, sometimes the animals tried persistently to access the old hanging places and long continued to fly up to their original roost area. On the other hand, however, in a few cases even minor changes to a building were not accepted: such as relocating openings or making them smaller, or changing the wall materials (e.g. the replacement of thin cladding with better insulating materials). This was particularly true if alternative roosts of the same type were still available in the near neighbourhood. In most cases this may have been due to the altered incoming access situation. Because when a roosting place was actually lost, the animals would search buildings for ingress openings of the same type (see box). Where the incoming access passages were similar they were prepared to accepted differently proportioned roosts. This is another argument in favour of a certain flexibility in this respect.

Where, during the course of structural alterations, roosts of noctule bats are first removed and then replaced at the same site, the prospects for success in gaining the animals' acceptance seem to be good, provided the following conditions are met:

- The incoming access situation should remain unchanged (e.g. it should still be possible to fly in by approaching from below, or if incoming access was below a window sill then the new opening should also be below a projection).
- The alternative roost should be usable straightaway.
- The hanging places used hitherto (or hanging places of the same type in the neighbourhood) should no longer be accessible.
- The new ingress openings should be fitted next to the original openings (at < 100 cm distance). Where such a short distance is not possible, the alternative should at least be on the same side of the house. However, in this case the prospects for success are lower.

- If the alternative roosting place is to be a box fitted on the outside of a building, an attempt should be made to fit the new roost adjacent to the site of the original hanging place, and then to move it to its new permanent location, step by step, during the following weeks.
- Alternative roosts should be provided on the same sides of the building as before. Basically this is to ensure the same or comparable conditions of orientation and temperature.

Alternative roosts at other locations

In none of the available case studies did noctule bats accept an alternative roost at another building or on a different side of a house. Swiss bat specialists assume that alternative roosts fitted a few metres above or to the side of the old roost will not be accepted if they are located on a different side of a house, or on the roof of a part of a building that is set back from the rest.

Especially during the migration time, noctule bats are lured into the roosts by the social calls of their fellows. So the use of “decoy animals” (territorial males) or playing recordings of the social call is a possible method for increasing the acceptance of new roosts (cp. common swift).

Design of alternative roosts / improvement of roosts

Except for their incoming access situation, alternative roosts do not necessarily need to correspond to the original roost. The width of the space should not be smaller, but can, if necessary, be larger than in the original roost. Yet in such cases the roosts should have compartments inside that are different in size in order to provide a range of different hanging places, that are appropriate for different climatic conditions and group sizes. It is probably an advantage to provide not only narrow (3 cm wide) and medium-size crevices (5 cm), but also wider spaces (10 cm) inside the roost.

If the original roost situation is simply being recreated (e.g. a gap behind wood cladding), the interior dimensions should not be less than: width 3 cm, depth 50 cm and length 100 cm. It must also be ensured that the animals can find a foothold on all the inner walls. This means that smooth surfaced cladding has to be made rough on the inside.

Using particularly thick or well insulated materials for building alternative roosts does not appear to be necessary. Noctule bats even over-winter successfully behind thin walls (wood only 1 cm thick). It should be assumed however that better insulated roosts are beneficial for small groups, because they need more energy to sustain their minimum temperature. Therefore, if several roosts are offered, differently insulated materials should be used. This applies particularly to cases where roosting places are fitted on top of insulating materials that have newly been applied on buildings. In such cases, the animals may miss the waste heat of the old un-insulated house wall. This could lead to the hanging places becoming extremely cold in winter. If there is a danger of this, some of the alternative roosting places should be equipped with thermal insulation on their outer surfaces (e.g. insulating panels instead of wood or asbestos cement). The remaining roosting places should be constructed from the same material as the original cladding. Ideally, the animals should be able to switch from one to another of the differently insulated compartments by slipping through connecting holes.

Roosting places that are too small (< 0.5 m^3) run the risk of warming up too much in winter, if they are used by larger groups of noctule bats.

When using wooden boxes, the need for good protection against weathering must be taken into account (cp. Andres BECK’s box model).

In respect of alternative roosts, the ingress opening should, if possible, be located at the bottom and designed in such a way that droppings can fall out or are “cleared away” by the animals leaving or entering the roost. (If the ingress opening is to the side, fit a sloping board as the roost floor, slanted

towards the opening.) In cases where this is not possible, the roost needs to be cleaned once a year and fitted in such a way that it is easily accessible. If the animals previously accessed their roost from the top, the new ingress opening must be designed in the same way. Here a box model with closed upper compartments should be chosen (cp. design suggestions in the appendix). To reduce the risk of egress opening becoming blocked with droppings or dead animals, the roost should be open at the bottom, along its full length, if possible.

Unsuitable roosts

In some cases noctule bats are able to get through cracks or holes from their hiding places on the outer wall into the inside of buildings. Sometimes they also appear to follow other bat species (e.g. mouse-eared bats) into the insides of buildings. In such situations, noctule bats do not always seem to be able to find the egress opening again. They cannot manoeuvre well in confined spaces and may therefore have problems getting to openings that are accessible only in flight (e.g. an opening in a smooth part of a wall). They probably have the same problem in flat roof constructions, with the half-height space between the top floor of apartments and the actual roof. When rebuilding or renovating roofs care needs to be taken that noctule bats are not able to reach such spaces.

Renovation examples

In three case studies in Switzerland, noctule bats spontaneously accepted alternative roosts (BECK & SCHELBERT 1999). In the experiences of these two authors, alternative roosts need to be fitted at once and as near as possible to the original roosts. It is important to keep to the same ingress situation: if, for example, the animals used to fly into the roost from below, the alternative roost has to be designed in the same way. According to BECK & SCHELBERT (1999), the animals always look for the same type of opening in a building, after a roost has been closed. So, after a roller shutter box roost had been closed, noctule bats flew around the building, searching roller shutter boxes on the different floors for ingress possibilities. The authors also report a successful relocation, where the alternative boxes were first fitted in front of the original (now closed) roost and were then gradually moved to their new permanent location.

Multi-storey building in Straubing (Bavaria, D)

Greater noctule bats were living all year round under the eaves of the roof. (Between autumn and spring there were about 200 to 250 animals; and in summer about 50.) The renewal of the roof and wall facade was planned to take place in summer. The roost was opened up in segments, so that the noctule bats could remain in the building. The animals avoided the parts where renovation work was being carried out and used the areas not yet renovated. However, in the end they left the building. Originally it had in any case been intended to close the roost down completely, because the residents complained about the droppings and the noise. The final outcome was that the ingress openings were preserved at the roof corners, where the main hanging places had been located. The space between roof and the overhang (the crevice width) was exactly the same as before. Only the material (sheet metal) was different. For 4 years the bats have not returned again.

Echelsbach bridge (Bavaria, D)

A colony of mouse-eared bats was living in the hollow, pre-stressed concrete arch of Echelsbach bridge. Time and again, greater noctule bats would also fly in through the round openings. They evidently were unable to manoeuvre inside and could not find the egress again. They congregated at both ends of the arch, where they perished. An opening was cut into the metal doors located at the

ends of the arch, and, as climbing aid, a coarse cloth was fitted, leading from the opening into the arch. Since then no further dead noctule bats have been found.

4.9.3 Guidelines for the renovation of buildings with roosting places of the noctule bat

Things one needs to know

- Which hanging places are used during the course of the year (ideally, notes should be taken on a regular basis during the year prior to renovation)?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Noctule bats can be found in buildings all year round. Therefore in each individual case a check needs to be made on when a particular hanging place is not in use. In alpine areas, the fewest animals are usually present in June and July, so that work at the roosts should be done during this period, if possible. However when there are animals present during these months, it should also be checked that this is not a nursery colony after all (as bats can shift the area in which they reproduce within a period of only a few years).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Replacing wood at the hanging places

Re-installing wood removed from the former hanging places does not seem to be necessary with this species.

Partly closing the roosts

The animals' social noise and droppings often mean that the people living in the buildings object to the noctule bats. In some instances this makes it necessary to close down one part of the roosts (e.g. above entrances, windows and balconies). In such cases, the following rules should be observed:

- The hanging places used to date should never all be shut down at the same time, not even if apparently identical alternative hanging places are available.
- It needs to be ensured that there are no noctule bats present.
- If the presence of noctule bats cannot be completely ruled out, closing roosts down must only be done at night, on warm evenings in June and July, after the animals have flown out. In the alpine area, at this time of year roosts in buildings are mostly used only by a few males.

Advice on how to check for the presence of noctule bats

It is rarely safe to assume that all the animals will be visible, when they are in the roost. Consequently their presence has often to be checked by observing them flying out. However during winter they do not fly out at all, and in autumn noctule bats often fly out when it is still day time. Thus one can only be

certain whether the animals are present by observation; and this is only possible between April and August, in warm, dry weather (>10 °C at the exit time).

The presence of larger groups can be checked in warm weather by their social calls (high volume call activity, especially towards evening). However, smaller groups do not always attract attention to themselves. In cold weather the animals call more rarely or not at all. It is possible clearly to verify the presence of the animals by the appearance of new droppings (this applies to roosts that are open from below). In so far as this test works, between the middle of March and the middle of October, after warm nights (temperature at egress time > 10 °C), the absence of new droppings allows one to infer that the roost is unoccupied.

In September the presence of animals at the roosts can also be proven by their morning-time swarming behaviour in front of the ingress point (time: between 6.30 am and 7 am; temperature: at least 10 °C).

Another possible way of dissuading animals from using particular sections of wall cladding – if it is indispensable to do so – is to fit some sort of smooth material (such as metal sheeting) at the ingress point, so that the animals are able to leave the roost but not to land again afterwards. This is an appropriate method to use in cases where it cannot be ruled out that there are still animals present. It is also appropriate where the animals might be able to regain access to the closed area behind the cladding by means of new side-entry openings. In this latter case, closing the old ingress point would mean that droppings would now collect in the closed area. When fitting such “bat repellents” one needs to ensure that there are no protruding screw heads, etc, that the noctule bats could use as a foothold. Furthermore, the metal sheeting needs to extend a few centimetres into the ingress opening so that it is impossible for the bats to land. On no account, however, must the ingress be made too small for the animals to fly out (a gap at least 2 cm wide is necessary).

Fig. 4-30: Metal sheeting “bat repellents”, to prevent noctule bats flying in above house entrances (Wasserburg, Bavaria, D). Photo: A. Zahn

Overview of the renovation of buildings with roosts of noctule bats	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Alterations to the micro-climate ▪ Loss of alternative hanging places ▪ Alterations to the incoming access situation ▪ Work carried out whilst the animals are present ▪ Vibration at the hanging places, scaffolding ▪ Relocation of roosts
Less critical factors	▪ Noise ▪ Replacement of the roosts (provided the incoming access situation is unaltered and that it is done whilst the animals are away) ▪ Alterations to the internal spatial situation of the roost (provided the roosts do not become too small)
Advice	▪ No alteration to the incoming access situation (e.g. do not replace an opening used for slipping-in from below by one at the side) ▪ If need be, improvements to the roost interior (cracks and gaps of different widths) ▪ At the roost the animals should be able to find a foothold on all sides ▪ Provided there are still previously used roosting places available on the sides of neighbouring buildings, it is likely that the animals will move there, if the renovation work cannot be carried out under “ideal” conditions
Prior to the renovation	▪ Find out how the hanging places are used. ▪ Ascertain which egress openings are in use. ▪ Perhaps check out (potential) alternative roosts ▪ Measure temperatures at the hanging places in use, in different weather conditions (heat, cold)
During the renovation	▪ No work in the roost area during the presence of the animals ▪ Egress openings and hanging places must remain accessible ▪ Do not fit any scaffolding in the vicinity of the roosts used
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-15: Overview of the renovation of buildings with roosts of noctule bats (Nyctalus noctula)

Tested bat boxes for the noctule bat, for use on buildings and bridges

Since 1993, during the course of renovation work in Switzerland, it has proved possible to preserve several hibernation roosts of noctule bats located in buildings and bridges. This has been done by providing an alternative roost in boxes from a range of different sizes and types. The boxes were accepted by the animals without further ado, and have been occupied ever since, year on year, by hundreds of hibernating animals. (BECK & SCHELBERT, 1999).

Monitoring the boxes over many years, and recording temperatures as well as any unexpected events for the last 10 years has furnished further insights into dealing with bat boxes for the noctule bat. These are itemised below.

The temperatures at the noctule bats' artificial roosts (such as building crevices and bat boxes) and natural roosts in tree hollows were measured over several years. The results showed that these roosts are not frost-free in winter and that there can be sub-zero (Celsius) temperatures for an extended period of time, without the animals dying. Therefore wooden bat boxes are sufficient and they do not need additional insulation.

The Christmas storm in 1999 resulted in the greater noctule bats invading the boxes. The boxes were completely filled and were far too small for such a number of animals. Situations became dangerous during the course of the winter. In boxes fitted with only a small, restricted ingress and egress opening, the animals became wedged in the opening so that none of them could either fly in or out. In designs of boxes with a floor to them, the animals at the bottom were probably crushed by those lying on top of them. Interior temperatures also rose far too high (e.g. up to 40 °C with an outside temperature of minus 10 °C) because of the vast mass of animals, this made energy saving no longer possible.

In boxes with a floor, the droppings do not fall out, so that they have to be cleaned at regular intervals. In the broader boxes time and again wasps, hornets and bees have also been found.

For these reasons only the flat box for wall facades, as described later, is still recommended as a roosting place replacement for the noctule bat. With this model no unfavourable or really dangerous situations arise, even with large numbers of individuals. Moreover, this box does not need to be cleaned, as the droppings fall out at the bottom.

Important points for replacement roosting places in boxes

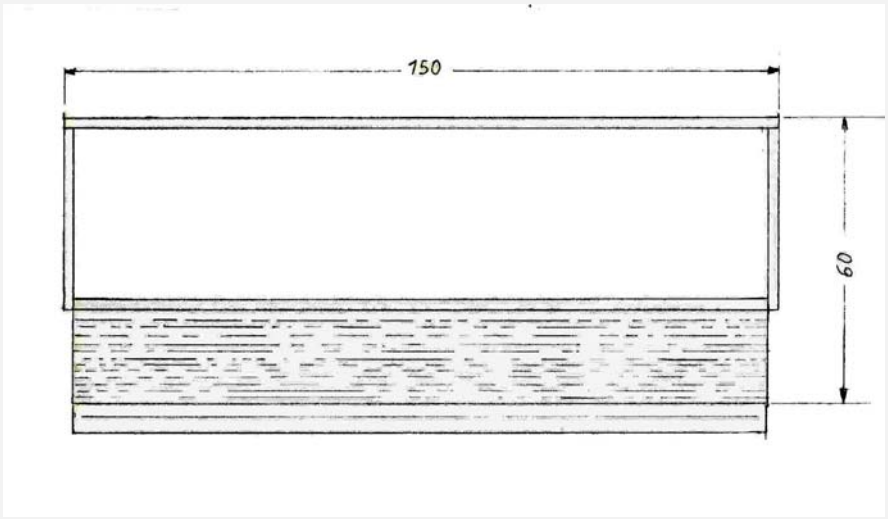
- Long boxes are preferable to tall ones (see sketch for dimensions)
- Wooden boxes made of untreated boards 20 mm thick and glued together, are sufficient. Close completely at the top and to the sides, and perhaps also seal the joints so that there are no draughts.
- Leave open the ingress and egress opening at the bottom, along the whole length of the box.
- Cut horizontal grooves 1 to 2 mm deep into the inside of the box, at intervals of 10 to 20 mm, so that the animals can get a good foothold.
- In order to avoid dirt on the wall facade, there should be a landing board at least 200 mm wide. A piece of metal sheeting fitted at the very bottom of the landing board (see drawing; do not use copper) will serve as a deflector and will also help prevent dirt.
- Boxes may be painted on the outside, if they need to match the colour of the facade.

