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Guidelines for bat monitoring

MINISTERO DELL'AMBIENTE
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ISTITUTO NAZIONALE
PER LA FAUNA SELVATICA

Paolo Agnelli, Adriano Martinoli, Elena Patriarca, Danilo Russo,
Dino Scaravelli & Piero Genovesi
(Editors)

Guidelines for bat monitoring: methods for the study and conservation of bats in Italy

Quaderni di Conservazione della Natura
Issue 19 bis

This publication series, specifically focused on conservation problems of Italian wildlife, is the result of a co-operation between the Nature Protection Service of the Italian Ministry of the Environment and for the Protection of the Territory and the Sea and the National Wildlife Institute.

Aim of the series is to promote a wide circulation of the strategies for the wildlife preservation and management worked up by the Ministry of Environment and Territorial Protection with the scientific and technical support of the National Wildlife Institute.

The issues covered by this series range from general aspects, based on a multidisciplinary and holistic approach, to management and conservation problems at specific level.

La collana "Quaderni di Conservazione della Natura" nasce dalla collaborazione instaurata tra il Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Direzione per la Protezione della Natura e l'Istituto Nazionale per la Fauna Selvatica.

Scopo della collana è quello di divulgare le strategie di tutela e gestione del patrimonio faunistico nazionale elaborate dal Ministero con il contributo scientifico e tecnico dell'I.N.F.S.

I temi trattati spaziano da quelli di carattere generale, che seguono un approccio multidisciplinare ed il più possibile olistico, a quelli dedicati a problemi specifici di gestione o alla conservazione di singole specie.

GRUPPO ITALIANO
RICERCA CHIROTTERI

Cover: *Miniopterus schreibersii*. Photo P. Agnelli

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e della Tutela del Territorio e del Mare
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The authors are members of the Gruppo Italiano Ricerca Chirotteri (GIRC), which is part of the Italian Mammal Society (Associazione Teriologica Italiana, A.T.It.), and currently also members of the GIRC steering committee.
GIRC was officially founded in December 1999, after the formal foundation proposal made in October 1998 in Varese, during the 2nd Congress of the Associazione Teriologica Italiana.
The GIRC's premises are at the Dipartimento di Biologia Strutturale e Funzionale dell'Università degli Studi dell'Insubria di Varese. The association aims to:

A. promote the development of bat biology research in Italy, supporting and presenting studies at national and international levels to further a better understanding of bats and their ecosystems;
B. coordinate and promote initiatives to protect nature, with special reference to bats;
C. represent a reference point for public and private institutions in the fields of bat research and protection;
D. represent a reference point for international institutions for all issues concerning Italian bats;
E. coordinate and promote actions to raise public awareness on bat biology and conservation issues.

GIRC c/o Dipartimento di Biologia Strutturale e Funzionale, Università degli Studi dell'Insubria, Via Dunant, 3 - 21100 Varese - http://fauna.dipbsf.uninsubria.it/chiroptera/

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1. Introduction

P. Agnelli & A. Martinoli

Echolocating bats are very specialised mammals. In fact, they show peculiar features such as the capacity to actively fly, to "see" in complete darkness through a sophisticated echolocation system, and to survive long winters in a lethargic state in order to overcome the shortage of food and the cold climate. The extreme specialisation and particular sensitivity to disturbance during crucial phases such as hibernation and reproduction make bats one of the most vulnerable mammal groups with respect to rapid environmental changes and interaction with humans. Bats are the order of Italian mammals with the largest number of threatened species.

Fossils demonstrate that bats already existed 50 million years ago, with forms similar to those we observe nowadays. Ever since their abundance, both in terms of numbers and species richness, has varied greatly due to shifts in climate and vegetation cover. Besides such factors, nowadays a major role is played by human impact. The historical records useful to reconstruct shifts in bat abundance across Europe are scarce. Most suitable information concerns colonies in buildings or caves; data on tree-dwelling species are much rarer. However, a comparison of available historical data with the current situation reveals that bat populations have declined considerably. This trend, still in progress, has led to local extinction ever since the '50s.

