Technical Guide No. 4

Conducting winter surveys in cavities

LIFE+ Chiro Med Program
2010-2014

Intergrated conservation and management
of two bat species
The Greater Horseshoe Bat and Geoffroy's Bat
in the Mediterranean region of France

LIFE+ CHIRO MED

is a Life*+ "Nature and Biodiversity*"
Dedicated specially to two species of bats :

The Greater Horseshoe Bat and Geoffroy's Bat

Cover photo : C. Boulangeat.

Contents

Bats, mammals that testify to the state of the biodiversity

From their position in the food chain, bats are good indicators of the ecological status of natural habitats.They are in effect directly impacted by the alteration of the ecosystems* in which they live. They are the flag bearing species* whose conservation involves many issues where man has a role to play.

In the course of the XX^th century the numbers of the 34 species identified on French metropolitan territory has vastly declined. Their rapid regression has aroused, for the last few decades, an interest from naturalists and scientists who seek to better understand the problems which weigh against them. The improvement in knowledge of these problems, as well as that of the biology of the ecology of bats, allowed them to propose methods to protect them. These methods are put in place on a case by case basis or within the framework of larger programs (The Regional Action Plan in favour of bats) and for the last few years has given positive and encouraging results and reinforces the continuation of scientific and technical research.

A strong concentration of the species in the south of France

Metropolitan France houses 34 of the 41 bat species present in Europe, of which a third are threatened or near threatened[1] because of the change in their environment. The Mediterranean, the Rhone Valley and the Alps have the highest diversity.For example, the regions of Provence-Alpes-Côte d'Azur and Languedoc-Roussillon Coast are home to 30 species.But these regions also have the highest proportion of threatened species at national level. The responsibility for these regions in terms of conservation is paramount.

Services rendered* to man, and unsuspectedly, from bats

- **An economic and health issue :** All species of European bats are insectivores. They eat tons of insects during the night including some pests of cultures[2]. They therefore play a natural and free regulating role in the control of insect populations and thus contribute to reducing the purchase and use of pesticides. A study Science has been able to estimate the economy of the U.S. agriculture could reach 53 billion dollars[3].

- **A natural fertilizer :** Bat guano is a powerful natural fertilizer because of its high nutrient content.

- **Recent scientific research into future medical issues :** The special morphology and physiology of bats are studied in many fields of medical research into new technologies for the exploration of body by imaging, and are providing solutions on viral outbreaks and cancers[4].

[1] According to the International Union for Conservation of Nature (IUCN) and the National Museum of Natural History (NMNH). 2009.

[2] Jay M., Boreau de Roncé C., Ricard J.-M., Garcin A., Mandrin J.-F., Lavigne C., Bouvier J.-C., Tupinier Y. & S. Puechmaille. 2012. Biodiversité fonctionnelle en verger de pommier : Les chauves-souris consomment-elles des ravageurs ? *Infos CTIFL*, 286 : 28-34.

[3] Boyles J. G., Cryan P. M., McCracken G. F. & T. H. Kunz. 2011. Economic importance of bats in agriculture, *Science*, vol. 332 (6025) : 41-42.

[4] Zhang G. *et al.* 2013. Comparative analysis of bats genomes provides insight into the evolution of flight and immunity. *Science*, 339 (6118) : 456-460.

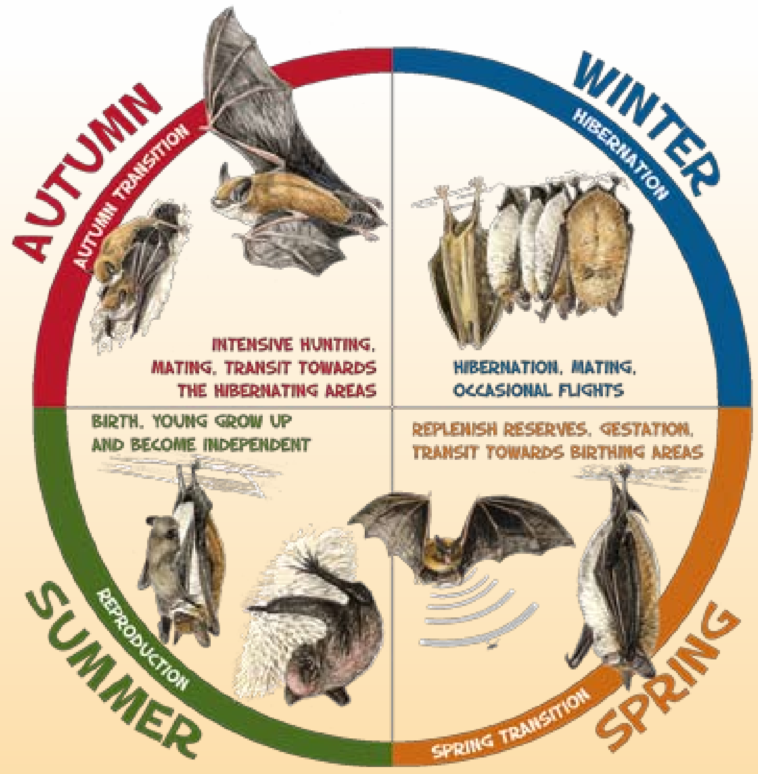
All bats are protected by law by means of :

- **International law,** by the Bonn Convention and the Berne Convention signed in 1979 and ratified by France in 1990. And by the agreement "EUROBATS*", created in 1991 and ratified by 31 countries, which commits signatory states to implement a concerted protection of the populations of bats from the European continent.

- **European Union law,** by Annex IV of the "Fauna-Flora-Habitat" Directive* (92/43/EEC) of 21 May 1992 dictates that all species of bat need of strict protection. Twelve species in France are listed in Annex II of the Directive, which lists species of community interest whose conservation requires the designation of Special Zones of Conservation (SZCs). Thus, bat populations, including their roosts and their habitats* were included in the designation of sites of the European Natura 2000 network.

- **French national law,** by Article L.411-1 of the Environmental Code and the Ministerial Decree of 23 April 2007 (Official Journal of 10/05/2007) which establishes the list of terrestrial mammals protected throughout the country and the terms of their protection. The new law now protects all species of bats currently present in metropolitan area by name, as well as the protection of breeding sites and resting places of the species, necessary for the proper performance of their life cycles.

A very specific life cycle



THE GREATER HORSESHOE BAT

The Greater Horseshoe Bat (*Rhinolophus ferrumequinum*) is the largest Horseshoe Bat in Europe. The main feature of this species is the morphology of his nose, decorated with a leaf-shaped horseshoe essential for echolocation.

Longevity : 15 to 30 years
Size : about 7 cm
Wingspan : 33 to 40 cm
Weight : 15 to 34 g
Coat : brown, more or less a type of red (dorsal) and grey-white to yellowish-white (ventral)
Ultrasound : between 79 and 84 kHz (Frequency Constant)

Reproduction : Females reach sexual maturity at 2-3 years. Their mating, in autumn, is accompanied by a winter sperm storage in females. Ovulation occurs when the sunny days return. Then their gestation lasts between 6 and 8 weeks, with a maximum of 10 weeks when spring is particularly unfavorable. From mid-June to late July, they give birth to one young per year which learns to fly at between 19 and 30 days, and is autonomous at 45 days.

Movement / Migration : A sedentary species, the Greater Horseshoe Bat rarely moves more than 100 km between breeding roosts* and hibernating roosts* passing through one or more transit roosts* (known maximum distance of travel 320 km).

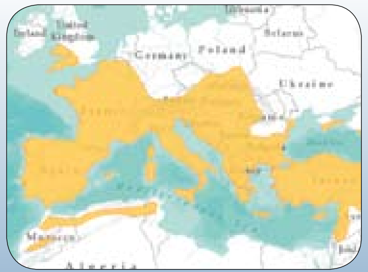
T. Stoecklé

Roosts : In summer, females settle in small groups in warm cavities (21-30°C) and often in buildings(barns, attics, hot cellars, roofs of churches, bunkers...) abandoned, maintained, or new, to give birth and raise their young until emancipation. Males generally pass summer alone.
In winter, the species hibernates from around October-November to April in natural or artificial underground cavities (mines, quarries, caves or cellars) which possess total darkness, a temperature between 5°C and 12°C, humidity at saturation, light ventilation absolute tranquility. These bats hang by the feet (typical of Rhinolophidae).

Hunting Grounds : Essentially wooded (riverine woodland, deciduous forest) and pastureland's surrounded by hedges. Hedgerows are very important for their resources of prey on one hand and also especially as travel corridors on the other (*see* Technical Guide No. 5 "Elements of area conservation management").

Diet : In general, the species feeds on dung beetles (beetles and dung beetles) and nocturnal Lepidoptera, but can also consume Orthoptera (grasshoppers, crickets), Trichoptera, flies, spiders, etc. (*see* Technical Guide No. 5 "Elements of area conservation management").

Distribution : Populations have much reduced in the north-west of Europe during the last century, sometimes completely disappeared (Belgium, Netherlands, Malta) **The epicenter of the European** distribution is in the **Mediterranean basin**.



Map source : IUCN (International Union for Conservation of Nature) 2008. *Rhinolophus ferrumequinum. In* : IUCN 2013. IUCN Red List of Threatened Species.

GEOFFROY'S BAT

Geoffroy's Bat (*Myotis emarginatus*) is medium in size with a distinct indentation, almost at right angles to the outer edge of his brown ear. His coat has a dense woolly appearance, red on the back, lighter on the belly (not much contrast).

Longevity : up to 18 years
Size : about 4-5 cm
Ears of medium size : from 1.4 to 1.7 cm
Wingspan : 22 to 24.5 cm
Weight : 6 to 15 g
Tragus* : sharp and does not reach the top of the notch in the ear
Ultrasound : begins at 140 kHz and ends to 38 kHz (Frequency Modulated Steep)

Reproduction : Mating take place in autumn. The females store sperm until spring. Ovulation occurs when the warm days return, and birth of one single young per year takes place between mid-June and late July, after 50 - 60 days of gestation. The youngster is capab e of flying at the age of 4 weeks.

Movement / Migration : A largely sedentary species. The distances between summer roosts and winter roosts is generally less than 40 km (maximum known movement : 105 km).