Fitting the boxes on buildings

- Boxes should be fitted on buildings by skilled craftsmen. This should ensure that the boxes are firmly fastened and that no damage is done to the building.
- Fit the box as near as possible to the original roosting place.
- Several boxes can be fitted next to each other on the same building, or on different sides of the building.
- To prevent the falling droppings troubling the people living in the building, the boxes must not be fitted above windows, house entrances, benches etc.
- It is best is to fit the boxes under the eaves of the roof so that they are protected from the weather. If this is not possible, a metal weather shield (do not use copper) of appropriate dimensions needs to be specially fitted above the box.
- The box must be fitted flush with the wall facade, because otherwise the animals will search for hiding places behind the box.

Ideal box type (fitted directly to the wall facade)

All measurements in cm; thickness of boards at least 2 cm



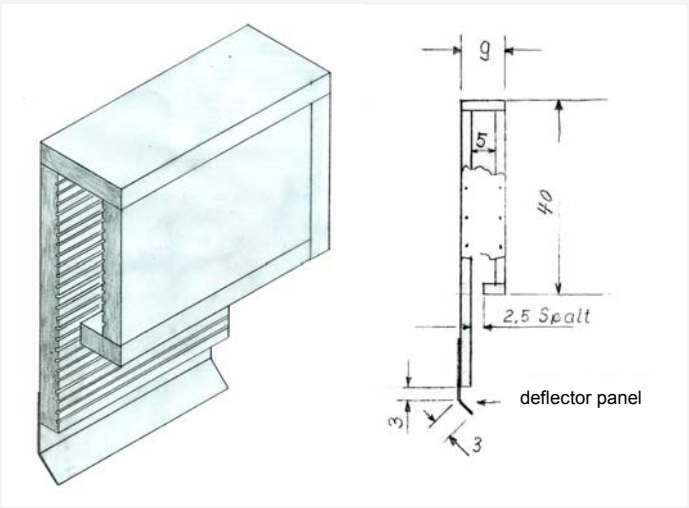


Fig. 4-31: Tried and tested alternative roosting place for noctule bats (Switzerland). Photos: A. Beck

4.10 Common Pipistrelle (*Pipistrellus pipistrellus*)

4.10.1 Roost ecology

Roosting places

These days, nursery roosts of the common pipistrelle in the alpine area are practically exclusively located in buildings.

Almost without exception, the animals here make use of crevice roosts, such as exterior wall cladding, roller shutter boxes, false ceilings, flat roof cladding, hollow blocks of un-plastered house walls, shutters, hiding places in roofs as well as cracks in walls.

Additionally, tree hollows and nest boxes are also used as mating roosts, and individual animals can be found in a great variety of hiding places.

Winter roosts of the common pipistrelle have been found in natural roosting places such as caves, but the numbers of individuals here are rather low. Mass winter roosts, on the other hand, are a characteristic of cellar vaults in stately homes and castles or monasteries, where the animals over-winter in the spaces between the bricks. In Nuremberg however, the winter gatherings with the highest number of animals, can be found exclusively behind facade coverings and in false ceilings (so-called slatted ceilings) of larger buildings. And in Hesse too, a very numerous winter roost was discovered behind the parapet of a factory building.

Fig. 4-32: The common pipistrelle. Right-hand picture: hanging place in a loft, between beam and wall. The animals go along under the ridge pole until they reach patches on the inner side of the house wall that are not completely plastered. They stay here if their hiding place in the crevices on the outside, become too hot. (Oberornau, Bavaria, D). Photos: A. Zahn

Seasonal use of roosts

Common pipistrelles take up residence at their nursery roosts comparatively early. From as early as the middle of April the first animals can already be found at the roosts (in Ticino, as early as the middle of March). Yet, the inward migration can take several weeks, so that the colonies are often not complete before May. In Bavaria the young are reared between the beginning/middle of June and the middle of July (in Switzerland from as early as the end of May onwards). As a rule, between the middle and the end of July the nursery roosts are already being abandoned again. Occasionally however, individual animals can still be found at the roosts until the beginning/middle of September (in Ticino, until the beginning of November!). Individual animals (males) can also be found in crevice

roosts at buildings. In some areas, once the nurseries have been dissolved, there are constantly repeated incidents of masses of predominantly young common pipistrelles flying into people's homes (so-called invasions). This behaviour is presumably linked with the search for roosting places.

At the large winter roosts, there are reports of individual bats already arriving during the invasions season. In northern Bavaria the spring residence time of the animals is very variable: In some years the common pipistrelles have stayed at the winter roosts until April, in others they have already disappeared by the beginning of March.

Spatial use of the roosts

Switching between several hanging places usually located in different buildings is characteristic in common pipistrelles. These changes are dependent upon temperature and seasons.

One nursery colony in Kleinseelheim (Hesse) demonstrably used at least 16 roosting places each year. The roosts are either all in one place or, with at larger sites, the colony divides into sub-colonies. It is very rare for individuals switch between two colonies that are located at different sites.

Before and after lactation, the nursery colonies are spread over several roosting places, but share one roost during the period of lactation.

In Hesse nursery colonies tend to take up residence at the same roosting places at the same times of the year. This involves roost changes taking place within the course of one night. On the following nights, there is still the same amount of nocturnal activity at the already abandoned roost, even though there are no longer any animals during the day.

In Bavaria it is reported that buildings will for the most part be populated for a period of 10 to 14 years. However, there are many colonies that do not use the same buildings for such a long time. On the other hand, examples of roosting places are known where common pipistrelles have stayed for more than 20 years.

Roost characteristics and temperature requirements

Common pipistrelles roosting places are characterised by a high degree of variability. So that even potential roosting places that have only recently come into being (e.g. the un-plastered hollow block walls of new buildings) are sometimes populated.

In Bavaria, roosts of the common pipistrelle can predominantly be found in walls on the east or south sides of houses. In Hesse, they show a slight preference for places facing west, south and east. The orientation of the hanging places can change during the course of the year, i.e. the animals perhaps use a fissure that reaches right around the building, favouring different places and facing different directions according to the different seasons and temperature conditions.

In Bavaria, the ingress and/or egress openings are located at a height of between 2 and 9 m, and in Hesse predominantly at a height of between 5 and 7 m.

In Hesse, nurseries of the common pipistrelle can increasingly be found in the older parts of small towns and villages.

The landing surfaces are usually of coarse material (plaster, wood or slate). Furthermore, buildings with common pipistrelle roosts are frequently in poor repair, at least in places.

Big fluctuations in temperatures in the crevice roosts and the considerable differences between the various types of roost are obviously a major reason for the relatively frequent changes of roosting place. In this way the colonies are able to seek out temperatures that are ideal, or as favourable as possible, for the appropriate stage in the reproductive cycle. When outside temperatures are very

high, roosts with a higher heat-storage capacity are chosen (giving lower temperatures during the day and higher ones during the night). Especially during the pregnancy period, roosting places with comparatively high temperatures are preferred.

In some cases, common pipistrelles are able to switch from (warm) hiding places located on the outside of a building and (cooler) hanging places on the inside of a wall, provided there is a linking passage (e.g. between the roof and the top of the wall). In such cases, the animals move to different buildings much more rarely. When new roosting places are created, therefore, a range of different temperatures should be provided for.

Ingress and/or egress openings

Ingress and/or egress openings can be found in many structures, such as in broken wall cladding, holes in the cladding, and gaps between walls and the roof.

As part of the E+E project a range of differently designed boards were tried out on the animals. The test showed that when they are looking for roosts, projecting features are important structures for them. Ingress gaps should, therefore, be located on conspicuous edges and corners, if possible.

Roost Requirements of the Common Pipistrelle		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Several roosts are used. Frequent switches from one to another are (amongst other things) because of their temperature conditions	Between 27 and 30 °C	At the nursery roosts between May and July

Tab. 4-16: Overview of roost requirements of the common pipistrelle (Pipistrellus pipistrellus)

4.10.2 Experience and examples

There was a total of 17 case studies to draw upon, relating to building renovations and/or roost changes, involving nursery colonies of common pipistrelles. The examples came mainly from Bavaria and Switzerland, however experiences in other federal states of Germany, as well as in England, were also taken into consideration.

Use of alternative roosts

Very often simple bat boxes and/or boards were provided as replacements for closed roosts in buildings and, as a rule, these were only very seldom accepted. Yet in other regions, the success rate for alternative roosts has sometimes been much higher, as was shown for example in the substantial renovation work carried out at pre-cast concrete buildings in Eastern Germany.

A study in Scotland lends further weight to the suggestion that the temperatures at the alternative roosts are a critical factor. According to this study, only heated alternative roosting places were repopulated (the first animals were registered 3 months after the roosts were erected). By contrast unheated boxes have not so far been accepted. A heating system maintained the temperature at about 27 to 28 °C, a level that was not lowered even during the night.

Renovation examples

Private house, Locarno (Switzerland)

This was a nursery roost consisting of between 40 and 50 common pipistrelles. It was located in a gap about 2 cm wide, between the roof guttering and vertical wooden boarding, that ran right round the

house facade. For more than 20 years different portions of the gap, facing a variety of directions, had been used in different seasons of the year.

In consultation with a bat specialist, the roof was renovated a few years ago. Specifically, a sub-roof was fitted and the gutters were replaced. It proved possible to preserve the vertical wooden boarding from which the bats hung. The work was carried out in the space of 2 weeks in November, after the animals had left the roost. When the gutters were being replaced, great care was taken that the width of the gap between them and the wooden boarding was the same as before. The depth of the gap, by contrast, could not be kept the same. The new sub-roof had made it about 2 cm deeper. All the new wood remained untreated.

In the following spring, the animals returned to their traditional roost, on time and in their usual numbers.

Private house, Großkampenberg (Bavaria)

A nursery roost of common pipistrelles was discovered when the wall facade cladding was being torn off. The hanging places were located behind the artificial slate cladding. Damaged slates served as access points for the hanging places.

After consulting a bat specialist, the work was suspended until the end of the nursery season and it was agreed that an alternative roost should be created.

The alternative roost was integrated into the over-hanging portion of the roof and fitted on the same side of the house as the original one, however the ingress and/or egress openings (3 cm wide) had to be provided at a new place.

So far the common pipistrelles have not accepted the roost.

4.10.3 Guidelines for the renovation of buildings with roosts of the common pipistrelle

Things one needs to know

- Which hanging places are used during the course of the year (ideally, notes should be taken on a regular basis during the year prior to the renovation?
- Which ingress and egress openings are in use?
- Are other roosts used by the nursery colony (within a range of 500 m)?
- During which seasons are the animals present (winter roosts)?

When may renovations take place?

For renovation of buildings with nursery roosts, measures implemented between September and March can be considered relatively unproblematic. In April and August there need to be checks before work starts, to see if the animals are already/still at the roost.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

For internal renovation work and for buildings with winter roosts, the period between April and May seems to be most suitable. However each individual case needs to be thoroughly checked out, particularly when it comes to mass winter roosts that are of trans-regional importance.

Tips for alternative roosts

In principle attempts should be made to preserve existing roosts. If this is not possible, the following tips may increase the chances of success in establishing alternative roosts:

- Fit the roosts as near as possible to the original roosts (ideally the openings through which the animals slip into the roost should be in the same places as before).
- Ensure that temperatures at the roost are high enough. For instance place it where it faces somewhere between the south west and the south east, or by choose a dark colour for its outer surface.
- To avoid overheating at times of high outdoor temperatures, make cooler areas available at the roost too. For instance make separate compartments in the box (cf. model boxes in the appendix), or make other alternative roosts available where the hanging places are cooler. Generally, making at least two roost available facing in different directions is recommended (e.g. on the south side and east side of a building).
- In cases where boxes are fitted under a projecting feature (e.g. the overhang of the roof), choose a model that allows access from the top (i.e. immediately below the projection).

Overview about the renovation of buildings with roosts of the common pipistrelle	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Alterations to the micro-climate, particularly temperatures that are too low ▪ Alterations to the incoming and outgoing access situation ▪ Alterations to the width of the inside of the roosts (crevice width) ▪ Preservation of the customary hanging places ▪ Loss of alternative hanging places
Less critical factors	▪ Light ▪ Reduction of the spatial volume of the roosting place
Advice	▪ With alternative roosts take care that a range of hanging places with different temperatures is provided. (These should include areas where high temperatures can be reached quickly).
Prior to the renovation	▪ Find out how the hanging places are used (also look out for hanging places used in winter) ▪ Ascertain which egress openings are in use ▪ Perhaps find out about other roosts in the neighbourhood (within a perimeter of 500 m)
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-17: Overview of the renovation of buildings with roosts of common pipistrelles (Pipistrellus pipistrellus)

4.11 Midge bat (*Pipistrellus pygmaeus*)

4.11.1 Roost ecology

Its status as a separate species was first established only a few years ago and, from a morphological point of view, it is not easy to differentiate between the *Pipistrellus pipistrellus* and the *Pipistrellus pygmaeus.* This factor means that only sparse data is available relating to the midge bat's prevalence, biology and ecology, and thus also to its roost ecology in the alpine area.

Roosting places

During the nursery period females predominantly live in buildings. Males and mating groups should rather be classified as "tree bats".

The few nursery roosts known in Bavaria are located either in buildings, or in one case at a hunting platform. In several other German Federal States as well as in Great Britain and Sweden, nurseries were found predominantly at roosts in buildings. Mostly these buildings were located on the fringes of settlements or outside the residential areas, near to hunting habitats that are mostly associated with expanses of water and woodland.

Colonies of midge bats can mainly be found in crevice spaces or, more rarely in buildings (in gaps and corners), for example in wall facade cladding, shutters, hollow spaces in walls, and in the roof area under tiles, or behind chimney cladding.

Originally, extensive crevice spaces between protruding bark and old tree trunks, or tree hollows may have been used by midge bats. This is also suggested by data about roosts in nest boxes.

The known nursery colonies of midge bats usually have a high headcount. Compared with common pipistrelles, midge bats seem to form nurseries with a higher average number of individuals.

The current state of knowledge, indicates that for their winter roosts they use crevice roosts that are protected against extreme temperatures: behind the wall facades of residential houses or large stone buildings, as well as tree hollows. Occasionally nurseries too may be used as winter roosts, which means that the roosting place is used all year round.

Seasonal use of roosts

Common pipistrelles spontaneously change roosts quite frequently, and in the process regroup. By contrast, it has been ascertained (in British and Swedish cases) that colonies of midge bats, with their high headcounts, often use roosts in the same buildings over many years, and usually for the whole of the nursery period.