Basic bat requirements are represented by the availability of suitable roosts and productive foraging areas where bats can feed upon insects. Any factor compromising these resources will profoundly affect bat survival. For instance, day roosts, including those used for hibernation or reproduction, are often destroyed by forestry (felling of trees with cavities suitable for roosting), demolition or renovation of old buildings, and alteration or occlusion of caves, quarries and abandoned mines. Unfortunately, foraging areas undergo a similar fate. Forest cover reduction, intensive coppicing and alteration of wetlands all determine a strong decline in the quality and availability of prey. Similar consequences ensue from the process of agricultural intensification, determining the progressive disappearance of traditional farmland (landscape mosaics with small cultivations interspersed with hedgerows and forest patches) replaced with intensively cultivated areas, characterised by high mechanization, pesticide and nutrient inputs and simplification of landscape structure. The so-called "landscape linear elements", i.e. riparian vegetation, hedgerows, treelines, etc., are likewise very important for bats which use them as landmarks in commuting between roosts and foraging areas. Timber remedial treatment (such as chemicals used to counter wood parasites in attics) and the spread of agricultural pesticides, which can accumulate in insect-eating bats (Clark, 1988; Shore *et al.*, 1990, 1991; Swanepoel *et al.*, 1999), represent further threats. High pollution concentrations in rivers, ponds and lakes used by foraging bats may also affect bat survival (Reinhold *et al.*, 1999). Moreover, in farmland small wetland areas often become dried up, and water courses are increasingly canalised in concrete beds. Consequently, insect prey diminishes, especially at the larval stages.

The study of bats offers many reasons of interest, in terms of taxonomy, systematics, zoogeography, physiology and ecology. In spite of the great importance of bats for Italian research and biodiversity conservation, there are still relatively few bat specialists in the country. The practical difficulties encountered in bat studies are in fact significant: bats select often inaccessible roost sites in the daytime, and are hard to observe at night. Moreover, several species are not easy to identify in the field, so that in many cases correct identification may be achieved only by well-trained, experienced specialists. It is thus understandable why bats are relatively unknown compared with other animal groups, such as birds. Italian bats are, among mammals, the least known under several aspects, including biology and distribution. Many gaps in our knowledge exist, and the overall information available is in fact limited.

The history of bat research in Italy includes some outstanding scholars. Lazzaro Spallanzani first suspected that bats find their way in the dark thanks to their hearing (Spallanzani, 1794). Senna (1892) and Gulino and Dal Piaz (1939) made important contributions with their studies and biological collections. The first comprehensive work on bats was carried out by B. Lanza, who published a monograph in the "Italian fauna" series which is still used in several respects and represented a milestone for bat research. In the last ten years, bat research in Italy has entered a new, exciting phase, and there is an ever growing number of researchers working on bat systematics, biology and distribution, following the trend characterising many European countries over the last thirty years.

It is worth mentioning the increase in species number determined by the application of innovative molecular techniques besides the "classical" morphological studies. These species include *Pipistrellus pygmaeus* (Barratt et al., 1997; Jones and Barratt, 1999) and *P. macrobullaris* (Kiefer and Veith, 2001; Spitzenberger *et al.*, 2002; 2003). Notably from the zoogeographical perspective, the first and only bat endemic to Italy was recently described – *Plecotus sardus* (Mucedda et al., 2002), unique to Sardinia. This new activity in species description is rapidly changing the faunal framework of Italy. Consequently, in the near future it will be necessary to critically re-assess all the information available on the species here presented.

Several international Directives and Agreements, ratified by Italy, have recently recognised the role played by bats as providers of ecosystem services and important biodiversity components, and the value of preserving them. The 92/43/EEC Directive, supported by corresponding funding action, has encouraged bat research, conservation and dissemination initiatives. These have included the publication of the *Iconografia dei Mammiferi d'Italia* (Spagnesi and Toso, 1999) (Iconography of Italian Mammals), in which bats play a major role, featuring outstanding colour plates and a critical review of bat systematics and ecology. Such a favourable scenario has certainly increased the number of zoologists currently working on bats. On the one hand, this is a positive fact because it will certainly ensure a growth in bat knowledge, but on the other it requires more coordination and caution in field work to avoid disturbance to maternity or hibernating colonies. In spite of its importance, bat research may become a threat to bats if the risk of excessively disturbing bats under study is underestimated. Well-trained, experienced researchers are needed, to avoid this happening and to achieve the best scientific and conservation results.

To favour the exchange of experience among researchers, on the occasion of the Second Italian Mammal Congress (1998), many Italian bat specialists founded the Italian Chiroptera Research Group (Gruppo Italiano Ricerca Chirotteri (GIRC), set up to promote bat research and conservation in Italy and encourage collaboration among zoologists, as in other European countries and especially the U.K. Details on the group's activity are given on the website http://www.pipistrelli.org/. Among the main GIRC-coordinated actions, the Roost Project led to a database of all roosts recorded in Italy. The project is designed to locate and protect key sites, detect population trends, define the current species conservation status and so lead to effective conservation. Another past project, made possible by active collaboration with GIRC members, was the so-called "Completion of basic naturalistic knowledge" (*Completamento delle Conoscenze Naturalistiche di Base*), coordinated by the Environmental Ministry and Calabria University. In that case, all literature and museum records of Italian bats (both historical and recent) were collected and used for a critical assessment of the available knowledge.