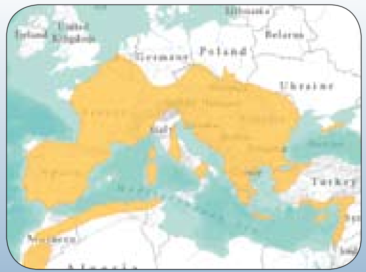
Roosts : The breeding roosts are mainly attics or lofts but can be barns, caves, or bunkers as in the Camargue, temperate (23-27°C). Females congregate in swarms of 50 to 600 individuals. Males generally pass summer alone. In winter, the species hibernates in caves, quarries, mines and large caverns which have total darkness, a relative humidity close to saturation, temperature below 12°C and almost no ventilation.

B. Morazé

Hunting Grounds : Mainly forest or wooded areas, deciduous or mixed. However this species also exploits parks and gardens, large isolated trees or small patches of vegetation, stables, pastures, groves, areas above rivers and also, in the Mediterranean, traditional olive groves, coniferous forests and orchards (*see* technical Guide No. 5 "Elements of area conservation management").

Diet : Very specialized, it is composed mainly of spiders, harvestmen and flies, supplemented by Coleoptera, Hemiptera and Neuroptera. In the Camargue there is a local particularity as it is composed mainly of spiders and Odonata, an abundant food resource in the area (*see* Technical Guide No. 5 "Elements of area conservation management").

Distribution : The species shows a very heterogeneous distribution over its entire range. In France there are strong disparities depending on the region. **The south of France** has a low population in winter but a **high population in summer**.

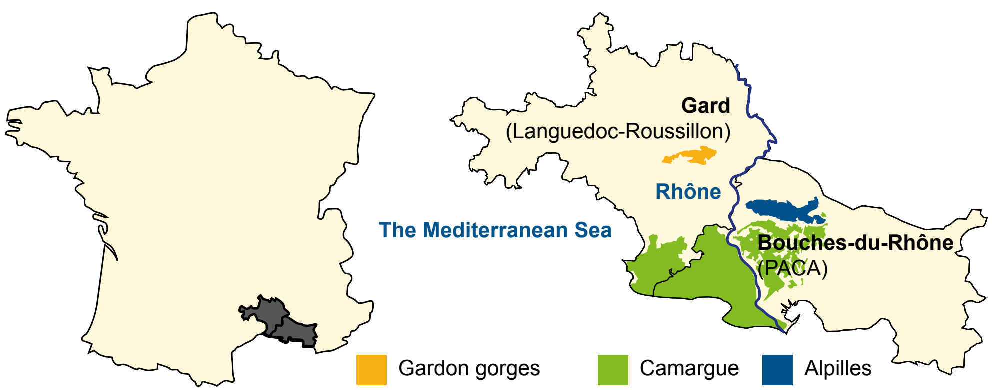


Map source : IUCN (International Union for Conservation of Nature) 2008. *Myotis emarginatus. In* : IUCN 2013. IUCN Red List of Threatened Species.

THE EUROPEAN LIFE+ CHIRO MED PROGRAM (2010 – 2014)

The LIFE+ CHIRO MED program (www.lifechiromed.fr) focuses on the conservation and integrated management of two species of bats, the Greater Horseshoe Bat and Geoffroy's Bat, in the French Mediterranean region. The objective of the program is to understand and to preserve each required biological compartment necessary for the annual cycle of local populations of the two targeted species. The strong anthropisation of targeted territories and interactions between the species and humans necessitates an implementation of concerted actions, most importantly close to human activities.

The program focuses on three geographic areas, the **Camargue**, the **Alpilles** and the **Gardon gorges**, and eight sites of community interest, called CIS. In effect in the French Mediterranean region, the main populations of the two species targeted by the program are concentrated in these three territories. In winter, these species hibernate in the cavities of the Gardon gorges and the Alpilles, while in summer they come to feed and reproduce in the Camargue.



The program allows, through 29 actions, to unite technical competence and territorial jurisdictions to overcome the **five major threats to these species :**

- *Threat 1* : the loss and alteration of hibernation and breeding roosts.
- *Threat 2* : the loss and alteration of habitats used as feeding sites (hunting grounds) and travel corridors.
- *Threat 3* : dwindling food resources related to the use of pesticides and modification of agro-pastoral practices.
- *Threat 4* : road deaths.
- *Threat 5* : an ignorance of bats which generates unintended destruction.

To address these threats to the two target species also means protection a large number of other species and their habitats. These are referred to as "umbrella species".

CONDUCTING WINTER SURVEYS IN CAVITIES

Why conduct winter surveys in cavities ?

Winter surveys in cavities are a response to a need for knowledge and an inventory of underground sites used by different species of bats during their hibernation*.

They are a preliminary assessment of the conservation issues of local populations of the targeted species, defining their conservation status at Natura 2000 sites and in applicable cases, at roosts subject to conservation actions. They can thereafter help to establish monitoring of the colonies discovered in order to measure changes in numbers and to assess the effect of protective actions, the impact of use of the sites or even the human influence on a region.

The inventory of hibernation roosts in caves is justified by the relative fidelity of bats to these roosts, linked to specific abiotic conditions* (fresh and constant temperature, high humidity, length of the network, etc., LECOQ 2006) which does not apply to all the cavities in a sector, particularly in the warm Mediterranean climate. The tranquillity of these sites is also a determining factor in whether there is a regular presence of bats, a factor concerning which it is easier for a manager or owner to intervene.

Specificities of the winter period for the conduct of surveys

- Hibernation is not directly triggered by cold but by the absence of insects available and the fact that bats do not migrate in Europe (except 3 documented exceptions). On the other hand the intense cold usually causes animals in some key sites suitable for hibernation to group together. The period used in France for winter monitoring is between 20 and 30 January (validated by the network of regional coordinators of the bat network the SFEPM - Société Française pour l'Étude et la Protection des Mammifères / French Society for the Study and Protection of Mammals).

- Not all bats hibernate in groups in the Mediterranean area . The Greater Horseshoe Bat can form hibernation groups (*see* photo 1) but none are known of in relation to Geoffroy's Bat, whose hibernation sites are currently unknown in this bio geographic area.

- It appears that the forming of groups by Greater Horseshoe Bats is both linked to the fact that some sites are very favourable for hibernation, the harsh winter prevents the dispersion of individuals to many sites, and the fact that individuals from the same summer breeding colony seem to hibernate together in winter.

- The extreme sensitivity of the bat : the process of hibernation depends on effective management by animals of fat reserves accumulated in the autumn, which indicates a strong sensitivity vis-a-vis external factors that could lead to awakening (direct touch, disturbance by another activity or awake bats, heat, noise, light).

- Inactivity of bats : unlike periods of activity where there are several methods that allow for the discovery of bat roosts whilst causing little disturbance (observations of bats leaving roosts with ultrasonic detector, radio tracking), the lethargy of bats in winter often necessitates visiting roosts and making direct observation of individuals to characterize hibernation and count the animals.

Photo 1 : *Group of Greater Horseshoe bats hibernating in a cavity.*

Objectives of the LIFE+ Chiro Med program

Geographically, the main actions proposed in the LIFE+ Chiro Med program focus on the so-called geological Camargue. This area hosts large parturition colonies of Greater Horseshoe Bat and Geoffroy's Bat, who readily use the buildings for birth and for rearing their young.
In winter, these species mainly look for hypogean* roosts, with cool temperatures and constant and saturated humidity. The lack of natural cavities in the Camargue makes the presence of colonies in the territory for hibernation unlikely, although isolated individuals in bunkers have been observed occasionally in February.

As such, the search for the hibernation roosts of the colonies of bats that breed in the Camargue was carried out on the two karst* massifs closest to the Camargue area, namely the Alpilles (15 km) and the Gardon gorges (30 km) (*see* photo 2). It was also proved, by tagging, that individuals from the colony of Aigues- Mortes, now disappeared, went towards Saint-Hippolyte-du-fFort, 80 km from the Gard's Camargue, to hibernate.

Photo 2 : *The karst regions involved in the surveys of the LIFE+ Chiro Med program Alpilles (left) and the Gardon gorges (right).*

These surveys were designed to clarify the conservation status of target species in these areas, and to identify new colonies in hibernation, in order to protect all roosts used during the life cycle of the Greater Horseshoe Bat.
When the target species were present in the roosts surveyed, observers took fresh guano samples for genetic analysis (micro satellite typing). This genetic typing was also performed on breeding colonies of the Great Horseshoe Bat to compare the different results and try to understand how bats use the network of roosts (*see* Technical Guide No. 5 "Elements of area conservation management").
In parallel, population monitoring was performed at hibernation roosts that were already known to house colonies, in order to find out the demographics and to evaluate the impact of actions taken, notably measures to protect roosts.

This guide aims to develop a methodology for conducting surveys of cavities, for use by managers, environmental protection associations, and bat protection associations, based on experience from the LIFE+ Chiro Med program in the Mediterranean with the limits of transposition following the biogeographical sector to be studied.

Several survey techniques have been tested and implemented throughout the LIFE+ Chiro Med program :

- "Conventional" surveys by caving (*see* photo 3), carried out either by two employees of the structure responsible for the sector (GCP "Groupe Chiroptères de Provence / Provence Bat Group" for the Alpilles and the SMGG "Syndicat Mixte des Gorges du Gardon / Mixed Syndicat of the Gardon Gorges" for the Gardon gorges) from November to March, or by several combined teams (involving volunteers) over a survey period of one week, to cover more area over a shorter period.

- Passive surveys using ultrasonic loggers (AnaBat™, *see* photo 4) to characterize the presence of the target species during their waking phases (especially the Greater Horseshoe Bat in the Mediterranean region). Sites reporting conclusive sound recordings were visited subsequently to specify the number of individuals present and possibly identify the species of the genus *Myotis* (the identification of signals in divisions of frequency of the genus *Myotis* is delicate and does not allow you to trace back to the species).