Females migrate into the nursery roosts up until the end of May. Just fledged young have been found in Bavaria from as early as the end of June. Migration out of the nursery roosts takes places after the young have been reared, from the end of July onwards.

Roost characteristics and temperature requirements

Usually the roosts are located at least 2 m above the ground. They need to provide retreats that are protected from the weather, draught-free and secure against cats. Access to preferred hunting grounds (stretches of water and woodland) seems to be important.

Currently no data is available from the alpine area about temperature requirements.

Ingress and/or egress openings

Access passages are mostly slit-shaped (at their narrowest about 1.5 cm). At one large colony in England, several openings were used. There, the animals preferred different openings at different times over the course of the summer.

Roost Requirements of the Midge Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Crevice roosts in buildings (nurseries), tree roosts (males and mating groups)	Not known	Between (May) June and July (prior to and during the birth of the young)

Tab. 4-18: Overview of the roost requirements of the midge bat (Pipistrellus pygmaeus)

4.11.2 Experience and examples

To date only one substantial case study of the midge bat is available. It relates to Scotland and the largest known example of a nursery colony, with almost 2,000 nursery animals. Because of its size, the colony came into conflict with the people living in the building (on account of the smell and noise).

Measures were taken and in the course of them, part of the loft was partitioned off and isolated for the bats' use. However, time and again, a substantial number of animals reappeared in the other portion of the loft. Consequently further steps were taken to 'bind' the colony to the space assigned to it: amongst other things a heater was installed.

However, groups of animals still reappeared in the rest of the loft, despite the fact that all potential ingress and egress openings had supposedly been sealed. Furthermore the colony was no longer as large as it had been. This led to the conclusion that such a big colony needs a considerable amount of space, allowing the animals to move to more appropriate hanging places as the prevailing conditions changed.

Since there is hardly any relevant experience available, when carrying out renovation work it is best to be guided by the behaviour and reactions of other species that live in crevices (namely common pipistrelles and whiskered bats).

4.11.3 Guidelines for the renovation of buildings with roosts of the midge bat

As midge bats are evidently more loyal to their roosting places, unlike common pipistrelles, and as they therefore know of, or use, fewer alternative roosts, midges may react more sensitively to renovation work than their sister species.

Things one needs to know

- Which hanging places are used in the course of the year (ideally, notes should be taken on a regular basis during the year prior to the renovation)?
- Which ingress and/or egress openings are in use?
- During which seasons are the animals present (winter roosts)?

When may renovation take place?

Because of the lack of phenological data relating to the species in the alpine area, at each individual roost it is necessary to ascertain when the animals are present. For renovation work carried out at buildings with nursery roosts, the period between September and March can probably be targeted.

For winter roosts even less data is available. This makes it impossible to say anything definite about them. Very often, winter roosts are only discovered during the course of renovation work.

4.12 Kuhl's pipistrelle bat (*Pipistrellus kuhlii)*

4.12.1 Roost ecology

Roosting places

In Central Europe, nursery roosts of the Kuhl's pipistrelle bat are almost exclusively located on and inside buildings, where they populate an extremely diverse range of crevice roosts. These can be the most varied of cracks and small hollows, such as shutters, roller shutter boxes, fissures in walls, in wall facades, false ceilings or crevices in the roof area.

The winter roosts of Kuhl's pipistrelle bats are also located in buildings. These can, for instance, be in hollow spaces in walls, and their facades, or in basements. In frost-free areas, summer roosts are sometimes also used in winter. However, on the whole hardly any winter roosts have been found in the alpine area, which makes it difficult to say anything about the subject.

Fig. 4-33: Kuhl's pipistrelle bat (Pipistrellus kuhlii). Foto: A. Zahn

Seasonal use of roosts on buildings

In Austria and Ticino the young are probably born in June and/or July. According to the currently available data, the young may develop in a similar way to common pipistrelles (after about 3 to 4 weeks they are fully fledged, and after another week or two they are independent). No other data about the phenology of nursery roosts in the alpine area is available.

Roost characteristics and temperature requirements

The height of the hanging places locations can vary greatly (between 4 and 15 m in Iraq). However no data is available for the alpine area. Nor, at present, is there data about the Kuhl's pipistrelle bat's temperature requirements.

4.12.2 Experience and examples

No relevant experience is currently available. When carrying out renovation work it is best to be guided by the behaviour and reactions of other species that live in crevices (namely common pipistrelles and whiskered bats).

When carrying out renovation work it is best to be guided by the behaviour and reactions of other species that live in crevices (namely common pipistrelles and whiskered bats).

4.12.3 Guidelines for the renovation of buildings with roosting places

Things one needs to know

- Which hanging places are in use?
- When and for how long are the animals present?
- Which ingress and/or egress openings are in use?
- Are there any alternative roosts nearby?

When may renovation take place?

Because of the lack of phenological data relating to the alpine area, at each individual roost it is necessary to ascertain when the animals are present.

4.13 Parti-coloured bat (*Vespertilio murinus*)

4.13.1 Roost ecology

Roosting places

Nursery roosts of the parti-coloured bat are predominantly found at crevice roosting places in manmade constructions. In Bavaria, they can very frequently be found behind exterior cladding, and, somewhat less often, in soffits and brickwork (especially hollow-block work). In the west of Switzerland, false ceilings are reported to be the place of preference for nursery colonies roosts. Besides, typical hanging places are located in chimney surrounds. Nursery roosts are characteristically located next to lakes or wetlands.

Parti-coloured bats form extensive colonies of males. So, in each individual case, it is necessary to establish whether a colony is a nursery or male-only. Colonies of males take up residence in similar roosting places to those chosen for nursery colonies: predominantly vertical exterior cladding, false ceilings, window shutters and hollow blocks. In the alpine area in most cases colonies are of males.

Seasonal use of roosts in buildings

In Bavaria, there is no detailed data available about times of residence at the nursery roosts. In the west of Switzerland it is reported that nursery colonies are populated from May (or end of April) onwards. The young are born at about the beginning/middle of June, and in Switzerland young parti-coloured bats were still found at the roosting place in August.

Colonies of males populate their roosts at the end of April, at the earliest, though most often only during the course of May. They usually reside in the building for a relatively short time. In Bavaria the

period of residence varies between a few days and a maximum of 8 weeks. The numbers there fluctuate, and, moreover, the animals do not appear at the same time each year.

Spatial use of the roosts

As a rule hanging places that are not readily accessible are used. However, in Switzerland roosts appear in false ceilings, though the animals use the loft, if there are high outside temperatures (about 30 °C).

Nursery colonies and colonies of males alike frequently switch from one roosting place to another.

Roost characteristics and temperature requirements

In the cases of five colonies of parti-coloured bats in Bavaria (nurseries and roosts of males), the height of the ingress openings was reported to be between 2 and 10 m from the ground. Out of 12 hanging places, four each faced south and west, three east and only one north.

In Switzerland temperature and humidity were studied at one nursery. The measuring instruments were placed in the loft, although the animals were actually in the false ceiling. Measurements were taken every hour between May and July and showed an average temperature of 19.4 ± 4 °C (min = 14 °C; maxi = 28.5 °C), as well as an average humidity of 71 ± 18 %.

The parti-coloured bat seems to react very sensitively to draughts, as is suggested by several instances of changes of roost during a period of cold winds in Switzerland.

Egress openings

The crevice hiding places in buildings that are used by the animals are mostly characterised by unobstructed incoming flight paths, with no vegetation in the way. The animals predominantly slip into their hiding places from below.

Roost Requirements of the Parti-coloured Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Several hanging places are used, located in one or more buildings	Not known	For nurseries, probably between the beginning of May and the end of July. It is nearly impossible to give details about colonies of males, as their periods of residence differ in each individual case

Tab. 4-19: Overview of the roost requirements of the parti-coloured bat (Vespertilio murinus)

4.13.2 Experience and examples

A total of 7 case studies of the parti-coloured bat in the alpine area are available in total. All of them relate to colonies of males in Switzerland.

Alternative roosting places at the same location

As shown by the Buch am Irchel example, it is possible to offer alternative roosts, at least for colonies of males. There are no case studies available for nurseries.

In Buch it was also shown that the animals found and accepted the new roost – even though it was a surprising distance from the original one. Admittedly, when the renovation work had been completed the alternative roost was still on the same house façade and this was of relatively simple structure.

The incoming flight path to the roost remained unchanged. It still remains to be established whether parti-coloured bats generally find new roosts more easily than (for example) noctule bats, or whether the dark ingress openings have made it easier for them to find them.

Alternative roosts at other locations

As shown in cases in Switzerland where roosting places were destroyed (by closing the ingress openings, for example) females are still able to find and populate alternative roosts in buildings in the neighbourhood.

Renovation example

Private house, Buch am Irchel (Zurich, CH)

The building accommodated a colony of male parti-coloured bats that resided behind wooden lagging.

Because of renovation work carried out on the outer wall facade (thermal insulation), a wooden bat board was designed and fitted, as alternative roost. The renovation work was done after the colony had migrated and the alternative roost was ready for the animals' return.

The size of the ingress and egress openings remained virtually unchanged, but their position was about 5 m higher than the original ones.

What effect the change in the volume of the roosting place had is not clear because the size of the original hanging place was not known. The size of the alternative roost was 200 x 70 cm.

For aesthetic reasons the bat board was painted white, although the ingress and/or egress openings kept their dark colour (see fig. 4-34).

The alternative roost was accepted in the following year. It was even the case that significantly more animals than before were counted.

Fig. 4-34: A parti-coloured bat and an alternative roost of a colony of males (Buch am Irchel, Zurich, CH). The dark triangles are the openings, through which the animals can slip in. Foto: A. Zahn, K. Safi-Widmer

4.13.3 Richtlinien für die Sanierung von Quartieren

Things one needs to know

- Which hanging places are being used?
- Which egress and/or ingress openings are in use?

- Are there any alternative roosts nearby?

When may renovation work take place?

Because there is only little data available, it is not possible to specify in detail a possible period in which renovation work would be unproblematic. Moreover, especially with colonies of males, it has to be assumed that each colony populates its buildings differently, and that for each building, the way it is populated can change over the course of only a few years.

It is therefore necessary to establish when renovation work can take place, judging each individual case on its merits. However, in general the period between autumn (October) and spring (March) should be targeted.

Alternative roosts at the same location

As the case study shows, offering alternative roosts at the same location can work. Yet, since there are no other examples to date, it is effectively impossible to provide a framework of guidelines for securing the successful acceptance of such roosts.

As a rule, the original roost situation (ingress and/or egress openings, micro-climate) should be recreated in so far as possible. This is despite the fact that the parti-coloured bat is probably more flexible than other bat species in its roost behaviour.

This species possibly switches so frequently from one roosting place to another to find appropriate temperature conditions. Therefore alternative roosts should provide as wide as possible a range of areas at different temperatures (including hanging places that warm up very fast, as well as some with permanently low temperatures).

For practical reasons a double bat board (with both a front and a rear panel) should be used rather than a board that is open at the back. This because otherwise, when a large number of individuals are present, problems may arise with the facade plastering (on account of the urine!).

Overview of the renovation of buildings with roosts of the Parti-coloured Bat	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Preservation of the original hanging place situation for colonies in false ceilings
Less critical factors	▪ Minor changes to the location of ingress and/or egress openings, at the same side of the building (up to 5 m)
Advice	▪ Alternative roosts at the same location seem to be promising, at least for colonies of males. However, no experience is available so far regarding nurseries.
Prior to the renovation	▪ Find out how the hanging places are used ▪ Ascertain which egress openings are in use ▪ Find out about alternative roosts
During the renovation	▪ No work in the roost area during critical times
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-20: Overview of the renovation of buildings with roosts of parti-coloured bats (Vespertilio murinus)

4.14 Serotine bat (*Eptesicus serotinus*)

4.14.1 Roost ecology

Roosting places

Nursery roosts of the serotine bat are found exclusively in buildings. Therefore this is a culture-dependent species.

The nursery roosts are predominantly located in roof spaces. However they are mostly in crevice roosts (chimney breasts, ridge boards, etc) as well as behind wall facades, or in roller shutter boxes. The hanging places are mostly well hidden. The summer hanging places of colonies of serotine bats have frequently been found even under insulating layers of mineral wool, fitted on the floor of the roof (HORN, 2005). The serotine bat prefers the lofts of private buildings to those of churches.

Fig. 4-35: The serotine bat. Photo: A. Zahn

Seasonal use of the summer roosts

Inward migration takes place from beginning of April onwards. However the nursery colonies are for the most part only at full strength by middle of May. The young are usually born in the second half of June.

Outward migration from the colonies often starts very early. It is rare that there are still many individuals present after the middle of August. However, some individual animals can remain at the roost until October.

Tip: serotine bats sometimes also over winter at nursery roosts!

Spatial use of the roosts

Frequently several different roosting places are used by one colony. However, in such cases, the distance between the roosts is only a few hundred metres. Nevertheless, the integrity of the colony

can sometimes be lost and hence one colony may represent only a single portion of a meta-population.

Yet in South Bavaria and in Luxemburg colonies have been described that were much more loyal to their roosts. Even in these two cases, the unwonted changes of roost were triggered either by extreme temperatures in both roosts or, in Luxemburg, by the presence of barn owls.

It can also be assumed that there are frequent changes of hanging place within one same building.

Roost characteristics and temperature requirements

A substantial study of roosting place characteristics for nurseries of this species was undertaken in Hesse. It highlighted the following features:

- The roosts predominantly faced south and/or west.
- The roost openings were located at a height of between 10 and 12 m from the ground.
- Very often the roosts were located in the old centres of towns and villages.

In general terms, roost temperatures at the hanging places of serotine bats are very often subject to big fluctuations. They can reach up to 40 °C, whilst the animals are present.

In a Bavarian case, measurements taken in the hanging place area showed temperatures of between 17 and 35 °C. At a roost in Luxembourg however, the average roost temperature at the hanging places was 22 °C. In this instance the hanging places were protected from extreme temperatures.

Serotine bats like to stay in crevices around chimney breasts in the loft. The warm walls quite possibly offer regulatory thermal advantages in spring and autumn.

Ingress and egress openings

Serotine bats very often use small openings for incoming and outgoing access, for example cracks under bricks or between a wall and the roof, or small openings in the roof, or brickwork. There are also cases on record where large openings (e.g. a window in a wall) were not used, and other, smaller openings were preferred as exits.

Roost Requirements of the serotine Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Depending on the temperatures, several hanging places are used, and in most cases also several roosts. In roof spaces the animals usually take up residence in crevices (near to the ridge and chimneys).	About 28 to 35 °C	Between the beginning of May and the end of August (especially before and during the birth of the young)

Tab. 4-21: Overview of the roost requirements of the serotine bat (Eptesicus serotinus)

4.14.2 Experience and examples

In total, 11 case studies relating to renovation work carried out on buildings with nursery roosts of serotine bats were available. Of these, 4 concerned the alpine area. It was also possible to draw upon data from Hesse and England.

Reaction to disturbance

Serotine bats' tolerance of disturbances caused by building work has to be regarded as comparatively low. In some cases, even work carried out at some distance from the hanging places led to the bats abandoning the roost.