In the short history of Italian bat research, this is certainly a crucial moment for the fate of Italian bat populations. Many species are in significant decline and too little information is available. As highlighted above, there is a rejuvenated interest in this mammal group, leading to new knowledge – indispensable for bat protection. However, the study of bats may never ignore their fragility and precarious conservation status. The idea for this book, designed to provide Italian researchers with methodological guidelines, stemmed from these considerations, based on the vital importance played by bats in ecosystem functioning and biodiversity. Besides providing a comprehensive picture of legal aspects of bat protection, this monograph aims to illustrate the main research methods adopted in bat studies, providing an easy-to-use tool for technicians and specialists in planning bat surveys and monitoring activities. This volume also fulfils the requirements of D.P.R. 357/1997 (modified by D.P.R. 120/2003), according to which the *Ministero dell'Ambiente e della Tutela del territorio* has the duty to provide guidelines for bat monitoring.

2. Bat species occurring in Italy

Paolo Agnelli, Elena Patriarca & Adriano Martinoli

2.1 Introduction

This section summarises the information available on all species either certainly occurring in Italy or whose presence is known from old sightings (i.e. current presence requires confirmation). Each species description includes main body measurements (Table 2.1), distribution, ecology, reproductive behaviour and considerations on conservation status.

Table 2.1 – Legend for body measurements abbreviations (values from both adults and sub-adults after Lanza and Agnelli, 1999)

Abbreviation	Meaning
WS	Wing span, i.e. distance between wing tips when wings are extended, moderately stretched
FAL	Forearm length
DB	Maximum diameter of bulla tympani
CM^3	Maxillary tooth row (from posterior edge of third upper molar to anterior edge of base of upper (homo-lateral) canine)
CBL	Condylobasal length (distance between anterior margin of premaxillary bone and posterior extremity of occipital condyles)
TL	Tail length
LD-V	Length of digit V (metacarpus + phalanxes)
LD-IV-P1	Length of first phalanx of digit IV
LD-IV-P2	Length of second phalanx of digit IV
EH	Ear height, from ear tip to base (ear should be moderately stretched to adjust for possible postural bending)
THL	Thumb length, from thumb tip (without claw) to joint between basal phalanx and metacarpal bone (best noticed when thumb is bent)
TrL	Tragus length, measured along the outer side, as the distance from base to tip
BL	Body length, from tip of muzzle to anus
W	Weight (body mass)

The species conservation status is assessed according to I.U.C.N. categories (Hutson *et al.*, 2001) with reference to the global range, and based upon criteria set in 1994 (I.U.C.N., 1994). In all, the conservation status of 16 species is regarded as not giving concern. Of the remaining, one has not been assessed, six species fall into the category "Lower risk-near threatened", and eight are "Vulnerable". The last category corresponds to a high risk of extinction in the middle- or long-term, and all eight vulnerable species are characterised as A2c (criterion A, sub-criterion 2c). According to I.U.C.N. (1994), this code identifies declining populations which, based on range contraction and/or habitat alteration, are expected to undergo (or suspected to have undergone) a population decline of at least 20% in the next (last) 10 years. If the process has occupied a longer period, the time considered corresponds to the survival of the next 2-3 generations (generation time being defined as the average age of all mature subjects, i.e. capable of reproducing, in the population).

It is worth highlighting how recent advances in taxonomy, leading to description of new species, will soon require a revision of those taxa erroneously regarded as made up of one species only. For updates on the I.U.C.N. Red List, see the website http://www.iucn.org/. Due to the lack of sufficient population data, and the impossibility of making comparisons across different areas of Italy, we decided to avoid defining the species conservation status for Italy. For the same reason, we have avoided referring to previously published assessments.

2.2 **The species occurring in Italy**

In his review produced for the "Species checklist of the Italian fauna" series (Amori *et al.*, 1993), B. Lanza mentioned 30 bat species occurring in Italy, belonging to three families and 11 genera. This checklist has been updated (Amori *et al.*, 1999) by excluding *Myotis dasycneme*, regarded as accidentally occurring in the country (the only record concerns a bat captured in Trento in 1881). Because of the lack of reliable, recent (i.e. obtained after 1980) presence data, in the present monograph we also defined as "unconfirmed" the presence of *Rhinolophus blasii* in Italy.