***Photo 3 :** Exploration of a cavity.*

***Photo 4 :** Recorder AnaBat™.*

Collection of information

The information needed

The first step in organising a campaign of surveys in cavities concerns the identification of underground sites to visit.
For this, several pieces of information must be known :

- List of sites to survey : the preliminary identification of known cavities in the territory allows the prioritization of visits to be made, to predict the time that will be required on to survey the area and to plan how many resources need to be mobilized to carry out these surveys in safety.

- Geographic location of the cavities : indispensable to locate the various underground sites, the positioning of the entries to cavities may be done by direct reference to a map or by using a GPS. The accuracy of this data is important to identify each cavity in the area, particularly in a sector where cavities are numerous and close to each other.

- Access to the cavities : in addition to the geographical location, knowledge about the access allows you to :
  - → Save precious time getting into sites.
  - → Avoid potentially sensitive areas.
  - → To protect yourselves for difficult access work, especially for caves in cliff sides.

- Topography* of the cavities: When they are available, topographies allow for (*see* Figure 1) :
  - → The planning of equipment necessary to progress the exploration of each cavity (personal protection equipment, rope length, number of anchor points).
  - → Finding the way underground, to avoid getting lost, passing several times through the same gallery, or omitting a part of the network.
  - → Identification of potentially hazardous areas.
  - → Organization of visits by sector, limiting the number of visitors to the areas that are most conducive to hibernation.

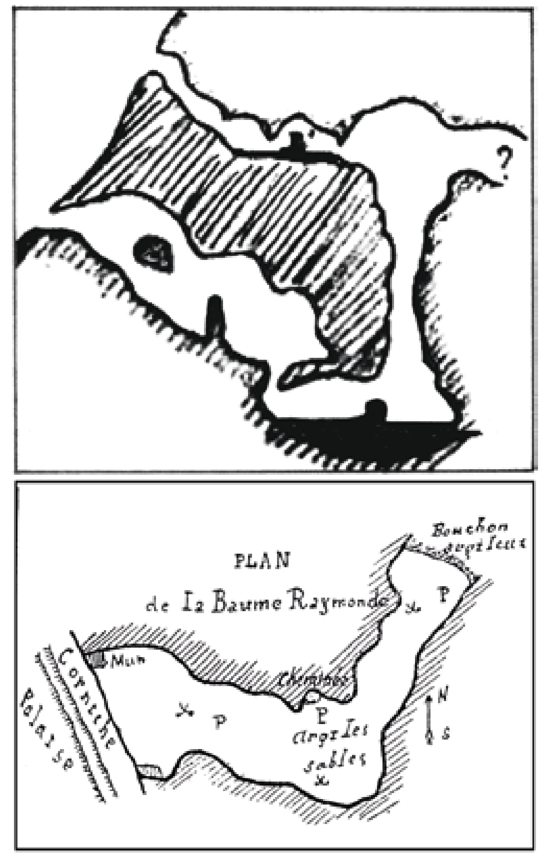


***Figure 1 :** Cross section of a cavity (Gagnière et Germand, 1929, top) and plan of a cavity (Mazauric, 1898, bottom).*

- Names of owners of cavities : a visit to an underground site is dependent on the agreement of the owner of the site entrance, which must be requested by the organizer of the surveys.

- Regulations : depending on the area in which a cavity is situated, several specific regulations may apply and must be identified (Order Prefectural Biotope Protection, Natural Reserves, National Parks, Classified Site, military sites, archaeological sites...). Most regulations in place mean a supplementary request for authorisation is needed, but may also help guide the organization of surveys in the specific issues of territory (possible access to caves outside sensitive periods for some fauna or flora species, outside periods of military activity). Some cavities could be closed, contact with managers is indispensable to collect the keys or be accompanied on site.

***Photo 5 :** A model of a CO^2 detector.* *An adhesive been attached (top right) on the alarm speaker to reduce its intensity.*

- The foreseeable hazards : specific technical difficulties (narrow space, climbing) and specific hazards of certain networks (instability, flood, presence of gas) are well known to cavers. Advance knowledge allows you to anticipate technical solutions to cope with these obstacles. For example, in the case of a network containing gas, only a CO^2 sensor (*see* photo 5) you will let know the exact concentration on site and adapt action to be taken.

- Historical data on bats : when this is available, it may allow you to prioritize which cavities to visit by targeting old sites frequented by bats. Some regions and departments also have a list of the major sites used by bats. These sites generally benefit from population surveys and should not be subject to further survey (contact bodies in charge of surveys to get the actual records).

Gas in cavities

Some karst areas are marked by high levels of carbon gases, which may interfere with the access to several cavities. The concentration of gas in a cave varies during the year, and it is generally in the cold season that the levels are lower. On the other hand, episodes of floods push the deep atmosphere upwards and raise the level of gas (Ek & Godissar 2009 and 2013).

Carbon dioxide in caves comes mainly from the decomposition of surface plants into humus and plant respiration by the roots. The free CO^2 in the ground is then driven down by rainwater (H_20) which reacts on the limestone ($CaCO^3$) to give calcium bicarbonate ($Ca(HCO^3)^2$), acid and water soluble. When arriving in a cavity, part of the dissolved limestone deposits itself in a concentrated form, causing a simultaneous release of carbon dioxide into the atmosphere of the cave.
The increase of CO^2 in the free atmospheric air, and the global climate warming of the planet since the beginning of the twentieth century also seems to have participated in the increase in CO^2 underground (which is growing faster than in the atmosphere), acting notably on the activity of vegetation.

Exposure to abnormal levels of CO^2 leads to psychological and physical consequences for Man, which vary according to the concentration of gas and the health of the person :
- Up to 1% in air breathed in (atmospheric concentration is 0.039%), the effects of CO^2 are not significant.
- 1 to 2% of CO^2, increase in the respiratory rate.
- 3 to 4%, CO^2 causes hyperventilation, headache, weakness, dizziness, stomach pain.
- Above 5%, CO^2 causes irreversible effects from reduced mental and physical abilities and loss of consciousness.
- From 10%, the loss of consciousness is rapid.
- Death is imminent at concentrations of 25-30%.

To guard against such incidents, there are good CO^2 detectors (around 500 euros) available in shops, adapted to the terrain and equipped with alarms configured according to professional standards in force : a first alarm (visual and audible) sounds at 3%. It can be stopped manually but warns the carrier to stop the exercise of his functions and turn back. A second alarm goes off at 5% and only stops when the gas level drops below that.

Without a detector, only the first symptoms will make you aware of the presence of gas... and should prompt caution.

And bats ? Caves and sinkholes containing gas can accommodate bat colonies in hibernation (the gas acts as a protection against anthropogenic disturbance). The distribution of animals within these deposits, however, shows that bats are also sensitive to gas and they occupy the spaces in the networks where there is least amount of gas (attached on the ceiling well above the level of gas, hanging points in a gentle air stream...). However, rare cases of bat mortality due to accumulation of toxic gases have been reported in Europe.

Sources of information

The database of cavities of the Geological and Mining Research Office

The BRGM (Bureau de Recherches Géologiques et Minières), a French public institution, offers a national database of natural and anthropogenic cavities. This is available directly on the BRGM website (www.bdcavite.net) and allows the identification of the cavities in a sector with the input of a department or commune. Each cavity pointed to has to a summary sheet indicating the geographical coordinates of the site.

Although this tool is simple and easy to use, it does not necessarily include all the cavities of a sector. In addition, the accuracy of certain locations is sometimes approximate (up to 200 meters), which complicates the search for the entry in the field. As such, be vigilant about the markers "Precise coordinates", "Position" and "Validity date" on the database, which allow you to asses the data accuracy.

Speleological bibliography

Caving areas are often the subject of publications, whether in simple club newsletters or national magazines (*see* Figure 2). The information is often accurate ,dense... and difficult to compile.

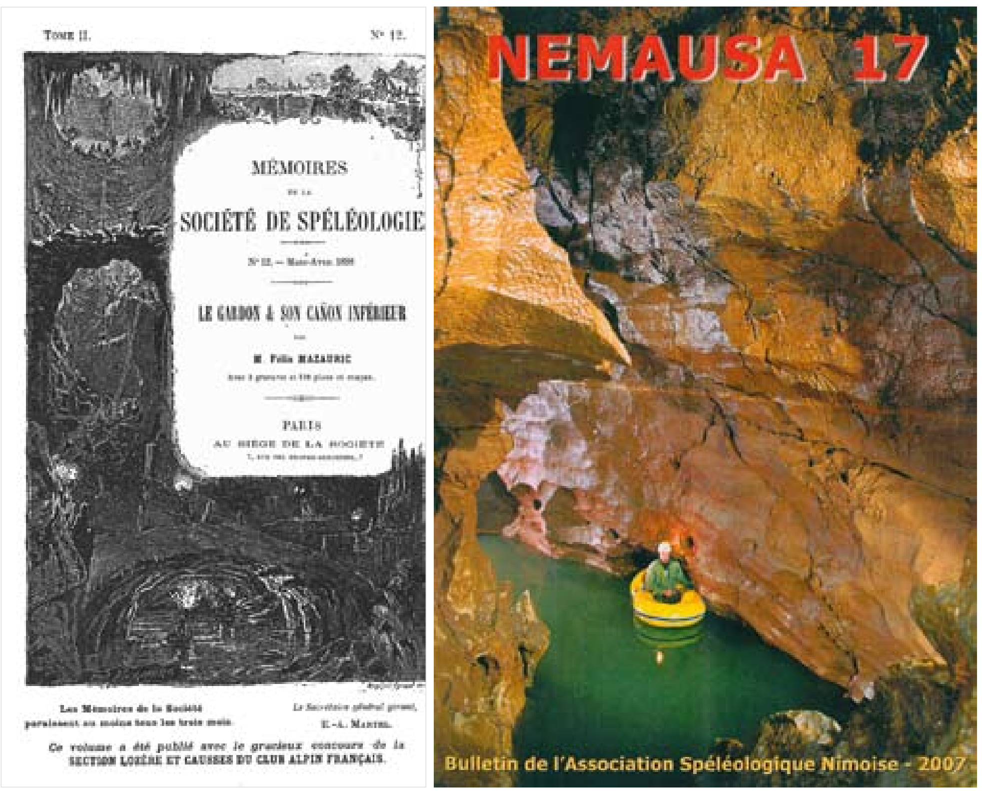


Figure 2 : *Examples of caving bibliography. Mémoires de la société de spéléologie, 1898 (left) et Nemausa - bulletin de l'Association Spéléologique Nîmoise (right).*

Luckily, some karst areas have become subject of a dedicated speleological Atlas, a reference guide of cavities in an area which provides information on equipment necessary for access and progression, topography (or schema) of caves and the potential hazards. Although these documents are valuable as a source of information, the location of underground sites is sometimes inaccurate (intentionally or not).