Use of new egress openings

As the example of Mittling (Bavaria, D) shows, providing bat bricks as alternative ingress and/or egress openings was a failure. The animals chose other openings that were presumably already known to them. Neither did they use a large window in the roof that had always been available.

In the case of a church renovation in Baden-Wurttemberg, the egress openings were known. At exactly the same place where the old incoming and outgoing access used to be, a new and relatively narrow ventilation brick was fitted. This was not accepted either. The animals stayed away for two years. Only then did part of the colony return again. Now the colony uses as its ingress and egress opening a gap between bricks at a different location in the roof. The animals have also now started to fly off in a different direction.

In another case however, new openings in were accepted. These took the form of slots 40 cm wide and 10 cm high at the cornice, through which the animals could fly in. It is not known where the original ingress and/or egress openings had been located.

Use of alternative roosts

In Kirchhain (Hesse) an alternative roost intended for a nursery colony of serotine bats had not been populated even after two years. It had been set up as part of the "Bat Species Living in Buildings: Conservation and Research" testing and development project. This case involved substantial building work, including the roof of the building being raised (a flat roof was replaced with a barrel roof). Additionally new crevice roosting places were created in one quarter of the roof facade. A possible reason for the animals staying away might be that sufficient alternative roosting places were already available and known to the animals.

Renovation example

Mittling Church (Bavaria, D)

In May 2000 the presence of bats was reported to the Nature Conservation Authority sub-office. 15 pregnant females were counted in the loft. External scaffolding (but without netting) had already been erected.

Building work was stopped. This was done in consultation with the parson, and after the Nature Conservation Authority sub-office had agreed to cover the extra costs (since the scaffolding would be needed for a longer period of time). The next step was a detailed check on the roost situation (number of individuals, hanging places, egress openings), carried out by a bat expert. It was discovered that displaced roof tiles in several places served as egress openings.

At the end of August a meeting with the roofing contractor took place. It was agreed that 10 ventilation tiles, with their grids removed, should be fitted all over the roof surface, and provide new egress openings. Building work was resumed in September.

Checks the following year showed that the ventilation tiles had not been accepted and that the animals were now flying out only from the tower, through a gap between the wall and the roof. Presumably this egress opening had already been known to the animals (as suggested by finds of droppings around the opening, prior to renovation).

Haunsheim Castle (Bavaria, D)

In summer 1996 the roof, including the area used by serotine bats, was renovated. The hanging place of a colony consisting of about 30 animals was screened off. By the end of May the whole of the colony was present. Contrary to agreements, however, re-roofing was also carried out, whilst the young were being reared, in the area partitioned off. The result was that the colony migrated.

Besides this, the newly fashioned ingress openings at the ridge of the roof turned out to be too small. (The animals had previously used damaged areas here for access.) In 1996 the roost was no longer accepted by serotine bats. After appropriate openings had been rebuilt in the original places, the animals repopulated the roost in 1997. On 25th July 31 animals were counted.

In the summer of 1998 numerous beams in the area of the base of the roof were either renovated or replaced, and the south side of the roof was also refurbished. Now only 3 animals could be counted flying out. Again in 1999 the serotine bats failed to populate their roost. This was despite the refashioning of the ingress opening, although admittedly it may now have been too large. Even though the work was carried out two floors below the serotine bats' hanging places, it appears to have disturbed the bats (perhaps on account of vibration) because again only 3 animals at the most were observed. In the summer of 2000 3 animals were counted, and in the summer 2001 the figure had risen to 6. However in 2002 only 2 individuals were observed, rising again to 7 in 2003. The small quantity of droppings suggested that the animals were not present all the time and no longer reproduced there.

Because of the new enlarged openings, the ventilation conditions at the hanging places changed significantly. It definitely became much cooler there and there may have been a through draught. Even when the ingress and egress openings had been made smaller again using foam, the animals still did not return.

4.14.3 Guidelines for the renovation of buildings with roosts of the serotine bat

Things one needs to know

- Which hanging places are in use (ideally, notes should be taken on a regular basis during the year prior to renovation)?
- Are other roosting places also in use (search for roosts within a radius of about 300 m from the roost)?
- With egress openings are in use?

When may renovation take place?

Measures implemented between the beginning of October and the end of March are unproblematic. At the preliminary planning stage, the completion date for the work should be set no later than the end of March. Even though the animals usually appear only in May, this is a precaution against possible delays. Wood preservation treatments may be applied only between October and March (for this, see also chapter 5).

Even work at some distance from the hanging places must not be carried out during the nursery period, if it involves noise and vibration.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Partitioning off the hanging places

Because of the serotine bats' sensitivity to disturbance, partitioning off portions of lofts is unlikely to be successful.

Replacing wood at the hanging places

Re-installing wood removed from the former hanging places does not appear to be necessary.

Hanging places in crevices

This species often chooses hiding places in gaps resulting from damaged materials, wear and tear, and inexact craftsmanship. In renovations, alternative hiding places need to be provided if possible at the same places and with the same dimensions. The opening through which the animal can slip into its new hiding place should be in the immediate vicinity of the original one. Roosts located under surfaces that heat up quickly (such as metal roofs) need to be recreated in such a way that temperature conditions remain the same.

Ingress and egress openings

Customary ingress and egress openings should by all means be preserved. This is because new openings are rarely accepted, unless they conform to the same properties as the old ones (in terms of location and size).

Ventilation conditions

Areas where warm air builds up are very important for the preservation of colonies. The following principles should be observed:

- No ridge ventilation (use mortar for fixing ridge tiles)
- The number and location of ventilation tiles located below the ridge needs to take into account maintaining (and in some cases improving) the build up of warm air. In principle it should be possible to work the situation out prior to the renovation. In cases where ventilation conditions are changed during renovation (e.g. by improved ventilation at the base of the roof), ventilation tiles should not be fitted in the upper half of the roof; and larger ventilation openings should only be supplied in the lower third of the roof. It is best not to fit ventilation tiles in subsidiary sections of the roof, e.g. in a side wing.
- No false or beamed ceilings

Overview of the renovation of buildings with roosts of serotine bats	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Alterations to the micro-climate ▪ Alterations to the ingress and/or egress openings ▪ Noise and vibration ▪ Closure of crevice roosting places
Less critical factors	▪ Light ▪ Re-installing wood taken from the original hanging places
Advice	▪ No external lighting, particularly not in the area of the egress opening
Prior to the renovation	▪ Find out how the hanging places are used ▪ Ascertain which egress openings are in use ▪ Perhaps find out about (potential) alternative roosts ▪ If possible, measure the crevice roosts used hitherto
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible ▪ If applicable, recreate new crevice hiding places
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-22: Overview of the renovation of buildings with roosts of serotine bats (Eptesicus serotinus)

4.15 Northern serotine bat (*Eptesicus nilssonii)*

4.15.1 Roost ecology

Roosting places

In Central Europe nursery roosts can be found predominantly in crevice roosting places in manmade structures. They are particularly often found in false ceilings and behind wooden panelling, and, more rarely, in soffits and brickwork (hollow block).

Northern serotine bats definitely use new buildings too. In Bavaria there are even reports of unfinished buildings being populated.

Colonies of male northern serotine bats are not unknown too. In each individual case, therefore, it may be necessary to ascertain, whether it is a nursery or a colony of males.

Seasonal use of roosting places in buildings

In Bavaria nursery roosts are populated between May and August, though they are often used for a short time only. The young are born from the middle of June onwards.

Spatial use of the roosts

There are recorded instances of colonies frequently changing their roosting places as well as of others that using a roosting place only during the nursery period.

Roosts can be often found behind structures that warm up well, such as sheet metal cladding or the metal casing around chimneys.

Egress openings

In Saxony, the ingress and egress openings are often located between the brickwork and the roof, along the side edges of lagging, or they are openings under the roof planking.

In three colonies in Bavaria, the openings were reported to be located at heights of between 5 and 14 m from the ground.

Temperature requirements

To date there is no data available about roost temperatures for nurseries in the alpine area.

Roost Requirements of the Northern Serotine Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
They use several hanging places, depending on the temperature; they can use alternative roosts; they can also make use of a hanging place solely as a nursery.	Not known	Between May and August

Tab. 4-23: Overview of the roost requirements of the northern serotine bat (Eptesicus nilssonii)

4.15.2 Experience and examples

In total 11 case studies relating to the northern serotine bat in the alpine area were available. It was also possible to draw upon further experience in other European regions.

Alterations to the roosting place situation

A Swiss case study has shown that apparently alterations to the roost situation may be critical, even though the actual reasons for the bats not repopulating the roost remain unclear.

The animals predominantly took up residence in the false ceiling and behind the chimney casing of a private house. Because of the annoyance caused by the noise and droppings and bats flying into the rooms, the roof space was enclosed and made smaller by means of a false floor (height up to the ridge: 60 cm).

A check on the effects of these measures was made three years after their implementation and it showed that the colony was still present. However, in the following years only a few individual animals could be detected. It remains unclear, however, whether the renovation was the main reason why the animals stayed away, or whether other factors were responsible.

Tip: Very often the presence of a colony goes undetected until the renovation work gets under way.

Fig. 4-36: The northern serotine bat (Eptesicus nilssonii).PhFoto: A. Zahn

Renovation examples

Cormoret residential house (Bern, CH)

Since 1989 at least the building had accommodated a nursery colony of northern serotine bats, consisting of up to 138 individuals. The colony populated the roof area, which provided an appropriate space about 10 cm high between the tiles resting on counter battens and the boards.

During the course of rebuilding work, the battens and counter battens as well as the tiles had to be renewed. The renovation work was monitored by bat experts.

The work was carried out in October; so no isolation of the colony was necessary. An underlay was fitted on the roof, however not at the areas where the hanging place were. The ingress and/or egress openings in the ridge area were preserved (size: 3 cm), and furthermore ventilation tiles were fitted.

The nursery roost was used again in the following years by the same number of individuals.

Bernina Suot Inn (Grisons, CH)

The inn's roof frame was populated by a nursery colony of northern serotine bats between May and August. Renovation work on the roof's surface and frame was urgently required. The roof covering and individual beams supporting structure needed to be replaced. Part of the loft was to be converted into residential rooms.

The animals' hanging places were mainly located in the false ceiling of the loft, whose covering was of sheet metal. The renovation work did not start until April. Even though an emergency roof had been fitted, the work was so much delayed that the new roost was not available for the bats before the beginning of July. Even at an altitude of over 2,000 m, this was obviously too late for the colony. That year no animals were observed at the new roost. In the neighbouring house, there were about 10 animals, but the whereabouts of the rest of the animals remained unknown.

Careful plans were laid in order to preserve the roost structure, and the construction was carried out accordingly. Thus, a metal roof was fitted on a wooden board shoring. At the apex of the ridge, this boarding was forced open at regular intervals so that the animals could again have direct contact with the metal roof. Besides this, a fabric reinforcement for the plasterwork was fitted to ensure that the animals were able to move about the whole roof area without difficulty.

It will not be possible to say until next year (after the completion of these Guidelines), whether the northern serotine bats accepted the roost again.

S-Chanf Church (Grisons, CH)

The church roof frame was populated by a nursery colony of more than 100 adult animals.

In 1986 the roof was renovated, i.e. the rust was removed from the old metal roof, and a new metal roof with back ventilation was fitted on top of it.

In the first year after the renovation the animals were still resident. However from the second year until now, the roost has remained deserted. Alterations to the micro-climate were probably the decisive reason why the roost was abandoned.

Residential house in Meuselbach (Thuringia, D)

The hanging places of this nursery of about 50 animals were located in the ridge area of the loft. 4 damaged points on an un-plastered outer wall served as ingress openings.

In the winter season 1999/2000, the slated roof was replaced by a metal one. During the course of work, the roof and the un-plastered house wall were both furnished with thermal insulation. The hanging places were preserved, and in the immediate area of the egress openings used hitherto, slits 2 x 20 cm in size were fitted and “treated” with droppings.

The whole of the colony returned in April 2000 and slightly increased in number over the following years. This was despite the fact that the thermal insulation must have significantly altered the roost climate (less temperature fluctuation).

Residential house in Deggendorf (Bavaria, D)

In Bavaria, during the course of work being carried out on the wall façade of a multi-storey building, it was discovered that three young northern serotine that had fallen down. The young animals were taken back to the roost and the work was continued, but with special procedures. So, portions of the wall facade were removed gradually enough for the bats to have time to move to another area. The ingress openings were preserved.

The colony stayed at the roost for the remainder of the year and returned in the following year, after the wall façade work had been completed.

4.15.3 Guidelines for the renovation of buildings with roosts of the northern serotine bat

Things one needs to know

- Which hanging places are used during the course of the year? (Ideally, notes should be taken on a regular basis during the year prior to renovation, otherwise guesses can be made, by judging from the quantity of droppings.)
- Which egress and/or ingress openings are in use?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Any renovation work at buildings with roosts of northern serotine bats that is carried out between October and March is unproblematic. However, it needs to be borne in mind that individual lethargic animals might be present.

For colonies of males, no data about the phenology of the roost use is available. This makes it necessary to proceed with a certain amount of caution.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Overview of the renovation of buildings with roosts of the Northern Serotine Bat	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Alterations to the micro-climate ▪ Light ▪ Noise and vibrations ▪ Relocation of egress openings and flight-transit passages ▪
Advice	▪ No external lighting, especially not in the area of the egress opening ▪
Prior to the renovation	▪ Find out how the hanging places in the building are used ▪ Ascertain which egress openings used ▪ Perhaps also find out about (potential) alternative roosts ▪ If possible, measure the crevice roosts used hitherto ▪
During the renovation	▪ No work in the roost area during the critical time ▪ Egress openings and hanging places must remain accessible ▪ If applicable, create new crevice hiding places
Result checking after the renovation	▪ Are any changes at the roost (e.g. regarding hanging places and/or ingress and egress openings) being accepted? ▪ Check of natural growth

Tab. 4-24: Overview of the renovation of buildings with roosts of northern serotine bats (Eptesicus nilssonii)

4.16 Brown long-eared bat (*Plecotus auritus)*

4.16.1 Roost ecology

Roosting places

In Central Europe, brown long-eared bats predominantly use buildings for their nursery roosting places. They also very often use nesting boxes for bats and birds, and less frequently tree hollows. Their natural roosts are presumably in tree hollows.

In buildings, brown long-eared bats can be found in lofts, preferably in crevice roosts, such as tenon holes, beam collars or ridge crevices. False ceilings, and hollows in the brickwork are also used, but less often. Then animals also take up residence behind window shutters.

Fig. 4-37: The brown long-eared bat (Plecotus auritus), and a hiding place in the ridge area. Photo: J. Meyer, A. Zahn

Seasonal use of roosts at buildings

Brown long-eared bats make their way to their roosts in buildings from beginning of April onwards (in Switzerland, weather permitting, sometimes from as early as at the middle of March). In autumn, the latest well-attested examples of nurseries in Bavaria date from the middle of October. In Bavaria, Switzerland and Austria, the young are born between June and beginning of July.

Spatial use of roosts

As a rule groups of brown long-eared bats should be regarded as parts of a nursery community. Consequently colonies can be divided into these sub-groupings. However the exchange of females between such nursery communities is rare. Frequent changes of roosting place are a consequence of this social system.

Roost characteristics and temperature requirements

In Scotland the following roost characteristics were identified as important factors: Lofts chosen for nurseries were often divided into several compartments. Moreover, the choice of roosting places also appears to be determined by the distance from the nearest woodlands and stretches of water, as the most important areas for food supplies.

In England, it was shown that lofts with higher temperatures were preferred. This was the result of a comparison of buildings selected at random. At temperatures above 40 °C the brown long-eared bats in England left the roosts.

Ingress and egress openings

Brown long-eared bats find ingress and egress openings in many structures, for instance open roof windows, behind eaves guttering, or gaps between the roof and the walls. They use openings through which they have to crawl as well as ones that they can traverse on the wing. The minimum size of ingress and/or egress openings is 2 x 5 cm.

Roost Requirements of the Brown Long-Eared Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Several hanging places are used, depending on the temperatures	Probably between 25 and 30 °C	Between (April) May and September (October)

Tab. 4-25: Overview of the roost requirements of the brown long-eared bat (Plecotus auritus)

4.16.2 Experience and examples

Where brown long-eared bats were involved, there were in total 22 case studies of renovations of buildings and/or changes to roosting places to draw upon. They mainly came from Bavaria and Switzerland, examples from other German Federal States as well as from England were also used.

Reaction to disturbance

In Switzerland one example, where roofing was removed and replaced in stages, showed that brown long-eared bats can sometimes be quite tolerant of disturbances. The animals (4 or 5 of them) were twice exposed under the ridge tiles and were carefully covered over again by the craftsmen. The animals did not allow this to disturb them.

In England too, brown long-eared bats were described as relatively tolerant of disturbance. However, there are six examples from Bavaria where churches were renovated when the animals were present without monitoring by a bat specialist. In these instances, the colonies abandoned their roosting places. The first signs of bats were again observed 3 to 5 years later, provided ingress openings were still available. In Austria too, a colony permanently abandoned the roost following the replacement of a church tower roof.

Cases where roosting places in buildings are repopulated again after renovation work can be ascribed to the customary use of the roost as well as to the species' roost loyalty.

New roof coverings

As examples from Switzerland and England show, new roof coverings are tolerated by brown long-eared bats, provided that the work is done whilst the animals are away, that the ingress and/or egress openings are preserved and that the micro-climatic conditions do not change too much.

Reaction to external scaffolding

External scaffolding without netting has been accepted by brown long-eared bats without any problems. It is not known, whether scaffolding with netting on the outside allows for unrestricted use of the roosting places.

Alternative roosts at other locations

During the construction of a motorway in England, buildings accommodating a nursery roost of brown long-eared bats (amongst other species), had to be demolished. By way of compensatory measures structures were built that were suitable in size and characteristics as alternative roosting places for the common pipistrelle and the brown long-eared bat. The distance from the former roosts was up to 1 km (precise information was not given).

The building for the brown long-eared bats had a rectangular layout (5.5 x 10 m), with a wall height of 3.3 m, a roof height of 4.3 m and an overall height of 7.6 m. The walls consisted of solid bricks, with openings for the bats. After only 2 months, there were already the first signs of population, and in the first year brown long-eared bats used the building as nursery roost (it is not known, if these were the animals from the former roost). The size of the colony was about the same as the one at the old roost.

Renovation examples

Old Gymnasium, Cinous-chel (Grisons, CH)

The old gymnasium was used as a nursery roost by about 30 brown long-eared bats and the roof needed renovation. (There was no check on the animals' species identity to confirm they were not alpine long-eared bats.) Thanks to the Cantonal Bat Conservation Representative, who monitored the work, it proved possible to preserve the roost.

Building work started after the colony had migrated. Prior to the renovation work the ingress and/or egress openings as well as the hanging places were checked out. Thus they could be preserved in an almost unchanged state after the rebuilding work. The old roof construction consisted of a framework of boards which was covered with roofing felt. On top there were counter battens with the roof tiles. Now, the new roof consists of a framework of boards, covered with protective sheeting (as a vapour barrier), and instead of the tiles, a metal roof was fitted on top of the counter battens. Furthermore, no thermal insulation was fitted in the higher area of the roof frame, where the long-eared bats live.

The first check after renovation was negative. The future will show, if the long-eared bats accept the new roofing.

4.16.3 Guidelines for the renovation of buildings with roosts of the brown long-eared bat

Things one needs to know

- Which hanging places are used during the course of the year (ideally, notes should be taken on a regular basis during the year prior to renovation, otherwise the hanging places can be identified by the quantity of droppings)?
- Which ingress and/or egress openings are in use?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Any measures implemented between the beginning of November and end of March are unproblematic. At the preliminary planning stage the completion date for the work should be set no later than the middle of March. Even though the animals usually appear only in April, this is a precaution against possible delays. Wood preservation treatment can be carried out only between November and March (for this, see also chapter 5).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

External lighting

Basically buildings with roosts of brown long-eared bats should not be illuminated (at least not during the time when the animals are present). In cases where this is not possible, every effort should be made to position the floodlights in such a way that the egress openings and flight paths remain in darkness.

Alternative roosts in the loft

As brown long-eared bats populate bat boxes and boards even inside the loft, it should be possible to use the same ones when hanging places are lost. However it is necessary that they should be already available before openings are sealed, and even then, only in cases where it can be proved that they have previously been used by the animals.

A better solution is to refashion hiding places lost in the course of the renovation in the same place as they were before. Their spatial dimensions should also conform to the originals. Wood taken from the old hanging places should be reinstalled. Hiding places that reach high temperatures (e.g. under metal roofs) should be recreated in such a way that similar temperature conditions are still kept.

Alternative roosts at other locations

Should it not be possible to implement measures to preserve the existing roost, creating an alternative roost may be considered. There is, however, only one case study available from England.

Overview of the renovation of buildings with roosts of the Brown Long-eared Bat	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Alterations to the micro-climate ▪ Relocation of ingress and/or egress openings ▪ Bright light
Less critical factors	▪ Noise and vibrations ▪ Use of external scaffolding
Advice	▪ No external lighting, especially not in the area of the animals' egress opening
Prior to the renovation	▪ Find out how the hanging places are used ▪ Ascertain which egress openings are in use ▪ Perhaps find out about (potential) alternative roosts
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-26: Overview of the renovation of buildings with roosts of brown long-eared bats (Plecotus auritus)

4.17 Grey long-eared bat (*Plecotus austriacus*)

4.17.1 Roost ecology

Roosting places

In Central Europe nursery roosts of grey long-eared bats can almost exclusively be found in buildings. In contrast to brown long-eared bats they comparatively rarely use nesting boxes for bats and birds. In Hesse, roosts of grey long-eared bats were particularly often located in the old centres of towns and villages.

In buildings, grey long-eared bats can predominantly be found in lofts, and very often in spacious lofts. There they like to linger well hidden in crevices in the roof frames. Grey long-eared bats can also be found in crevice roosts behind wall cladding, even though this is rarer.

Seasonal use of roosts in buildings

In Bavaria, grey long-eared bats populate their nursery roosts from middle of April onwards. Their latest reported presence there was the end of October. Between the end of July and the end of August the highest number of animals could be registered. In Bavaria, the young are born between the end of June and the beginning of July, at the end of July the first young are fledged.

Spatial use of the roosts

Grey long-eared bats use various hanging places within one loft. Switching between hanging places is triggered by thermal-regulatory factors. There are also known cases of switching to roosts located nearby.

Whilst in spring and autumn the animals were more commonly to found in cervices, in midsummer they predominantly hung free at the ridge. Speculatively, it is also possible that they switch between hanging places according to the time of the day.

Ingress and egress openings

Grey long-eared bats liked to use crevices as ingress and egress openings. These they can find in many places in buildings. For instance they may use gaps in the roof surface (displaced or missing tiles, etc), an open roof window, behind eaves guttering, or spaces between the roof and the walls.

Usually they fly out from more than one opening and the egress opening preferred can change over the course of the year.

Temperature requirements

Temperatures recorded at hanging places in lofts showed overall temperatures of between 15 and 32 °C. The bulk of them were within the range of between 20 and 30 °C. Temperatures above 30 °C were avoided.

Fig. 4-38: The grey long-eared bat (Plecotus austriacus), and a crevice hiding place in brickwork. Photos: A. Zahn

Roost Requirements of the Grey Long-Eared Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
Depending on the temperatures, they use several hanging places at the roost, and sometimes also in other buildings nearby	20 to 30 °C	Between April and October

Tab. 4-3: Overview of the roost requirements of the grey long-eared bat (Plecotus austriacus)

4.17.2 Experience and examples

For the grey long-eared bat 9 case studies are available from the alpine area. They came mainly from Bavaria but a few were from Switzerland.

Reaction to disturbance

In Bavaria, a church roof was being renovated (fitting new roofing) during the time the animals were present. However the work was monitored from the point of view of specialist knowledge of bats. In this case, the animals' hanging place was screened off in such a way that the egress openings were still accessible from the hanging place. The roof was uncovered only one segment at a time and each portion was immediately re-covered. The area over the hanging place was only given its new roof after the animals had migrated and it was preserved so that it remained otherwise virtually unchanged.

The bats stayed on at the roost whilst the work was being carried out and the same number of individuals used the roost also afterwards. These facts suggest that this species is characterised by a relatively high tolerance of disturbance.

Two other examples from Bavaria show how important it is that renovation measures are monitored from the point of view of the specialist knowledge of bats. In both these cases, the nursery colonies abandoned the roosts (in a church tower, and/or under a wooden church floor) during the nursery period, because neither of the cases was monitored by a bat specialist.

Alterations to the roost characteristics

The reaction of a nursery of grey long-eared bats (about 20 to 30 animals) in Bavaria suggests some sensitivity towards alterations to roost characteristics.

During the course of the renovation of parts of a church loft, roost characteristics were significantly changed. Before, the loft had been generally dark and warm. Whilst the animals were away, windows and large ventilators were fitted in the whole of the new church roof, so that the roost was light, draughty and much colder than before. The animals subsequently retreated to the old part of the church (which had remained almost unchanged), and they no longer used the renovated part.

Alternative roosts in the loft

Grey long-eared bats also use bat boxes and boards hung up inside the loft. It is worth considering using the same ones when hanging places are lost. However it is necessary that they should be already available before openings are sealed, and even then, only in cases where it can be proved that they have previously been used by the animals. As far as possible any hiding places that have to be disposed of should be recreated at the same place (cf. brown long-eared bat).

Reaction to external scaffolding

As experience in Switzerland shows, external scaffolding without netting does not represent a problem for the grey long-eared bat. However, no experience is available in respect of scaffolding with external netting.

Reaction to external lighting

Ittenthal Church (Aargau, CH) was used by a colony of grey long-eared bats for rearing their young. When they flew out in the evening, they used the slatted belfry louvres on all four sides of the tower.

Renovation example

St. Wolfgang's School, Straubing (Bavaria, D)

The school loft accommodated a nursery of grey long-eared bats (16 to 20 animals). Essential renovation work was carried out when the bats were absent (in autumn), and the roof and its frame were renewed. Moreover part of the roof space was reconstructed and the roof frame became smaller as a result.

However, it proved possible to preserve the hanging places virtually unchanged. The roof frame was only repaired in place. It was furnished with thermal insulation and a plastic sheet, but not, however, around the hanging places. As the ingress and/or egress openings were not known for sure, the bat specialist decided that several possible places for the animals to fly out should be created in the roof (bat bricks and holes in the roof covering).

In the following year, the roost was populated again by the bats when they returned from their winter roosts. On the last occasion in 2005, when the animals were counted as they flew out, there were 17 of them.

Yet it is still not clear, whether the new ingress and/or egress openings were accepted, or whether the original openings had not been affected by the renovation.

4.17.3 Guidelines for the renovation of buildings with roosts of the grey long-eared bat

Things one needs to know

- Which hanging places are in use during the course of the year (ideally, notes should be taken on a regular basis during the year prior to renovation)?

- Which ingress and/or egress openings are in use?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Grey long-eared bats spend a comparatively long time at the nursery roosts, which means that renovation work is best done between October and March.

Wood preservative treatment may only be carried out in the same period too.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Partitioning off the hanging places

In general work should not be carried out whilst the animals are present. It appears to be possible to screen off the hanging places whilst the animals are present, as the example in Bavaria shows, but this should only be done in exceptional cases. The following supplementary tips need to be born in mind:

- Partitioning off should be carried out in winter/spring, prior to the animals' appearance.
- The hanging places used at different times of the year all need to be available to the animals. (They should all be inside the "bat area".) This includes the alternative hanging places used at times of high or low temperatures. If important hanging places are inaccessible, the colony may, at least in part, migrate as a consequence. The temperature range at the hanging places in the screened off area is probably decisive in determining whether the long-eared bats accept it.
- Access to the customary egress openings needs to be possible (an unobstructed flight path).
- Temperatures in the screened off area do not alter excessively (in small areas, temperatures may rise too high when sheeting is used).

Use of external scaffolding

As there is no experience available to date about the use of scaffolding with outside netting, avoid fitting netting, if possible. The use of external scaffolding without netting is permissible even whilst the bats are present.

External lighting

The use of external lighting needs to be avoided. If this is not possible, the egress openings and the flight paths should not be illuminated by the floodlights.

Overview of the renovation of buildings with roosts of the Grey Long-eared Bat	
Critical factors	▪ Unsuitable wood preservatives in the hanging place area ▪ Relocation of the egress and transit openings ▪ Alterations to the micro-climate → no false ceilings, or ridge ventilation
Less critical factors	▪ Use of external scaffolding (without net)
Advice	▪ Features of the route from the roost to the hunting grounds (hedges, tree rows, etc) should be preserved in so far as possible. ▪ No external lighting, particularly not in the area where the egress openings are. ▪ Screening off the hanging places seems to be possible
Prior to the renovation	▪ Find out how the hanging places are used ▪ Ascertain which egress openings are in use ▪ Find out about (potential) alternative roosts
During the renovation	▪ No work in the roost area during critical times ▪ Egress openings and hanging places must remain accessible
Checks after the renovation	▪ Have any changes at the roost (e.g. to hanging places and/or ingress and egress openings) been accepted by the animals? ▪ Monitoring of population trends

Tab. 4-39: Overview of the renovation of buildings with roosts of grey long-eared bats (Plecotus austriacus)

4.18 Alpine long-eared bat (*Plecotus macrobullaris*)

4.18.1 Roost ecology

Hardly any data is available relating to the biology and ecology – and therefore the roost ecology – of the alpine long-eared bat. This is because its status as a species has only been recognised for a few years in Europe and because differentiation between the long-eared species is not easy from the point of view of morphology,

Roosting places

In Northern Tyrol 15 nursery roosts were found during the course of an enquiry about the distribution of this species. The bulk of them were found in churches (two in church towers, twelve in lofts above the nave), and one was found in a loft of a castle. However, it can be assumed that there are other roosts in the lofts of residential buildings too.