Cavers

They often provide the best access to speleological literature, that they can complete with their knowledge of the field. Collaboration with cavers in a survey campaign saves time in identifying sites (and their local names, sometimes numerous) and facilitate the visits (direct access to the cavities , safe air passages...).

People Resources

They are field workers, farmers, hunters or local educators, all the people who can bring you information about the caves in an area should be listened to, or associated with the surveys to be conducted.

Survey techniques

Visits to the cave

This is the survey technique most commonly used to characterize the presence of bats in winter. The operation consists of visiting (usually during the day) the roosts identified and visually identify the different species.
The limitations to this method of inventory come from the difficulty in identification and observation of hundreds of species in an underground environment (including fissuricoles).

Organization of the field phase

- Obtain the approval of the owners and managers concerned : when there is a manager, he can serve as an intermediary with different owners.

- Check that each participant is insured to go underground, either with a professional insurance, a "caving" insurance ("provided" with membership to the French Speleological Federation) or any other insurance that covers underground hazards. The FFS also provides insurance for the day.

- Establish an internal organisation of prevention and assistance : this is to ensure that the chain of triggering emergency measures works effectively.
  For this, several measures must be taken :
  - On the ground, work systematically in team (s) of two people : the first stage of initiation and organization of help depends on the unaffected partner in the pair.
  - Equip personnel with a means of communication to ensure contact with the surface (mobile or satellite phone).
  - At the office, display the internal protocol for triggering emergency measures including telephone numbers (Note : The French Speleological Federation has a useful document on "What to do in case of an accident" (*see* figure 3 - Ref SSF026 which can be downloaded from the internet) and an accessible chart referencing the planned visits (dates, locations, hours depart / arrival). Consider, before each visit, informing a person who acts as referent responsible for initiating or relaying an emergency call if needed.

Réf. : SSF026	Fédération Française de Spéléologie SPÉLÉO SECOURS FRANÇAIS	MAJ du 09/01/06

CONDUITE A TENIR EN CAS D'ACCIDENT

En cas d'accident spéléo, téléphoner par ordre de priorité jusqu'à l'établissement d'un contact :

1) A un responsable local du SPÉLÉO SECOURS FRANÇAIS
Adresses fournies par la Fédération Française de Spéléologie (voir ci-dessous) ou sur le site Web du Spéléo Secours Français : www.speleo-secours-francais.com

2) A un responsable national du SPÉLÉO SECOURS FRANÇAIS

N° vert : + 33 (0)800 121 123

3) Au Centre de Traitement de l'Alerte : 112 en précisant :

- qu'il s'agit d'un "accident de spéléologie"
- qu'il faut alerter le "Conseiller Technique Départemental de Spéléologie" du spéléo-secours du département.

4) A la Gendarmerie locale ☎ 17 en précisant :

- qu'il s'agit d'un "accident de spéléologie"
- qu'il faut alerter le "Conseiller Technique Départemental de Spéléologie" du spéléo-secours du département.

En cas d'accident corporel

Il est indispensable que l'alerte soit transmise par un témoin direct. Il pourra ainsi répondre aux questions qui lui seront posées relatives au lieu, à l'heure et aux circonstances de l'accident.

Le message d'alerte devra également comporter un bilan de santé minimun de la victime : (les six questions).

Il faut consacrer le temps nécessaire à la collecte et à la rédaction des renseignements qui constituent le message d'alerte.

Savoir :

- **L'heure et les circonstances de l'accident**

Pour le bilan de l'accidenté, le minimum sera :

1. **La victime répond-elle aux questions ?**
2. **Peut-elle bouger tous ses membres ?**
3. **Sa respiration est-elle normale ?**
4. **Le pouls bat-il au poignet ?**
5. **A-t-elle des blessures évidentes ?**
6. **Est-elle en train de s'affaiblir ?**

Figure 3 : *FFS document detailling the action to be taken in case of accident.*

- Collect and check safety equipment : in relation to the location to be visited, gather material indicated to progress (ropes, karabiners, fixations) and individual protective equipment required (harnesses, lanyards), ensuring their validity (equipment to be inspected every year by a qualified person). Provide a CO^2 sensor if there is a known risk of gas and a suitable first aid kit (including pressure dressings, haemostatics type, to ensure points of compression).

Conduct

The field phase consists of visiting the cavity and visually counting the bats present, distinguishing numbers of each species. Fill out a survey visit form on leaving the cavity to limit the time spent in the cave.

For large swarms of bats, it is possible to count using photography. In this case, be careful with the set up so you only take one picture (with flash) and leave quietly. The close-up shots can be taken by softening the flash through a layer of tracing paper.

Equipment to be used (excluding specific security equipment) for the fieldwork is the following :

Per person :
- Appropriate clothing.
- Headlamp.
- Torch.
- Binoculars.
- Helmet for caving.

Per team :
- Camera + tracing paper.
- GPS.
- Compass.
- Thermo-hygrometer.
- Standard survey forms (*see* Figures 4a and 4b).

At the office, store field data forms in a database, as well as photographs.


M. Picart

LIFE+ CHIRO MED
Standard Identification Form
Winter Survey

Site name : ....**No. / name commune :** ....

Date of visit : ..../........./........ **Observers :** ....

Weather : ....

Temperature interior : .... *Temperature exterior :* .... *Hygrometry :* ....

Cavity data :

Type of cavity :	pothole	cave			
Total expanse (m) :	0-126	126-795	>795		
Surface (m²) of the main access :		<1	1-2	2-4	> 4
Vegetation cover at the cavity exit :			yes	no	partial
Air current in the cavity :	none or weak		light	assez fort	
Fréquentation humaine de la cavité :		rare	occasionnelle	fairly strong	
Altitude (en m) :					
Exposition of the main access :					

OBSERVATIONS :

Species	Total number	Compact swarm	dispersed	Comments (signs of activity, bodies, etc)

COMMENTS :
....
....

* In bold the data to be completed imperatively, in italics the optional data

Figure 4a : Model of the data sheet used by LIFE+ Chiro Med (page 1).

Description of the location of Greater Horseshoe Bats

type of underground environment : space with joint blocks — space without block — tunnel — break wall — narrow — shaft

Volume of the underground environment (m³) : <11 — 11-101 — 101-1001 — 1001-10001 — >10001

Darkness : weak — strong — total

Type of location : wall — Inclined wall — roof — overhang — fallen blockl — reinforced wall — concretion

Distance from the main access (en m) : 3-12 — 13-30 — 31-66 — 67-138 — 139-282 — >282

Height (m) : 0-0,1 — 0,1-0,3 — 0,3-0,7 — 0,7-1,5 — 1,5-3,1 — 3,1-6,3 — 6,3-12,7 — > 12,7

Temperature (°C) : 4,2-6,2 — 6,2-8,2 — 8,2-10,2 — > 10,2
Hygrometry (%) : < 80 — 80-85 — 85-90 — 90-95 — >95

Air current : none or weak — light — fairly strong

DESCRIPTION OF THE ACCESS :
....
....
....
....
....
....
....
....

* In bold the data to be completed imperatively, in italics the optional data

Figure 4b : Model of the data sheet used by LIFE+ Chiro Med (page 2).

The identification of bats in winter

Identification of species of bats by visual observation in the roost is tricky, especially when the animals are hung vertically or they occupy inaccessible cracks (*see* photo 6). The time taken to visit the roosts in winter must be limited to avoid disturbance, identification must also be done as quickly as possible.

Finally, note that all species or individuals are not necessarily identifiable in winter, and it is sometimes necessary to note just the genus or simply the name "Bat *sp.*".

As a guide, there are several keys to determining bat species during the winter season, access and download directly from the net.

For your information, here are two keys available and well presented (which do not concern only the Mediterranean species) :
- « Key of determination of bats in Brittany during winter, Groupe Mammologique Breton / GMB », website : **www.gmb.asso.fr/PDF/CleDetermChssBretagne.pdf**
- « Memo for the determination of bats in winter : genus *Plecotus* », website: **www.natagora.be/fileadmin/Plecotus/Documentation/Memo3.pdf**

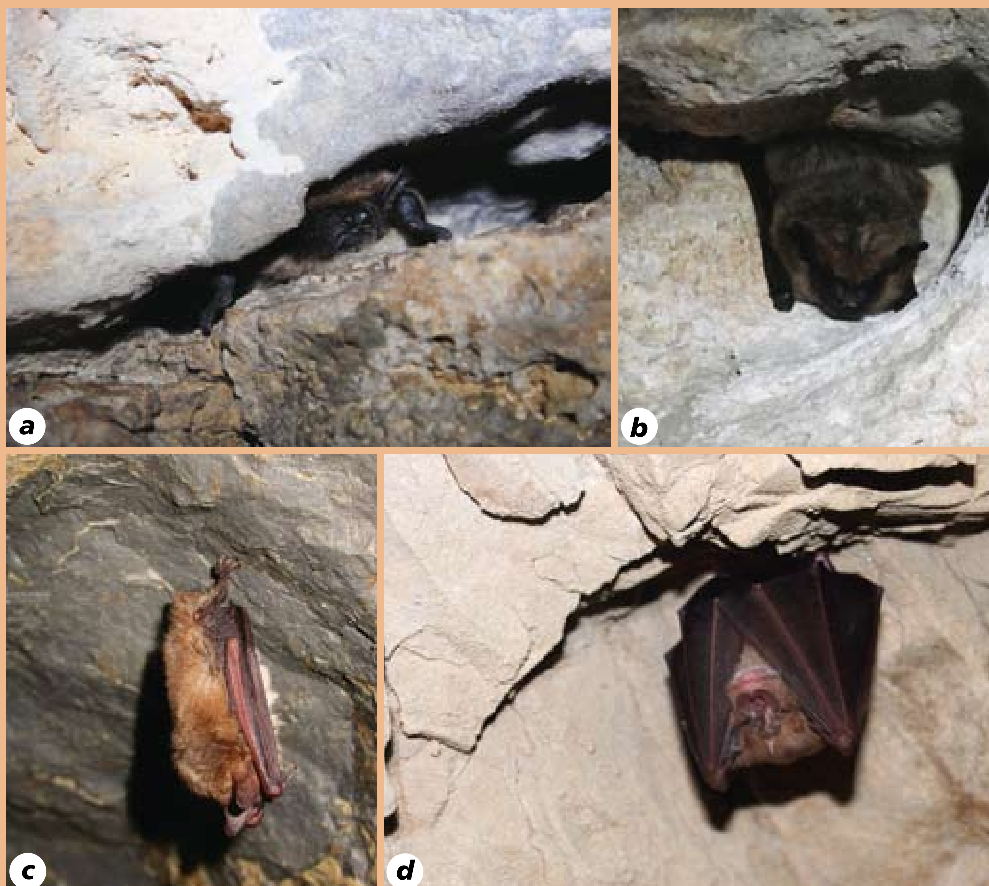


***Photo 6 : Four examples of species of bats. a** - Savi's Pipistrelle in a crack, **b** - Serotine Bat in a crevice, **c** - Geoffrey's Bat and **d** - Greater horseshoe Bat in hibernation.*

Reminder of the precautions

Precautions in relation to bats

Because of the particular sensitivity of bats during hibernation, it is imperative to follow these recommendations :
- Allow the body to cool before entering the cave : human heat is detected by bats and forces them to wake.
- Walk and move slowly and think about leaving as quietly as you arrived.
- Do not light them up directly and dim light through a cloth or hand.
- Use lamps that do not heat (LED) to illuminate the animals.
- Do not talk loudly or shout.
- Do not touch bats.
- Never pass directly under the colony.
- Watch where you walk to avoid dry crackings.
- Avoid wearing rainwear which produces ultrasound when it rubs together.
- Do not stay too long near animals in lethargy.

Precautions in relation to other species

It is possible to meet various animals underground (insects, mammals, *see* photo 7), which are potentially dangerous if cornered or wounded. Remain cautious during progression underground... an appropriate first aid kit should help you deal with bites or stings.

***Photo 7 :** The European beaver, an original occupant of the Gardon in resurgence during dry periods.*

Look at the weather forecast before you leave

Some networks may become water logged quickly after rainfall or during floods. In case of rain, change plans to visit sites with sensitive access in favour of those without difficulty.

Avoid getting lost

In the absence of available topography, navigation underground requires taking regular note of landmarks (the most unusual possible) and turn around frequently to visualize the return journey.

Watch out for falls...
- Walking : wear good shoes and move carefully.
- From a height : in the case of vertical passages, ensure the presence of a competent person equipped with a rope
- Of rocks : wear a helmet used for caving (less than five years old) and identify walls that may be unstable.

Anticipate problems of health and equipment

To prevent physical problems, always work in pairs and know, if possible, some first aid. In addition to a first aid kit , pack, systematically, water and food, even for a short visit. Inform someone of your exit and note it on the exit form.

In terms of equipment, use PPE*, well maintained and checked and provide batteries and emergency lighting systems. Master (or teach) survival techniques which make it possible to deal with a lack of equipment (in case of breakage or loss) and to come to the aid of a team mate using a rope.

Surveys by employee and by team

Although both methods follow the same protocol, it is possible to point out multiple differences in their implementation. As such, Table 1 below shows the advantages and disadvantages of surveys by teams compared to surveys by employees.

Table 1 : Comparison of surveys by teams compared to surveys by employees.

Advantages	Disadvantages
Surveys done simultaneously Surveys by teams help mean a large amount of surveying can be done over a short period, overcoming the bias factor that animals move throughout the winter	**Cost** Although participants are volunteers, paying for meals and accommodation are a financial cost considerations.
Awareness of participants The mobilization of many volunteer participants is the opportunity to have an effective awareness campaign about the biology of bats and their sensitivity in winter.	**Logistics** The organization of surveys team requires having enough material available (cars, caving helmets, GPS...).
Exchange of experiences Volunteer participants often have diverse skills related to various underground environments (cavers, naturalists, managers) encourages exchanges of experience.	**Time for organization** Team leaders must sometimes make advance visits to the site. The organization of the survey calendar and registration of participants can be time-consuming.

Surveys by ultrasound loggers

Problematic

Automatic ultrasonic recorders, AnaBat™, were used in winter surveys with the idea of optimizing the survey time.

In winter, the low activity level of bats in roosts (individuals in lethargy) questioned the effectiveness of AnaBat™ to characterize the presence of individuals in the cavities. The Mediterranean climate of the two study areas was, in turn, a factor which may reduce the hibernating period of bats or mean that individuals wake up temporarily during the hibernation period.

To answer these questions, AnaBat™ was used during the first winter of the program for the pre and post-hibernation periods (November 1 - December 15, 2010, and February 15 - March 31, 2011), when bats joined or left the hibernation roost and were partially active.

Meanwhile, a cave test in each of the study areas was equipped during the coldest months (January and February) to measure the effectiveness of AnaBat™ during this period on known colonies.

Following the conclusions drawn from the caves tests study, the use of AnaBat™ for subsequent surveys was extended throughout the winter season, from November to March.

Conduct of surveys by AnaBat™

In order to optimize the various survey techniques, the sites to be surveyed by AnaBat™ had previously been identified based on several criteria :

- The potential of the cavity for bat hibernation (based on known topographic elements).
- Low public frequentation (to avoid the risk of theft of the AnaBat™).
- The number of entries limited (each entry needs to be equipped with a recorder, sites having too many openings could not technically be surveyed by AnaBat™).
- Risks associated with visits : some sites have difficult access or specific risks (presence of gas, instability) which complicate the visit. These sites have the priority to be equipped with AnaBat™.

In terms of implementation, the protocol for surveying with AnaBat™ involves an initial placement of the unit for four consecutive nights at the entry (or entries) of the study site.

From the second winter of the program, with the experience gained from the caves tests, this placement time has been extended from 4 to 8 nights (*see* section "results from control sites").

When sites were accessible, the AnaBat™ was placed inside, within a few meters of the entrance. Otherwise, it was installed outside, less than a meter from the entrance. In either case, the microphone was directed towards the inside of the cavity (to limit extraneous sounds "rain, wind" and the signals from bats potentially active outside the cavity) with a gain set to 6.

Thereafter, the sound files recorded were analysed on a computer, using the software Analook, to find out which species were recorded. Note that the identification of signals from the genus *Myotis* is delicate, and is limited to just the genus in the analysis.

The equipment used by AnaBat™ surveys consists of :
• One or more AnaBat™ (depending on the number of entries in the cave to be surveyed).
• An AnaBat™ cover for cavities frequented by the public.
• GPS and compass, headlamp.
• Standard data sheet for installation of the AnaBat™ and a pen.

Reminder of the precautions

To ensure sufficient autonomy in cold conditions, The AnaBat™ must be powered by an external battery. The experience of LIFE+ Chiro Med shows that the power supply can be easily broken, both at the fuse holder and at the exterior connection of the apparatus. Moisture associated with the condensation that forms at the cave entrance can rupture the external power to the device (short circuit), as well as causing rust on the microphone, making it inoperable.

The risk of vandalism is high at some sites. Be sure to hide the AnaBat™ using a AnaBat™ cover or by using things at the site (*see* photo 8). Also inform others of the nature of the installation by attaching an explanatory note to the AnaBat™.

Photo 8 : *Examples of concealment of the AnaBat™ using materials on site.*

Data classification

The information collected at the end of a campaign of cavity surveys is numerous and of several different natures.

Data relative to bats is usually grouped in a computer database such as Excel or Access (Microsoft, *see* figure 5), which require certain fields :

- The position of the roost : indicate at least the name and GPS positioning of the roost as well as the department and commune where the cavity is situated.
- The type of roost : characterize the use of the roost by bats according to their life cycle, knowing that winter surveys will primarily highlight hibernation roosts…
- Data relative to bat species : specify the number by species contacted and the nature of the contact (visual and /or acoustic). In case of survey by AnaBat™, specify the number of sequences obtained by species (or genus for *Myotis*).
- The date of the visit and the names of visitors.

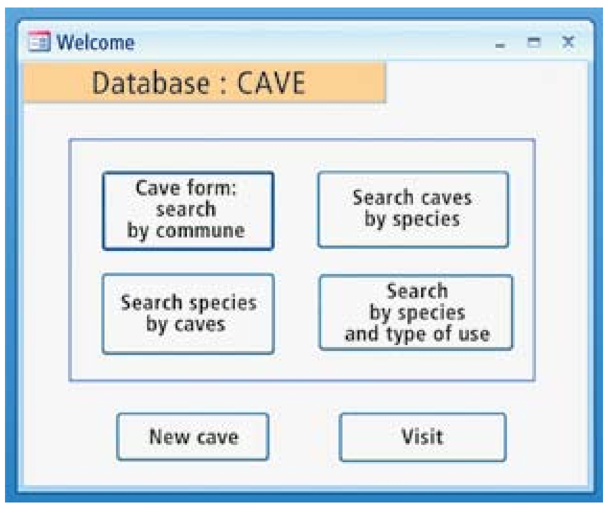
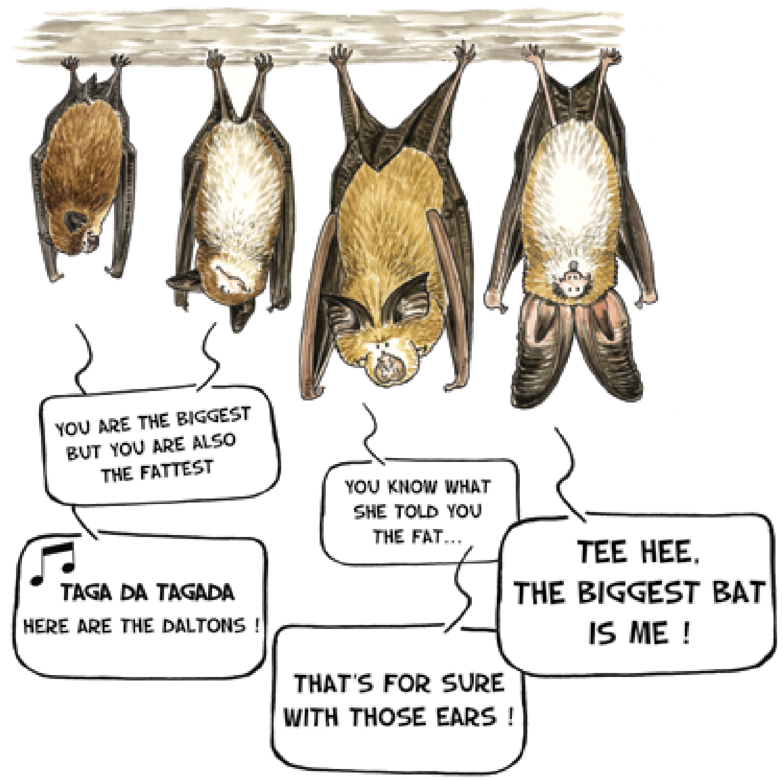


Figure 5 : *Example of cavity database on Microsoft Access.*

Note that recordings by AnaBat™ generate relatively heavy sound files which require several Megabytes of computer memory to be preserved.