Roost characteristics

Buildings with roosts of alpine long-eared bats had different kinds of roofing. However predominantly metal roofs were used, and in fewer cases wooden or asbestos cement shingles. The fact that alpine long-eared bats prefer metal roofs may suggest that they like high temperatures.

Individuals were found free hanging as well as in crevices.

4.18.2 Experience and examples

So far there are only 2 case studies available relating to renovations of buildings and/or alterations to roosting places, where alpine long-eared bats were demonstrably involved. They come from Austria and Switzerland.

External lighting

Part of a church in Thomatal (Salzburg, A) is illuminated. However, when the bats fly out, they do not use the illuminated section but the dark area of the church (namely the tower). This shows that external lighting may influence the exit behaviour of the alpine long-eared bat and consequently, it should be avoided.

Renovation example

Camuns Church (Grisons, CH)

The attic of the church in Camuns is populated by two nursery colonies: one of alpine long-eared bats (about 30 adult animals) and the other of lesser horseshoe bats (a maximum of 23 adult animals). Additionally the same attic is occasionally used by one individual animal of each of the greater mouse-eared bat and the greater horseshoe bat species. Yet, these two individual animals only use the roost occasionally and in the summer season.

Renovation work needed to be carried out on the roof and its frame. The Cantonal Bat Conservation Representative for Grisons was the specialist monitoring the work (fig. 4-40).

The start date for work on the roof was set for 1st September, after the animals had migrated. The ingress and/or egress openings were known and were largely preserved. Three windows in the tower that were used as outgoing and incoming access passages were equipped with wooden louvres (as protection against snow). One window remained without a louvre. The distance between the individual slats (rough-sawn boards) was 10 cm. At the suggestion of the bat specialist, the original sheet metal roofing was in essence retained too. Only the layer of wooden shingles was replaced with simple wooden cladding.

The work was carried out according to instructions, and the alpine long-eared bats re-populated the attic in the second year after renovation.

Thomatal Church (Salzburg, A)

A nursery of alpine long-eared bats (between 30 and 45 individuals) as well as individual greater mouse-eared bats lived in the church attic. The building needed to be renovated, and between 2001 and 2003 a range of renovation jobs were carried out on the inside and the outside of the church. When a check was made in Summer 2001, no animals could be found – presumably because of the disturbance brought about by the renovation work. When the roof had been renovated some years before, the individuals had already temporarily moved to the loft of the neighbouring presbytery. In 2001 however, it was not possible to check on this, but according to the sacristan that is where the bats were. When the nursery was checked again in 2002, the animals were using the church attic as usual. A count of the animals as they flew out registered 38 individuals. In the following years between 40 and 45 animals were also counted in the church attic. This leads to the assumption that the animals had come through the renovation largely unharmed.

Fig. 4-40: A nursery colony of alpine long-eared bats in Thomatal Church (Salzburg, A), and the renovation of the Camuns Church (Grisons, CH). Photos G. Reiter, E. Mühlethaler

4.18.3 Guidelines for the renovation of buildings with roosts of the alpine long-eared bat

Things one needs to know

- Which hanging places are used during the course of the year (ideally, notes should be taken on a regular basis during the year prior to renovation; otherwise usage can be identified by the quantity of droppings)?
- Which ingress and/or egress openings are in use?
- Are there any (potential) alternative roosts nearby?

When may renovation work take place?

Because there is insufficient data about the phenology of alpine long-eared bats, the best time for renovation work needs to be established in each case. But as a general rule essential work should be carried out in autumn, wherever possible. In this way, if there should be delays, everything will still be completed by spring, in good time before the start of inward migration.

Ingress and/or egress openings

10 cm high x 30cm wide has been specified as the appropriate size for ingress and/or egress openings.

External lighting

No external lighting, particularly in the area where the egress openings are.

Use of alternative roosts

In Thomatal, the nursery colony found an alternative roost in the neighbouring building (presbytery), when their actual nursery roost was suffering from disturbances. During the last decade this building was used at least twice. No data is available about the seasonal use of the two roosts, when there are no disturbances.

4.19 Barbastelle bat (*Barbastella barbastellus*)

4.19.1 Roost ecology

Roosting places

Under natural conditions, nursery roosts of the Barbastelle bat can be found behind the projecting bark of trees and, more rarely, in tree hollows or cracks in tree trunks. Now the species has adapted to the manmade environment, they also populate similar structures in buildings, such as window shutters, crevices behind soffits, wall facades, or overlapping boarding in barns, as well as flat bat boxes.

Fig. 4-41: The Barbastelle bat. Photo: A. Zahn

Seasonal use of the roosts in buildings

In Bavaria, nursery colonies are mostly seen between May and the end of July (August). The young are born in June. In a Swiss case, a colony had already populated the roost by early spring (end of March/beginning of April), and by the middle of October at the latest no animals were any longer present. In Hesse, a colony was found to be residing at a building roost between the middle of April and the end of August.

In some roosts the colonies do not appear every year by, or appear only for a short time. Such was the case with three nursery roosts in Salzburg. In one instance, the roost was re-populated after an interval of several years, when no animals were observed. An example of a secondary roost in a building is known from Bavaria; there the animals appear only for a time in August (i.e. after the young have been reared).

Spatial use of the roosts

Nursery colonies in the natural environment of woodland, depend on several tree roosts within a small area, because they switch roosting places almost every day. By contrast, roosts in buildings are occupied for a longer time (from several weeks up to four months).

However, switching from one roosting place to another in the same building is typical behaviour - different window shutters may be used for example. In Hesse, a colony used thirteen different places in the same building during one summer.

Switching to roosting places in neighbouring buildings also occurs, though the nursery colony from Hesse mentioned above nearly always stayed in one building.

Roost characteristics and temperature requirements

In buildings in Bavaria, the openings through which the animals slipped into the hanging places were at a height of between 3 and 9 m from the ground (7 examples), and in Salzburg, between about 5 and 10 m. In Bavaria, the directions the hanging places faced were fairly randomly spread (12 examples).

There is no data for the Barbastelle bat's temperature requirements in the alpine area.

Roost Requirements of the Barbastelle Bat		
Preferred hanging places	**Optimal temperatures**	**Particularly critical times**
A very dynamic use of hanging places can be identified; several hanging places are used in the same building or in different buildings.	There is no data available	Between (April) May and August, however this may differ from colony to colony.

Tab. 4-27: Overview of the roost requirements of the Barbastelle bat (Barbastella barbastellus)

4.19.2 Experience and examples

In the alpine area, no experience is available about renovation work done on buildings with roosts of Barbastelle bats. Yet in Austria, a nursery colony that lived behind window shutters caused substantial damage to their hanging places on the wall façade (crumbling plaster, see fig. 4-42). The situation in Switzerland is similar, where wooden facades are frequently soiled by urine and therefore need to be cleaned at regular intervals.

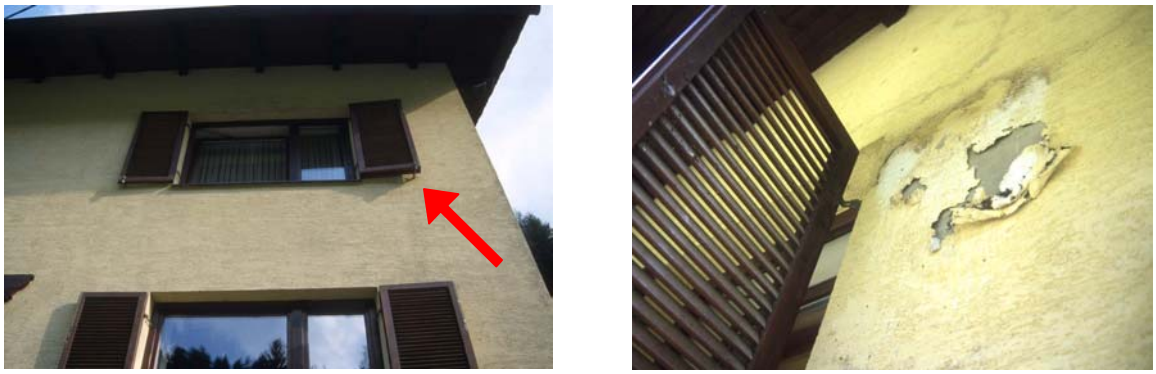


Fig. 4-42: Damage to a wall façade caused by the urine and droppings of a Barbastelle bat nursery behind a window shutter (Bad St. Leonhard, Carinthia, A). Photos: M. Jerabek

There is one renovation example from England, where a nursery colony of Barbastelle bats has populated a barn since the 16th century. The animals' main hanging place is located above the frame of the entrance-door. Because of the poor condition of the building as well as a change in its use, substantial renovation work has been, and still is being carried out (re-roofing, new doors, etc.). The work is being monitored by a bat specialist. Work in the area of the colony has mostly been carried out whilst the animals have been away, although there have been delays at times.

The fact that the colony frequently switches from one roosting place to another within the same building leads the bat specialist to suppose that the animals feel somehow disturbed by work done in their vicinity (even though a frequent change of roosts is typical with this species). So far the colony has remained at the roost.

4.19.3 Guidelines for the renovation of buildings with roosts of the Barbastelle bat

Things one needs to know

- Which hanging places are used?
- When and for how long are the animals present?
- Which ingress and/or egress openings are in use?
- Are there any alternative roosts nearby?

When may renovation take place?

The available data shows that measures implemented between October and March are very likely to be unproblematic. However, the actual seasonal usage of the building should definitely be checked in advance.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Green Unproblematic | ***Yellow*** Some work allowed | ***Red*** Work in proximity to the roost not normally allowed

Potentially significant factors for renovation work

Data is available for only one case of renovation work on a building accommodating a roost of Barbastelle bats. Therefore it is necessary to fall back on experience gained when dealing with other crevice-dwelling species. For this reason the following points should be understood as no more than tips about factors that are probably important.

Any problems with roosts behind window shutters (e.g. broken wall facade, dirt) can perhaps be solved with bat boards. These should first be fitted at the existing hanging places. Once they have been successfully populated they should then be moved to a more unobjectionable place (but still on the same side of the building).

In a case in the Czech Republic, it proved possible by this method successfully to resolve a conflict of interests between a house's owners and the Natterer's and Daubenton´s bats living behind the window shutters.

For roosts located behind wall facades, the primary goal be to try and preserve the original hanging places and the openings through which the animals slip into them.

In Austria bat boards fitted on buildings (predominantly barns and stables) were used by Barbastelle bats from as early as the first year. They were even used as the nursery roost, so they seem appropriate as alternative roosts. When trying to establish alternative roosts the following advice may increase the chances of success.

- At least two, or where possible more, alternative roosting places should be made available. These should face in different directions(e.g. on the south and the east side of a building)
- Fit the alternative roosts next to the original roosting places
- Fit the alternative roosts as early as possible, i.e. before the original roosting places are lost. This means that the animals can explore them and can even begin populate them

5 Bats and wood preservatives

Preliminary note

From the point of view of bat conservation, wood preservative treatments that work without the use of toxins have to be preferred to those containing chemicals. In this category are included high-frequency technology, hot air processes and gassing with CO_2.

Tip: Even with non-toxic wood preservative treatments, it is necessary to ensure that there are no bats present at the time of treatment.

In many cases there is no need to apply wood preservative treatments at all, particularly for new roof constructions or refurbishment jobs.

Chemical wood preservatives

Surprisingly little data is available about the effects of using wood preservatives in buildings with bat roosts. This is because of (among other things) successful work in the area of bat conservation. In recent years, treatment of the hanging place areas used by bats could in most cases be prevented, provided bat specialists took part in the renovation.

Many bat colonies resident in roof frames have undoubtedly been wiped out because unsuitable wood preservatives were used (e.g. substances containing lindane). Since the research carried out by KULZER (1985), a list of bat-friendly wood preservatives has been available. However it is concerned with the results of laboratory tests, and only in few cases has the use of these agents in buildings with bat roosts been documented and published. Therefore there is still considerable uncertainty when it comes to using such agents in practice. For example, pyrethroids were for a long time regarded as only slightly toxic to endotherms. However lately indicators have been accumulating that suggest they are not, after all, as harmless as had been thought.

In the meantime other agents with new names and new combinations of active ingredients have come onto the market. The most up-to-date list comes from Switzerland (cp. BLANT 2000). In cases where the use of wood preservatives cannot be avoided, agents should be used whose active ingredients and/or combination of active ingredients are on the list compiled, on page 116.

According to the current state of knowledge, products based on saline solutions (as a rule, boric saline solutions) are preferable to organic compounds (deltamethrine, permethrine, etc).

Please note:

- Treatment may only be carried out after the animals have left the roost (depending on the species, between September and November). It must be completed by at least two months prior to their return (which as a rule means by January or February), so that there is a sufficient interval for the active ingredients to become fixed and for the solvent to evaporate off.
- Wood preservatives with diluted solvents should be used (increasingly water is used as the solvent and/or means of application).
- It should be checked, whether it is necessary to treat the whole roost area, because often only certain parts of the beams are infested with insects or fungus.

- If possible, the agent should not be sprayed over a large surface, but applied directly to the inside of the wood, soaking out from drill holes.
- If possible, the Bats' hanging places should remained untreated (use boards or a screen to cover them). In cases where this is not possible, check whether important hanging places can be lined with untreated wood. Some of the untreated laths should be pre-fitted at the hanging places in the year prior to the treatment, so that the animals will already have made use of them and the laths will have acquired the characteristic odour. These laths can then be removed after the animals have migrated, and once the wood preservative treatment has been completed, used again to line the hanging place area.

In recent years it has become increasingly common practice to gas the interiors of buildings, using substances such as sulfuryl fluoride (SO_2F_2). In most cases bats populating the roof space are not affected by these measures. However the bats may be endangered, if the gas can get into the roof space through non-airtight ceilings and false ceilings, for instance from the interior of a church into its attic. For effective pest control outside temperature must not be too low. Because of this fact not all gassing can be done during the "bat free" period. In practice the following rules have proved their worth:

- At individual roosts, extractor units have been fitted in the roof space. This was to prevent concentrations of any gas that might have entered becoming too high.
- At nurseries, gassing needs to be done after the animals have migrated (September or October, depending on the species). If there are still individual animals present (in colonies of mouse-eared bats some animals are usually still there in October) an extractor unit should be installed.

Many bat species take up residence behind wooden cladding on buildings and this is painted or treated with wood preservatives on the outside. Provided the inside of the cladding is untreated, it seems to have little effect on the bats. It is essential to carry out after treatment and/or apply a new coat of paint, after the animals have migrated (usually in autumn). This kind of work should not be done in spring and summer. In cases where animals over-winter at the roosting places in question (e.g. noctule bats), it needs to be ascertained when the roost is not populated (by counting them at regular intervals). The decision about when treatment should be carried out should be made in consultation with an expert on the species in question. Environment-friendly agents should be used.

Practical cases

ROER (1989) describes the use of permethrine as without negative effects on bats. At roosts of mouse-eared bats in Bavaria, the agent was used in four cases. In two of these cases parts of the colony left and in two others they moved from the church roof to the tower. However, it remains unclear whether this was a consequence of the treatment.

At two other colonies of mouse-eared bats, boric saline solution was used. In one case the population remained steady. In the other case, there was a serious decline in population in the next year but one after treatment. A large number of dead animals were also found. However it could not be ascertained whether this was a late effect of the treatment, or whether another agent had been used.