Beyond bats data, all the information collected on underground sites should be conserved by means of additional fields, for later use by managers :

- Owners of underground sites : keep the name of the owners of surveyed sites (and managers if applicable) to facilitate contact and future permission requests.
- Limitations in access to the site : indicate constraints that may limit access to certain sites at certain times, depending on different issues (presence of protected species, specific authorizations necessary, natural hazards).
- Materials needed : quickly define specific equipment needed to access the site to be visited (PPE, rope length, number of fixations). Also specify in this field the means of access to the site (boat available for cavities accessible by water, length of rope for the caves opening onto cliffs...).
- Sensitivity of the site : specify in this field if there are known heritage issues (natural, archaeological) and specific recommendations to respect when visiting..



SURVEY RESULTS

Control sites

The equipment at the control sites included the installation of an AnaBat™ the entrance of the roost throughout winter, coupled with an AnaBat™ placed in the heart of the cavity in the coldest months (January and February). This protocol was designed to compare the signals recorded at the entrance of the cavity with those signals generated inside the hibernation roost, and to learn more about the stages of awakening and winter lethargy of the Greater Horseshoe Bat in the Mediterranean region.

The data acquired in these caves tests has helped identify several conclusions :

- Placed at the entrance or in the middle of the site, the AnaBat™ detected the presence of the target species throughout the winter.

- However, over several periods lasting three to seven days, Greater Horseshoe Bats remained undetected at the site entrance, although they were active in the middle of the cavity.

- The activity of the Greater Horseshoe Bats in the middle and at the entrance of the cavities tested did not depend on the minimum temperature outside and the species can remain active up to the entrance at temperatures below 0°C.

***Photo 9 :** Awakening of a Greater Horseshoe Bat during the hibernation period.*

Regarding the location of the AnaBat™, although a device placed in the heart of the site allows the more effective recording of the presence of bats than a device placed at the entrance (number of contacts, regularity), this advantage is upset by a longer installation time (need to know the network, access) and remains dependent on the penetration of the site by humans (several sites in the Alpilles could not have been equipped by this method).

Sites surveyed

The comparison of the results registered by ultrasound recorders and those obtained during visits show that the correlation between these two surveying techniques is far from linear and that different situations can be observed :

The AnaBat™ has not registered ultrasounds but a site visit establishes contact with the target species

This case was experienced mainly during the first winter survey. In connection with the experience gained from the cave tests, it seems that the duration of the installation was too short during the first exercise which explains this result.
Another explanation relates to the sites where all the entries could not be fitted with AnaBat™. Bats were therefore likely to be using other passages, underlining the need to "lock down" all entries of survey sites with recorders to avoid this kind of disappointment.

Target species were contacted by AnaBat™ but not during the site visit

This phenomenon has several explanations. The first is the difficulty in making comprehensive visual counts in complex underground networks, with bats in refuges inaccessible to humans. Furthermore, the number of contacts made the cavities remains modest, which suggests that numbers are of the order of a few individuals.
In addition, some signals may be issued by passing animals and not by animals using the hibernation roost. Finally, individuals were also able to move from one roost to another between the registration period and the period of the visit, which were sometimes separated by several weeks. The latter shows the importance of limiting the time interval between recovery of the recorders and the site visit.

Target species were contacted by AnaBat™ but a site visit was not possible

Several sites could not be visited due to their inaccessibility to humans (narrow network, *see* photo 10) or specific hazards (gas, instability).
At these sites, the use of AnaBat™ yielded information (presence or absence of the target species) which, although incomplete, could not be acquired in another fashion.

***Photo 10 :** Some sites inaccessible to Man were worth equipping with AnaBat™.*

SURVEY RESULTS

Target species were contacted by AnaBat™ and during the site visit

This last case occurred in the majority of the caves tested with AnaBat™ and shows a relative correlation between the two survey techniques. The estimation of numbers present from only the volume of recorded signals is revealed as illusionary : there is no direct correlation between the total number of recorded signals and actual numbers of individuals recorded during visits.

To go further, it is possible to draw a phenology graph (*see* Figures 6 and 7) of signals recorded by time slots that provides a more detailed view of the activity of the Greater Horseshoe Bats at the entrances of different sites.

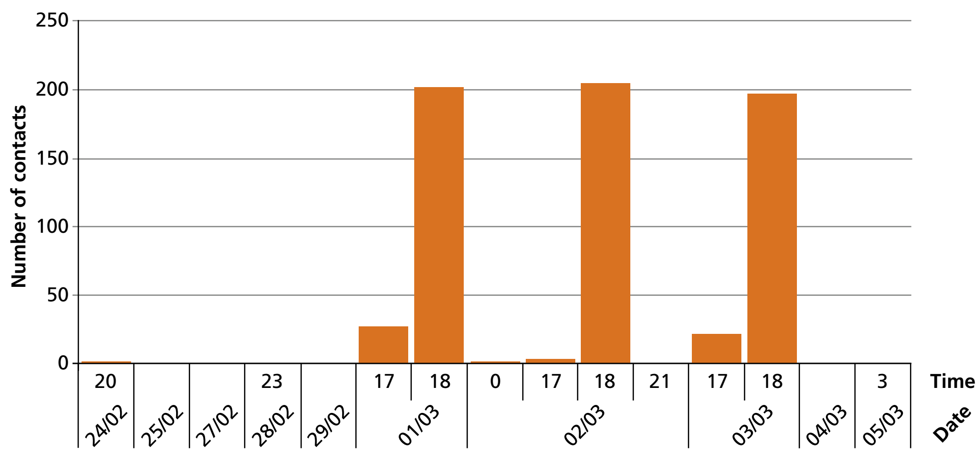


***Figure 6 :** Phenology for Pothole X (note : 1 individual Greater Horseshoe Bat). Distribution of contacts from 14 February to 05 March 2012.*

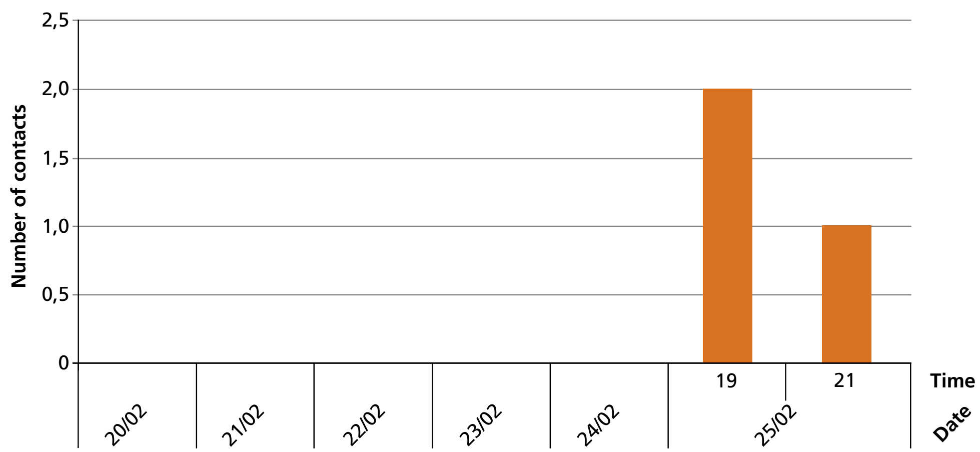


***Figure 7 :** Phenology for Pothole Y (note : 17 individual Greater Horseshoe Bats). Distribution of contacts from 20 to 25 February to 05 March 2012.*

From these graphs (in relation to visual contact with populations) it is possible to point to several factors that may improve the estimation of the numbers of hibernating Greater Horseshoe Bat from ultrasonic recordings obtained.

Number of signals on returning to the roost

In general, there is a significant gap between the number of contacts made at the beginning at the night (exit of the roost) and the return to the roost (Arthur & Lemaire 2009). This result demonstrates the delay in leaving the roost by the Greater Horseshoe Bat (prudence, hunting activity within the roost, social behaviour between several individuals who are awake) while the return is much more direct and fast. As such, the inclusion of signals from the return from hunting appear much more relevant for estimating populations in each roost.

For example, the graph relative to Pothole X is particularly explicit : for only one Greater Horseshoe Bat counted, it remained audible to the detector for more than 30 minutes in the pothole, before going out to hunt (on average 200 contacts at the start of the night). The signals on the return to the roost were about 1 or 2 contacts, and better reflect the reality of occupation. In relation to the sites where there are several individuals, the results for the return to the roost give lower number counts than those counted during visits, the Greater Horseshoe Bat are not all active simultaneously.