Gassing the interiors of churches with sulfuryl fluoride has been carried out on several occasions without effect on the bats. In these cases an extractor unit was fitted.

List of non-harmful active ingredients (according to Prof. KULZER and M. BLANT, 2000):

Saline compounds

- Borax
- Boric acid
- Boric acid–alcanolamine-soap

Organic compounds

- Deltamethrine
- Dichlofluanide
- Dinatriumoctaborate
- Permethrine
- Phosalone
- Tributyltinoxide

6 Future prospects

In essence these guidelines summarise the current state of knowledge about renovation work carried out on buildings with bat roosts in the alpine area. It seems perfectly clear, however, that these guidelines will need to be updated in a few years time. Hopefully those species for which so far there is only a little experience to draw upon will in future receive more attention and will be carefully documented.

A very important factor for carrying out successful renovation projects is co-operation between bat specialists, unpaid bat conservationists, local authorities, owners of buildings, architects and the companies carrying out the work. If targets are to be met, it is essential that bat specialists should consulted from as early as the planning stage, that all participants should be kept informed, and that they should be prepared to look for solutions that everybody can live with.

Experience gained in the context of this project shows that the following points need to be recorded as common deficiencies in renovation work carried out on buildings with bat roosts:

- No, or only very limited, documentation of the renovation work. It is very helpful to have detailed documentation, especially when problems and conflicts occur.
- No checks, whether the measures implemented have been successful.
- Monitoring of the bat population(s) after renovation has been completed. Monitoring of population trends should be carried out at regular intervals after the renovation (even in cases where the colony stays away). In particular this practice should also apply when dealing with species that are less endangered and/or are widely distributed (e.g. many species that live in crevices). Especially in respect of these species is the state of knowledge inadequate.
- Failures in the exchange of information between bat specialists working in this area.

Some of the many unanswered questions about the renovation of buildings with bat roosts can possibly only be answered by adopting an experimental approach, for instance the question how bats find new roosts.

We hope that this work can play its part in highlighting existing gaps in knowledge as well as encouraging bat specialists to dedicate themselves more fully to this exciting and important area in the field of bat conservation.

After all, the conservation of local bat species will not be possible in the long run without extensive protection of their roosts.

7 Summary

Many bat species in the alpine area, including some listed in appendix II of the EU regulations on fauna and flora habitats, almost exclusively set up their nurseries in or on buildings. Consequently, they are sometimes seriously endangered when rebuilding work or alterations to the buildings are carried out or when disturbances occur. The preservation of roost locations is, however, a decisive factor for the long-term conservation of local bat species.

Monitoring of building work from the point of view of specialist knowledge of bats has already taken place in several countries. But little, if anything, of most of the work was documented or has been published, so that it is not available for a larger circle of users. The first discussions of this topic were in work predominantly concerned with procedural matters, or the implementation of conservation measures in general.

The aim of this work has been to deal with the effects of renovation work at the species level - and in the process, to define the precise, basic requirements for successful renovation work. The available specialist knowledge and the experience gained so far in renovation work carried out on buildings with bat roosts have been combined, and should now become available to bat specialists as a set of guidelines.

All bat specialists working in the field of this investigation were asked to pass on their experience of renovation of buildings with bat roosts as well as of the bats' roost of requirements (copies of internal reports, publications, oral information). Additionally, the technical literature was searched for published articles on this topic. To collect data about renovation work that had not been documented, a questionnaire was also designed and posted out. So as to be able to incorporate colleagues' additional experience and to scrutinise the results, three workshops were convened at conferences (BAG Bat Conservation, at NABU in Tübingen, INTERREG IIIB meeting in Trento, Xth EBRS in Galway).

As far as possible from an evaluation of the literature and questionnaires, the roost requirements of the individual species were summarised and critical, as well as less critical factors, relating to renovation work were listed. These "hypotheses" about individual species were checked and revised again in co-operation with the participating bat specialists.

In total these guidelines were able to draw upon 230 case studies of renovation work, mainly coming from the alpine area (Bavaria, Switzerland, Austria, Italy). Experiences were collected and evaluated for almost all of the bat species populating buildings in the alpine area (sequence in accordance to the number of renovation cases): greater mouse-eared bat (*Myotis myotis*, including mixed colonies with lesser mouse-eared bats, *Myotis blythii*; 33 % of all cases), brown long-eared bat (*Plecotus auritus*), lesser horseshoe bat (*Rhinolophus hipposideros*), common pipistrelle (*Pipistrellus pipistrellus*), noctule bat (*Nyctalus noctula*), whiskered bat (*Myotis mystacinus*), Serotine bat (*Eptesicus serotinus*), northern serotine bat (*Eptesicus nilssonii*), grey long-eared bat (*Plecotus austriacus*), Natterer's bat (*Myotis nattereri*), long-eared bats (*Plecotus sp.*), parti-coloured bat (*Vespertilio murinus*), Geoffroy's bat (*Myotis emarginatus*), greater horseshoe bat (*Rhinolophus ferrumequinum*), Daubenton's bat (*Myotis daubentoni*), alpine long-eared bat (*Plecotus macrobullaris*), Brandt's bat (*Myotis brandtii*), Barbastelle bat (*Barbastella barbastellus).* No documented renovation work was available in respect of the Kuhl's pipistrelle bat (*Pipistrellus kuhlii*), the Savi's pipistrelle bat (*Hypsugo savii*) and the Nathusius' pipistrelle bat (*Pipistrellus nathusii).*

The results were discussed at the species level, and the individual chapters about each species - so far as there was sufficient data – were arranged under the following headings:

- Roost ecology: roosts, seasonal and spatial use, roost characteristics, temperature requirements, ingress and egress openings
- Experience and examples: Reaction to disturbance, reaction to different alterations to the roost and/or measures implemented during the course of renovation work
- Guidelines: things one needs to know, critical factors, when should renovation work take place, under which conditions should renovation work take place

Another chapter dealt with experience relating to wood preservative treatments.

As a basic rule, renovation work should be carried out whilst the animals are absent, and the roost characteristics (micro-climate, ingress and/or egress openings, hanging places, flight paths, etc) should be preserved in so far as possible (this is the ideal case). However practise shows that very often the work has to be carried out under less than optimal conditions (for example: when a roost is discovered during the course of ongoing renovation work, when economic considerations are involved, or when there are delays in carrying out of the work, etc). In such instances, professional decisions based on the observed facts often have to be made at short notice by the monitoring bat specialist. In essence these guidelines summarise the current state of knowledge about the renovation of buildings with bat roosts in the alpine area. They should provide help and support to bat specialists so that the implementation of necessary renovation measures turns out successfully. It should be borne in mind, however, that there are still big gaps in our knowledge of many species, and that therefore these guidelines cannot be regarded as definitive in respect of renovation work. Each renovation has to be considered as an individual case for which bats specialists have to conceptualise an individual scheme for the preservation of bat roosts – with the aid of the knowledge made available in these guidelines.

When compiling these guidelines, shortcomings in current practice became evident. These need to be subjected to a sharper scrutiny in the coming years, as part of an applied and practice-oriented bat conservation. For in the long term it will not be possible to conserve our local bat species without an extensive preservation of their roosting places. Therefore what is needed is: no renovation work without monitoring from the point of view specialist knowledge of bats; detailed documentation of the renovation cases, to help out when problems and conflicts arise; monitoring of the bat population(s) after the renovation work has been completed; checks on the success of the measures implemented; a more intensive exchange of information between bat specialists not only about successful measures, but failures too; closer co-operation between local authorities, building planners, building contractors and bat specialists.

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9 Appendix

9.1 Examples for the construction of new bat roosts

All drawings by Harri ZAHN

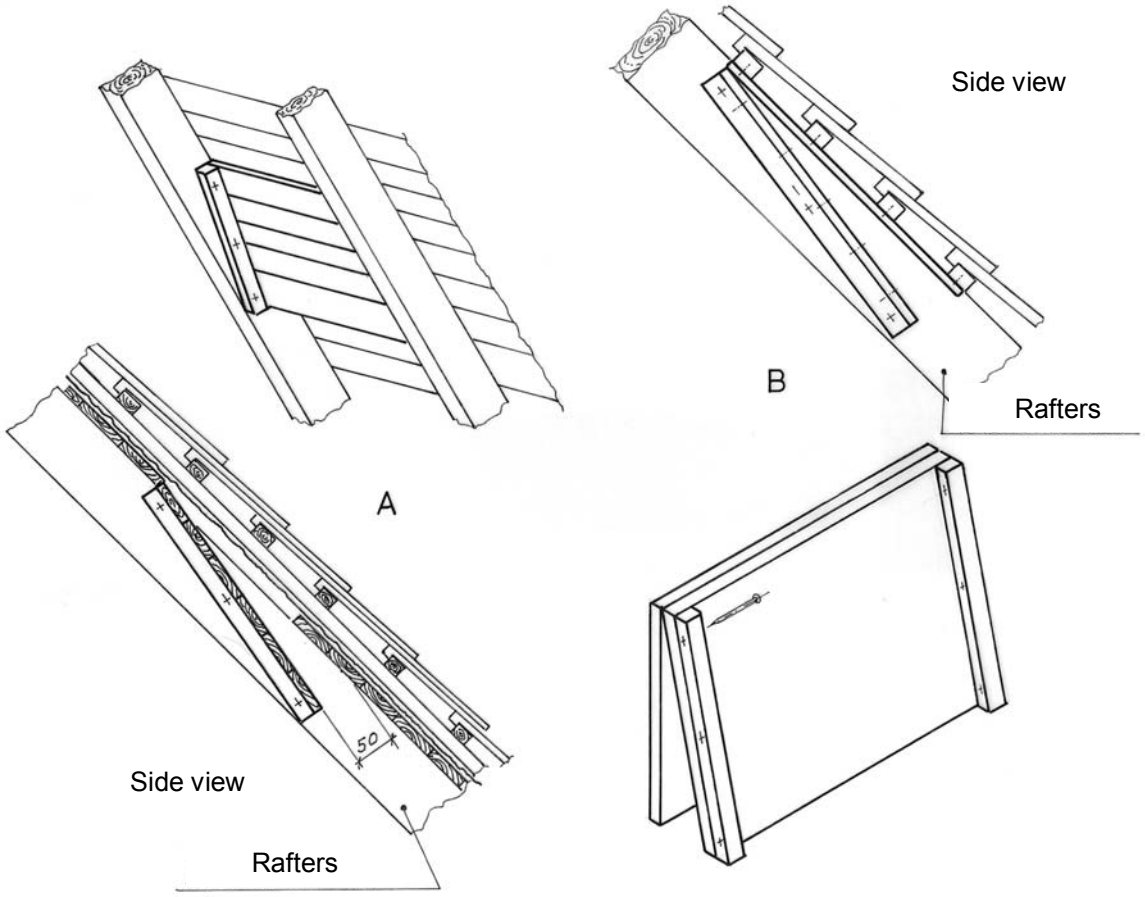


Abb. 9-1: Fitting of bat hiding places between the rafters. If the roofing consists of several layers (A), it is preferable to remove the layer at the bottom (laths) in order to accelerate the hiding place heating up through solar radiation. In cases where there are no other layers underneath the roof tiles (B), bat boards with a rear panel can be fitted between the roof beams (size in mm).

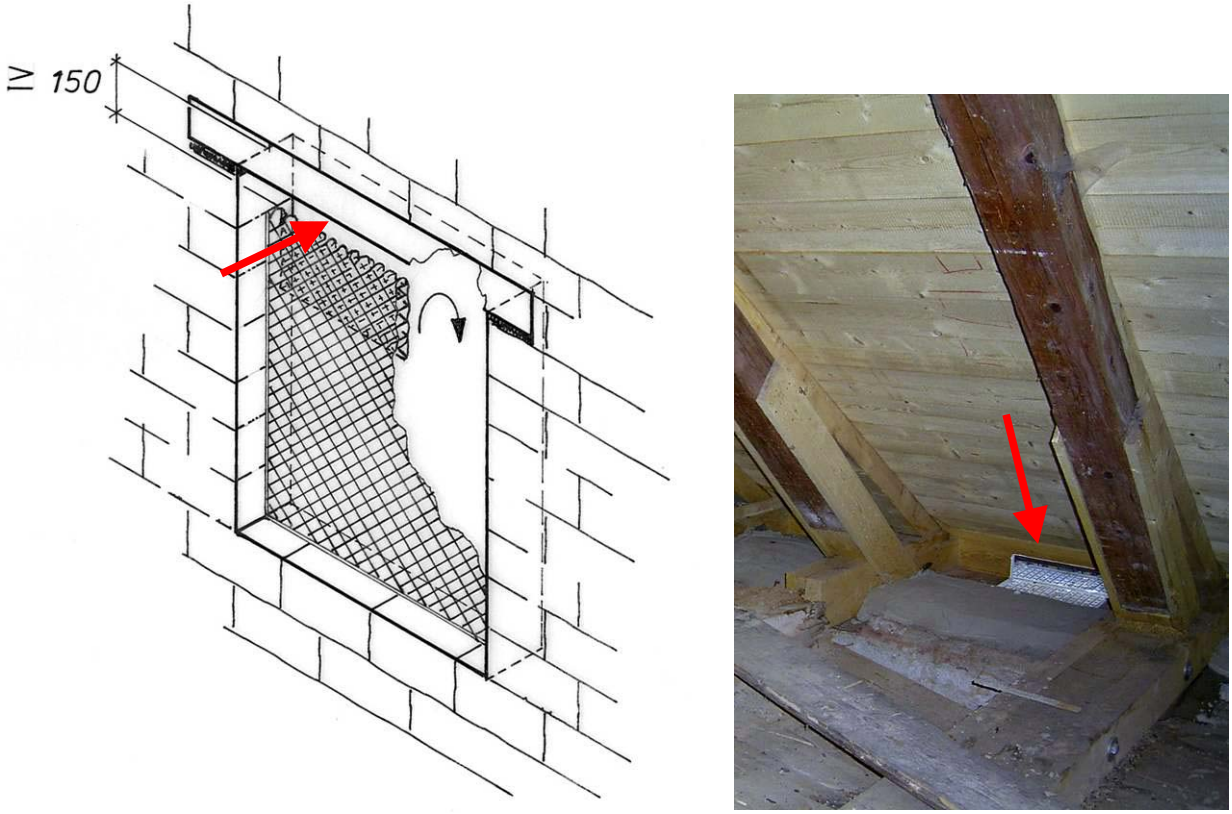
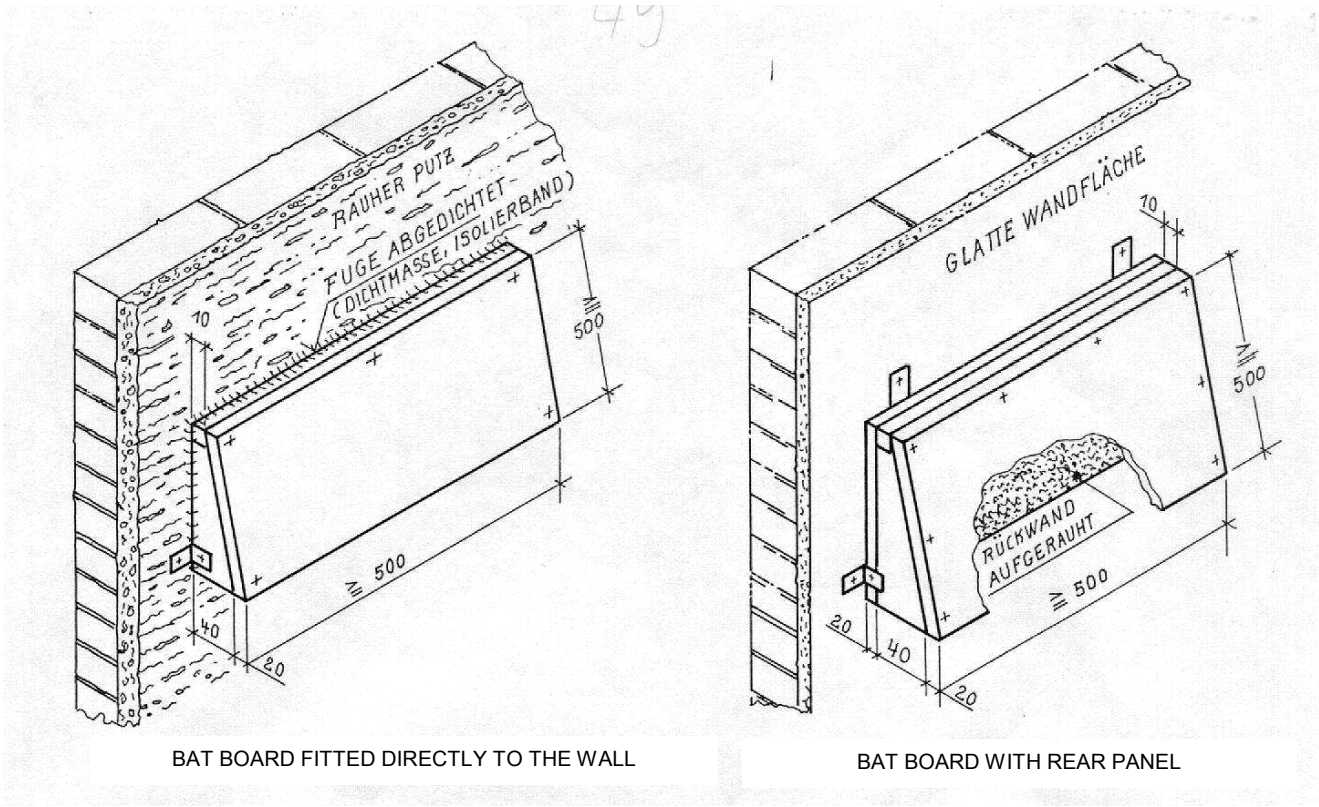