Duration and regularity of contacts at the start of the night

In parallel to the number of signals recorded on the return to the roost, the period over which the signals are concentrated can be used to refine the estimate of hibernating populations. In the case of Pothole X, we note that over 90% of signals leaving the roost were recorded between 18 and 19 hours. Besides the remarkable regularity the Greater Horseshoe Bats show in leaving the roost, this result shows a limited average time of exit (on average 31 minutes of contacts). Moreover, signal recording was regular and almost continuous during this period of exit from the roost, which suggests that it came from a single individual. Further, the signals recorded on exit over several hours, and comprising of some periods of quiet would tend to suggest several individuals, waking up in turn and leaving in a staggered pattern. The estimated of numbers of individuals with these types of signals, however, remains very delicate, this factor mainly allows us principally to differentiate the sites where there are one individual from those where there is a larger population.

Period of inactivity in the cold season

If the Greater Horseshoe Bats have the ability to wake up from time to time during the hibernation period to hunt, this potential appears limited for each individual. As such, a site that only has a few individuals should statistically have periods of inactivity exceeding that of a site where there is a colony, Greater Horseshoe Bats do not necessarily awake simultaneously.

This principle does not always appear linear and colonies of several dozen individuals can remain undetectable at the entrance for 5 consecutive days (*eg*. Pothole Y). In contrast, one single Greater Horseshoe Bat can remain active for 6 days out of the 10 days of recording by Anabat™, with a maximum continuous period of inactivity of 2 days.

LIFE+ Chiro Med in numbers

In the Alpilles, the visits to cavities were made the first two winters of the program (2010 and 2011) by two employees of GCP.

In the Gardon gorges, they were performed over the three winters of the program by two agents of the SMGG, to which was added two sessions of surveys done by a team (five teams over five days each time), which were organised in January 2011 and 2012.

All surveys by site visits, particularly surveys done by teams, benefited from the active participation of many people resources and volunteers (cave explorers, naturalists, managers, locals). Participants in the team surveys (40 people) were trained at the beginning of each session on the identification of bats in lethargy and the precautions to follow when visiting roosts.

In the Alpilles, the Greater Horseshoe Bat was the only species of bat they made contact with during the field surveys. The species was present in 5 of the 39 sites visited, but only 2 cavities housed several individuals in hibernation.

In the Gardon gorges, 240 sites were visited and contact was made with191 bats from more than 10 different species. The proportion of sites occupied by bats in winter is about 25%, but less than 1 cave in 10 shelters the Greater Horseshoe Bat, 22 sites in all. Of these, 5 sites sheltered several Greater Horseshoe Bats in hibernation.

Limitations of comparison between sites

Several limitations exist concerning the comparison of results obtained by AnaBat™ at different sites :

- Malfunction of AnaBat™ : in the Alpilles as well as the Gardon gorges, the AnaBat™ experienced several technical problems that caused them to stop working. Due to this, the duration of the collection of audio signals is variable depending on the site, which does not favourably assist in the comparison of results obtained.

- Specifics of survey sites : each underground site features its own specifics (network length, vegetation cover at the entrance, form of the entrance...). The behaviour of animals at the entrance of the roost may be partly related to these characteristics. For example, the time it takes the Greater Horseshoe Bat to leave a site with a horizontal entrance, with an ample cover of vegetation, was consistently faster than at sites with an vertical shaft entrance without cover around it. Similarly, a site with abundant cave entomofauna can be used occasionally for hunting in winter, whereas another site, which is less rich, leads the Greater Horseshoe Bats to go outside to hunt.

- Individual particularities of the Greater Horseshoe Bat : Depending on their age, sex and experience, Greater Horseshoe Bats do not all enter into hibernation with the same quantities of fat reserve. This factor can influence the phases of awakening and force some individuals to go hunting when others continue their lethargy.

- Periods of installation of the AnaBats™ : The AnaBats™ were used for surveying during the whole of the winter period (November-March). However, the phases of waking of the animals are different during the heart of winter (January-February) and at the start and finish of hibernation.

Evaluation of the survey methods

In relation to the evaluation of the surveys by AnaBat™, the results obtained by this survey technique highlight several limitations.

The first concerns the significant shortcomings of the device when it is used over a long period. The second limitation concerns the difficulty of extrapolating the number of individuals hibernating from sound data obtained by AnaBat™. If the device is used to confirm the presence or absence of Greater Horseshoe Bats, the precise quantification of the individuals very often requires a subsequent visit to the site. As such, the time required for surveys by AnaBat™ appears to be longer than direct surveys by site visits.

The use of the AnaBat™ for winter surveys is limited also in terms of the bioclimatic zone in which the study area is situated, and the species targeted. The results achieved by LIFE+ Chiro Med concern the Greater Horseshoe Bat in the Mediterranean area, and are not necessarily extrapolated to other climates or other species. In the study area, the results show that some species (Geoffroy's Bat, for example) do not wake up during hibernation and thus remain undetectable by the AnaBat™ at roost entrances.

Despite these limitations, the use of AnaBat™ during the bat hibernation period can nevertheless be justified and bring added value in some cases.

It can help you to judge whether it is pertinent to carry out a site visit in a network which is very extended by providing advance information about the presence of bats and an estimate of the size of the population that occupies the site. The program experience shows that it is possible to differentiate, from sound recordings, a site with one or two individuals from a site with a group of individuals, a useful tool in a large network site where visual counting is delicate when the population is very limited.

Finally, in the case of a network which is inaccessible or too dangerous to be visited, the use of AnaBat™ at the entrances is a method of obtaining, none the less, information on winter use by bats.

Both methods may therefore be particularly complementary in some networks which are extended or difficult to access.

The follow-up after a campaign of surveys

Based on the results obtained during the winter survey, several follow-ups can be considered for the cavities visited.

Firstly, in some cavities there may be an indication of a large and recent presence of bats (fresh guano, traces of urine, *see* Photo 11) even if no individual was observed during winter survey. This result suggests these sites are unsuitable for hibernation but they are used during active periods.
On these sites, it is necessary to plan one or several follow-up visits during the periods of activity, to find out when the bats are present, identify the numbers of different species and characterize the exact nature of the roost (transit, reproduction).

***Photo 11 :** Traces of bat urine a ceiling cavity.*

Hibernation roosts identified during the survey should be monitored annually to survey the populations of bats in winter, to measure changes in numbers and assess the conservation status of colonies. In parallel, following indications of an identified presence, it may be interesting to monitor these roosts during periods of activity to verify whether they shelter bats during other seasons.

Colony of Mediterranean Horseshoe Bat.

M. Picart

SURVEY RESULTS

Finally, some roosts may possess important conservation issues for several species of bat and require special protection measures (Mitchell-Jones *et al.* 2007 et SFEPM 2008).

The degree of protection of the roosts is determined by several factors :

- The level of threats to the colonies : identify threats that may affect the smooth passing of hibernation or other periods where bats are present. The protection measures subsequently taken should directly aim to neutralize these threats.
- The importance of the roost for the conservation of bats : this is defined in terms of the rarity of the species present, their numbers and the use of the roost (hibernation, reproduction, transit, mating), certain seasons appear particularly sensitive for the biology of bats.

From this analysis, several types of protection can be considered for the key roosts identified :

- Regulatory protections : the establishment of prefectural orders concerning Protection of Biotopes and Nature Reserves on some roosts allows you to fix specific regulations to ensure the conservation of bats based on the issues identified. This may be to prohibit access to the whole roost or part of the network where the animals shelter, temporarily or permanently, depending on the time when the bats are present.
- Physical protection : these protections are designed to physically prevent human access to the roosts whilst allowing the passage of bats. Again, the prohibition of access can be permanent or temporary. The physical models of cavity barriers usually consist of grids of horizontal bars (*see* photo 12). However, some species react negatively to the presence of grids and require closure of the roost by the installation of a perimeter fence located several meters from the entrance (*see* photo 13 and photo page 34).

***Photo 12 :** Example of grid bars preventing access to the cavity.*

***Photo 13 :** Example of perimeter fence surrounding the access to cavities.*

Each time a roost has a specific protection put in place the design of the closure should be carefully studied beforehand to ensure the success of the operation in relation to the bats. The closure of a roost must also have the approval of the owner, and can generate conflicts with other users of the underground environment (cavers, archaeologists, geologists) if theses groups are not integrated at the earliest possible point in the process of protection.

Example of the closure of a bat roost

In the Gardon gorges, the LIFE+ Chiro Med program provided physical protection for a Greater Horseshoe Bat hibernation roost, which featured several specific constraints :

- A strong constraint in terms of the landscape : the unusual landscape and the location of the cavity on the edge of a canyon involved a major constraint in respect of the protection of the landscape (Classified Site). The installation of a conventional perimeter fence more than 5 m from the entrance would mean land clearing that was not acceptable vis-a-vis the landscape constraint.
- A constraint related to the presence of certain species : in addition to the hibernation of the Greater Horseshoe Bats, the site concerned hosted the Common Bent Wing Bat in spring and autumn transit and the Mediterranean Horseshoe Bat in the farrowing season, species which do not tolerate grids of horizontal bars (Moeschlere *et al.* 2009) at the entrance of their roosts (during gestation and rearing of the young for the Mediterranean Horseshoe bat).

To limit the impact of the physical protection on the landscape and allow the passage of the species through the closure, a study was conducted at the site in autumn 2010 to study the behaviour of the Common Bent Wing Bat on leaving the roost and there acceptance in facing perimeter fence located close to the entrance of the cave.

To do this, a first evening was devoted to the observation of normal behaviour (without protection) of the species leaving the roost (exits, numbers, duration of trips...) using a thermal camera (*see* Technical Guide No. 6 "Imaging techniques in the service of Conservation") and ultrasonic detectors.

The next day, a temporary perimeter barrier of tape (to prevent injury in case of collisions) was installed at the entrance of the roost for a period of one week (*see* photo 14). During this period, three nights of observations of the exit from the roost were organized to verify the behaviour of the Common Bent Wing Bats faced with this obstacle (duration of trips, number of collisions...) and to assess how the species adapt to the different landscape.

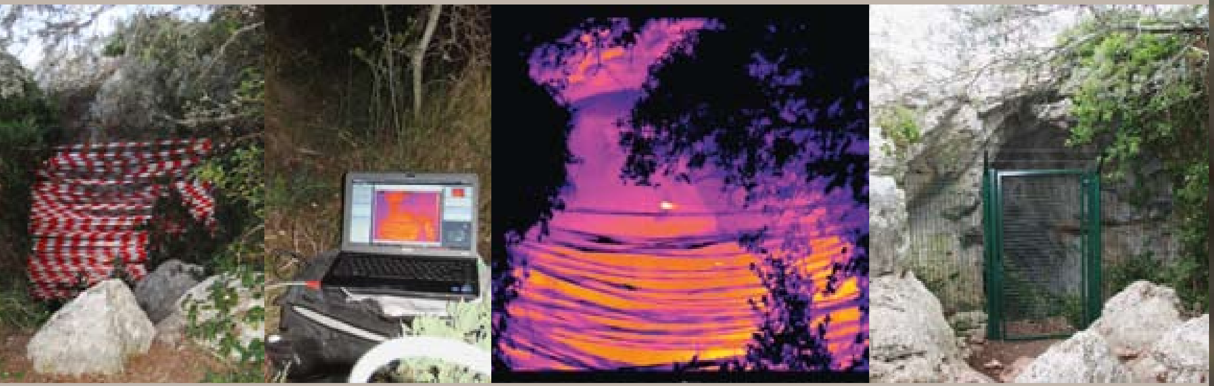


***Photo 14 :** The different stages of the action to protect the cavity.*

The findings of this study show a satisfactory adaptation by the Common Bent Wing Bat to the proposed protection with no collisions at the end of the study week. As such, the same temporary perimeter barrier tape was installed a week before carrying out the final work in autumn 2012, to allow the animals to get used to the obstacle before installing the perimeter fence.

D. Demontoux

Geoffroy's Bat.

Abiotic : in ecology, means an ecological factor independent of living beings.

Biodiversity : refers to the diversity of living things. This diversity is expressed and plays a role in all organizational levels of life : diversity of species, diversity in a species, between individuals at any given moment, ecological diversity, the associations of species in a given environment. (source : National Biodiversity Strategy 2011-2020).
Variability among living organisms of all origins : terrestrial, marine and other aquatic ecosystems among others, and the complex ecology of which they are part ; including diversity within species, between species and of ecosystems (source : Convention on Biological Diversity).
Diversity of living organisms, which is assessed by considering the diversity of species, that of genes of each species , as well as the organization and distribution of ecosystems. Maintaining biodiversity is an essential component of sustainable development. (source : vocabulary of the Environment published in the Official Journal of 12 April 2009).

Breeding Roosts : from June to September, females gather in birthing colonies and give birth to their single young of the year (from mid- June to late July). Sites occupied by these colonies are characterized by a high temperature, the absence of air flow, the absence of disturbance and abundant food nearby. The most favourable sites are roofs and attics, barns, stables, cracks in trees, warm caves...

Ecosystem : functional ecological unit formed by the biotope and biocenosis, in constant interaction. (source : vocabulary of the Environment published in the Official Journal on 4/02 /2010).

EUROATS : this agreement has the aim of protecting 36 species of bats identified in Europe, through legislation, education and conservation, as well as international cooperation between the signatory countries and other European governments. The signatories to the Eurobats Agreement committed to a common goal: the conservation of the European populations of bats.

Habitats Directive Fauna and Flora (Directive 92/43/EEC of 21 May 1992) : a regulation made by the European Union to maintain the biological diversity of the Member States by conservation of natural areas and species of fauna and flora of Community interest. The Natura 2000 network brings together these sites of community interest consisting of Special Conservation Zones defined by the Habitats Directive, and Special Protection Zones as defined by the Birds Directive (Directive 79/409/EEC of 2 April 1979). Annex II the DH list of species whose conservation requires the designation of Special Conservation Zones.

Habitat, Priority Habitat : place where the species and its immediate environment are both abiotic and biotic. (source : Dictionnaire encyclopédique de l'écologie et des Sciences de l'Environnement - François Ramade).
A natural or semi-natural habitat is an environment that meets the physical and biological conditions necessary for the existence of a species or group of animals or plants. (source : Natura 2000).
The habitat of a species is in the midst of the life of a species (breeding area, feeding zone, hunting area, etc.). It may include several natural habitats. (source : Natura 2000).
A priority natural habitat within the meaning of Directive 92/43/EEC, is a type of habitat in danger of disappearance, present in the territory of the European Member States to which the Treaty applies, the conservation of which the Community has particular responsibility for given the importance of the natural range within this territory. Types of priority natural habitat are listed in Annex I to the Directive.

Hibernation : lethargic state, due to a lowering of body temperature, wherein some mammals spend the winter.

Hibernation Roosts : bats hibernate in natural or artificial cavities, such as caves, mines, tunnels, basements, old quarries, cracks, holes in trees... These roosts offer them total darkness, absolute tranquillity, a cool stable temperature which protects them from frost, light ventilation, and humidity generally close to saturation to avoid their wings drying out.

Hygrometry : measurement of humidity. Relative Humidity, RH denoted, which is the percentage of the maximum value of humidity in the air at a specific temperature.

Hypogeous : organism or element located below the ground level.

Karst : relief particular to regions of limestone which results from the action, largely underground, of water that dissolve the calcium carbonate, resulting in the formation of caves, potholes, sinkholes, etc.).

PPE (Personal Protective Equipment) : device or material designed to be worn or held by an individual for protection against one or more hazards likely to threaten their safety or health, mainly at work.

Services rendered by ecosystems or eco-systemics : these are the direct or indirect benefits that man derives from nature; they include the provision of services (food, water, timber, fibre, etc.), regulating services (climate, floods, disease, wastes, pollination, etc.), self-maintenance services (soil formation, photosynthesis, nutrient recycling) and cultural services (recreation, aesthetic, spiritual).

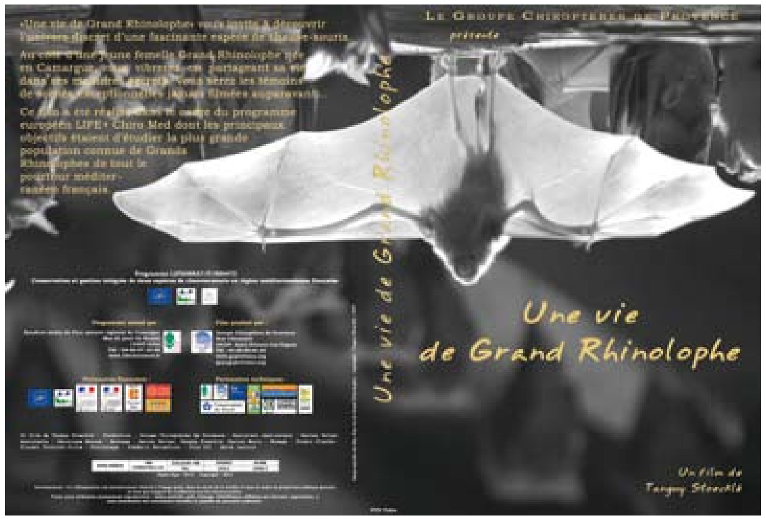
Species : basic taxonomic unit in the classification of the living world. A species consists of all individuals belonging to breeding populations who exchange freely their gene pool but, in contrast, do not breed with individuals constituting of populations of neighbouring taxa belonging to the same population. (source : Dictionnaire encyclopédique de l'écologie et des Sciences de l'Environnement - François Ramade).
Priority Species : a species of community interest at risk and the preservation of which EU has a particular responsibility for, given the importance of part of its natural range within the European territory of the Member States. Priority species of community interest are listed in Annex II of the Fauna-Flora-Habitat Directive 92/43/EEC

The Financial Instrument for the Environmen (LIFE+) : the LIFE+ program funds projects that contribute to the development and implementation of environmental policy and law. This particular program facilitates the integration of environmental concerns into other policies and, more generally, contributes to durable development.

Topography : technical representation on a plan of the form of the land with details of natural or artificial features.

Tragus : projecting appendage inside the ear.

Transit Roosts : these are shelters occupied by bats more or less temporarily in spring and autumn. They are quite varied (sheds, barns...), but their conditions are not conducive to reproduction. Their role is still unknown, they often provide a stopping point between winter and summer roosts, and house a large variety of numbers.



Between 2010 and 2014, Tanguy Stoecklé directed the film "Une Vie de Grand Rhinolophe / Life of the Greater Horseshoe Bat" under the framework of the LIFE+ Chiro Med program. This film is dedicated to the Greater Horseshoe Bat and tracks a female and her baby throughout their lives. You will see exceptional scenes never filmed before.

V. Hénoux

Greater Horseshoe Bat.

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The reports of LIFE+ Chiro Med on different actions are available on the website :
www.lifechiromed.fr

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Editions LIFE+ Chiro Med

www.lifechiromed.fr

General Coordination

Véronique Hénoux et Katia Lombardini
Parc naturel régional de Camargue (PNRC)
www.parc-camargue.fr

Editing

Thibaut Clémencet et Martin Picart
Syndicat mixte des gorges du Gardon (SMGG)
www.gorgesdugardon.fr

Véronique Hénoux
(PNRC)

Proof readers

Emmanuel Cosson ***(GCP)***

Sarah Fourasté ***(GCP)***

Graphic design and layout

Vincent Lemoine
lemoine_v@yahoo.fr

Translation

Sally Simmonds
sallymsimmo@hotmail.com

Illustrations

Cyril Girard
www.cyrilgirard.fr

Photo credits

Élodie Appessetche *(photo 3)* - ***Sophie Bernard*** *(photo 7)* - ***Jean-Michel Bompar*** *(photo 9)*
Daniel Demontoux *(photo 6c)* - ***Séverine Fabre*** *(photo 2d)* - ***Emmanuel Garnier*** *(photo 10)*
Véronique Hénoux *(photos 2g, 6d, 8g)* ***Martin Picart*** *(photos 1,4, 5,6a et b, 8d, 11, 12, 13, 14)*

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The Technical Guides by LIFE+ Chiro Med

This collection was created by the LIFE+ Chiro Med program
coordinated by the Camargue Regional Nature Park
is intended for a specialized audience.

Each guide addresses a specific theme resulting from the synthesis
and results of actions undertaken
by the European program LIFE+ Chiro Med

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Developing roosts suitable for breeding

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