Fig. 9-2: Left: Offering an opportunity for ingress, by means of bent grating (arrow). The bent part should lie flush against the back of the grating, so that the animals cannot get caught in the opening (size in mm). Right: Ingress opening located at the base of the roof (between roof and wall)



BAT BOARD FITTED DIRECTLY TO THE WALL

BAT BOARD WITH REAR PANEL

Fig. 9-3: *Left: bat board fitted on the house wall. Important: The wood must be rough-sawn on the inside.*

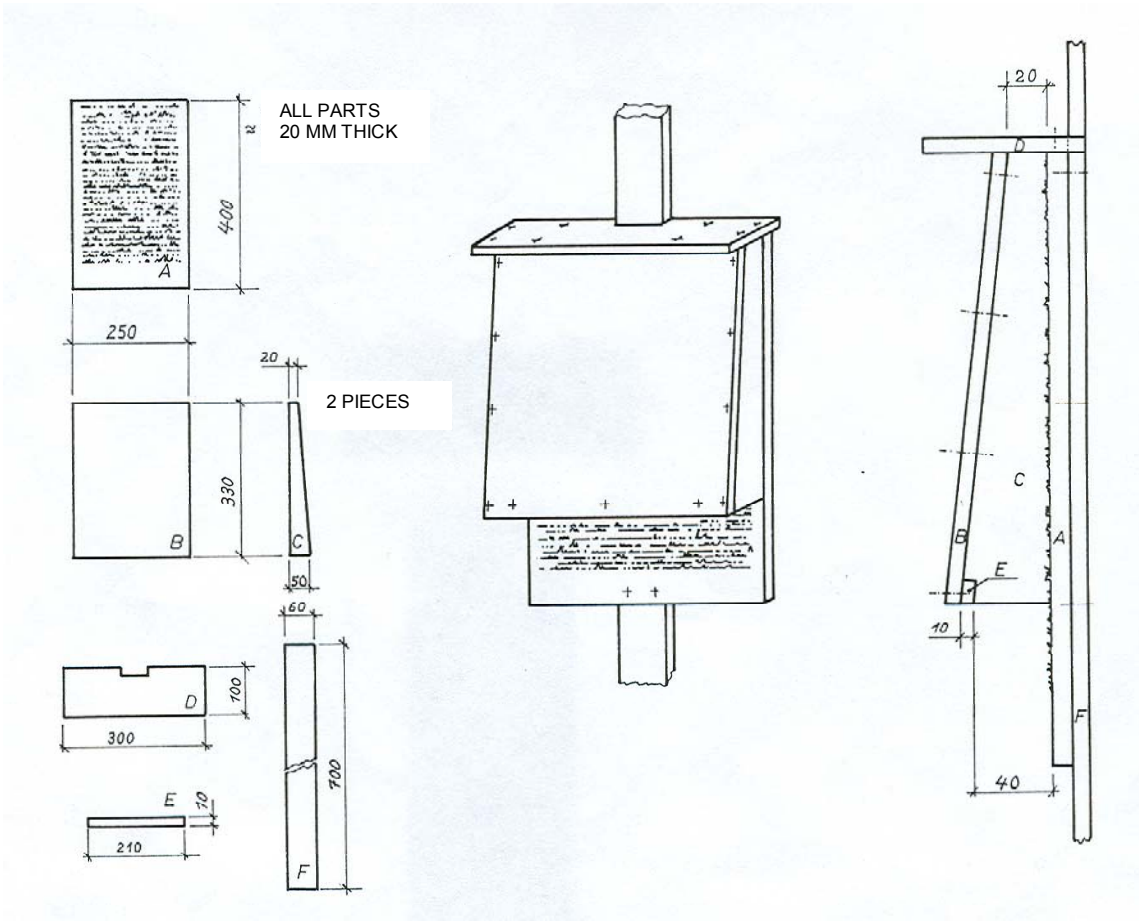


Fig. 9-4: Flat bat box

The models of bat boxes described so far have mostly been characterised by a consistent internal climate. But this does not always satisfy the bats' temperature requirements, and leads to them switching to another roost. The following models provide hanging places with different temperatures within the same box and thus reduce the need to change roosts. They have not yet been tested. The Co-ordination Centre for Bat Conservation in South Bavaria would be grateful for feedback, critical appraisals and reports of experience.

The boxes should best be fitted to buildings at a height of at least 3 metres and should face somewhere between the south-east and the south-west. Boxes for noctule bats should be fitted as close as possible directly below the roof edge, or under projecting surfaces. If there are already existing roosts, then the boxes should be fitted in such a way that it conforms to the original roost and ingress situations (cp. chapter about the species in question). If fitted on the south side, it makes sense to fit them below a projecting surface, so that the box is not exposed to direct sunshine. The boxes may be painted on the outside, using a dark colour. On the inside the wood needs to be rough-sawn. If the wood surface is relatively smooth, horizontal grooves cut at 2 cm intervals will provide footholds for the animals.

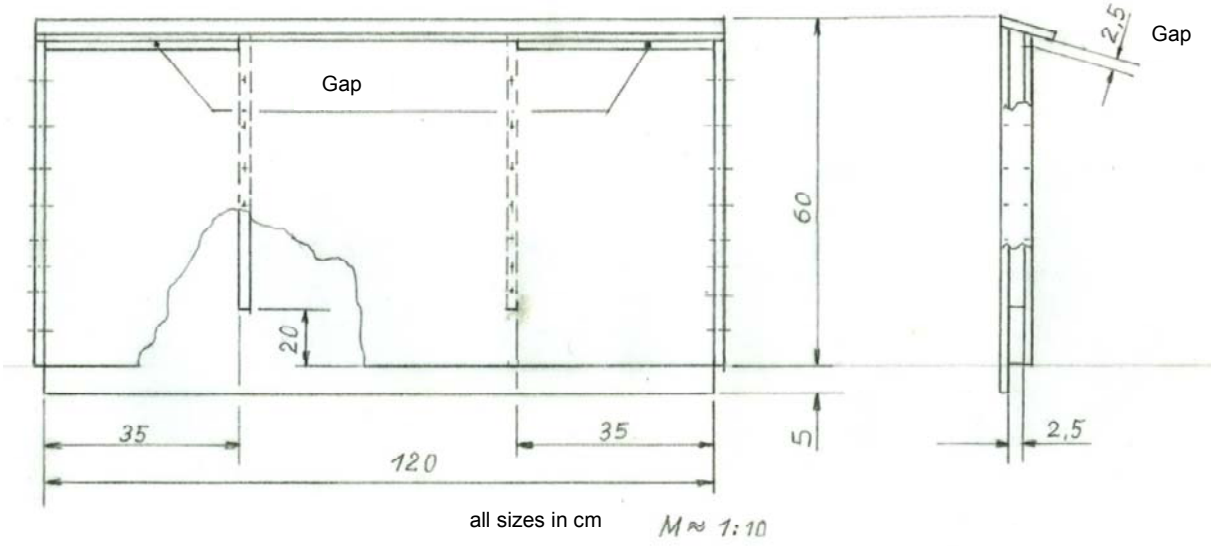
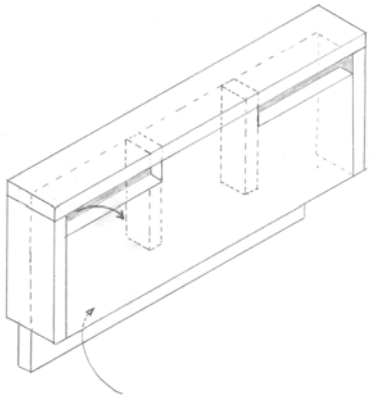


Fig. 9-5: Box A: box with a closed compartment in the centre. At top right and top left there is are ingress gaps that also dissipate hot air. At the bottom the box is completely open. The interior width is 2.5 cm.

If one wishes to make it possible for larger species, such as the noctule bat, to take up residence, the box length should be at least 1.5 m. In this case the interior width of the compartments must be 4 to 5 cm. Another solution is to taper the interior width from the bottom (4 cm) to the top (2.5 cm).

The closed compartment and the one of those to either side of it should be painted in a dark colour, the other side compartment should be in a light colour.



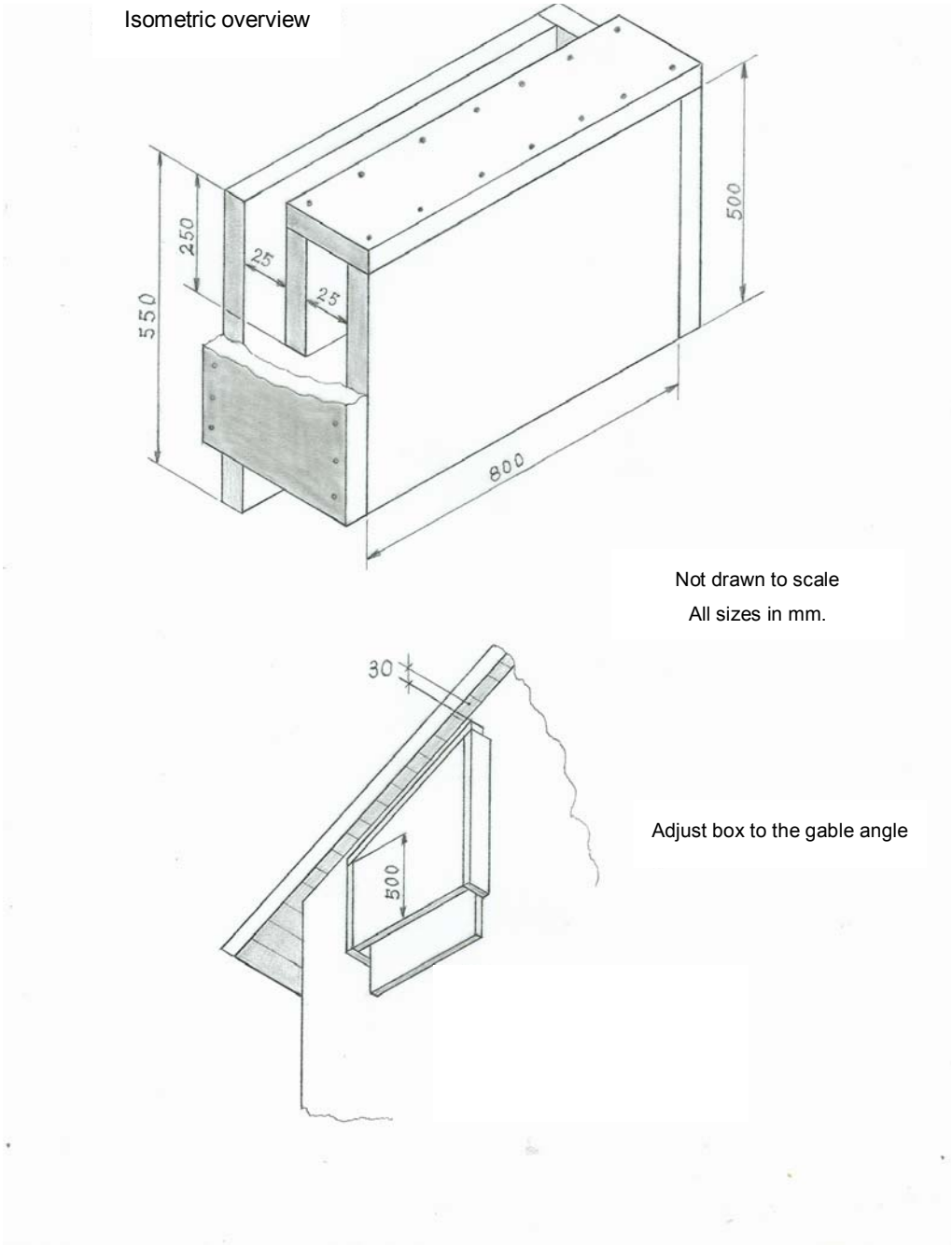


Fig. 9-6: Box B: flat box with closed compartment at the front. The rear compartment is open on top to allow the animals to slip through and for hot air dissipation. The box is open at the bottom. It should be fitted underneath a projecting surface. If a projecting surface is not available, an inclined roof can be fitted above the box in such a way that an ingress gap 3 cm wide is created at the top of the leading edge. The interior width is 2.5 cm. If one wishes to make it possible for larger species, such as noctule, to take up residence, the length should be at least 1.5 m. Then the interior width of the compartments must be 4 to 5 cm.