In the above mentioned checklists some taxa recently described and accepted as valid species were also missing. In 1999, *Pipistrellus* *pygmaeus* (Jones and Barratt, 1999) was definitely accepted as a valid species. In a former paper, it had been separated from *P. pipistrellus* and proposed as a new species (Barratt *et al.*, 1997). Russo and Jones (2000) demonstrated that the species also occurs in Italy.

Recent studies (Kiefer and Veith, 2001; Spitzenberger *et al.*, 2002; 2003 Mucedda *et al.*, 2002; Chirichella *et al.*, 2003; Kiefer and von Helversen, 2004; Trizio *et al.*, 2005) have demonstrated the existence of two new *Plecotus* species, also present in Italy: *P. macrobullaris* in Friuli Venezia Giulia, Trentino, Veneto, Lombardy, Piedmont and Liguria, and *P. sardus* in Sardinia. For this island the taxonomy of mouse-eared bats has also been revised (Castella *et al.*, 2000; Ruedi and Arlettaz, in press), adding a new species, *Myotis punicus,* also found in north Africa and Corsica. A bat from the taxon *Myotis aurascens*, proposed as a good species by Benda and Tsytsulina (2000), was also reported in the Trentino region. However, recent molecular work by Mayer and von Helversen (2001) showed that *M. aurascens* does not stand out from the "*mystacinus*" group sufficiently to be regarded as a separate species.

To complete this overview of Italian bats, two further taxonomic issues deserve mention. Savi's bat, formerly regarded as a *Pipistrellus* species (*P. savii*), in fact shows characteristics which are intermediate between that genus and *Eptesicus*; following a proposal made in 1986, it is now generally classified as a separate genus – *Hypsugo*. The characteristics considered include penis morphology and features of teeth, skull and pelvic skeleton (Horacek and Hanak, 1986). However, some authors still regard it as a *Pipistrellus* species, so confusion is possible. Another case is offered by *Eptesicus nilssoni*. Tiunov (1989, 1997) found significant differences in the uro-genital anatomy of *E. serotinus and E. nilssonii*, concluding that the latter should be classified as a separate genus – *Amblyotus*. Although Lanza and Agnelli (1999) agreed with this taxonomical approach, molecular work by Mayer and Helversen (2001) highlighted a close genetic relatedness between the two species. Following these authors and Lanza (*in verbis*), in this monograph we ascribed the two species to the same genus.

Summing up, the Italian bat fauna currently includes 35 species, excluding *M. dasycneme*, whose presence should be regarded as accidental. The recent activity in the description of new species is likely to change the situation so far described. In the near future it will be as well to consider that the information provided in the descriptions below might well be in need of revision or update.

2.3 **Species descriptions**

A description is also provided for *M. dasycneme*, although it is accidental, and *R. blasii*, unrecorded in recent times (i.e. since 1980). Geographical range maps are presented only for the 34 species for which recent records (since 1980) are available. Records considered for map preparation come from literature, museum collections and unpublished information. Special thanks are due to several GIRC members for generously providing much of the latter. In order to present only fully reliable data, the quality of each record was assessed critically. The data were then classified according to the region they referred to. For some species, including both those of recent taxonomic revision and those difficult to identify in the field, we followed special procedures, i.e.:

- *Myotis myotis* and *M. blythii* have been told apart with a relatively high level of confidence only since the second half of the '90s. Hence we used recent capture data, museum specimens only when re-examined recently, and literature records only when presenting sufficient information for correct species identification.
- Telling apart female *Myotis mystacinus* from female *M. brandtii* is still problematic. Most of the rare specimens of *M. brandtii* held in museum collections were re-examined by P. Agnelli and B. Lanza and often turned out to be *M. mystacinus*.
- Several of the numerous *P. pipistrellus* records obtained before 1999 might in fact concern the cryptic *P. pygmaeus*. We give two separate maps, one for *P. pygmaeus* (records dating 1999-2006), the other for *Pipistrellus pipistrellus s.l.* (*P. pipistrellus/P. pygmaeus*, data collected 1980-2006).
- Satisfactory field discrimination methods to tell apart female *P. auritus* and *P. austriacus* represent a relatively recent advance. When mapping species presence, we only used recent data, museum specimens when re-examined recently, and literature records only when presenting sufficient information for correct species identification. Moreover, the recent discovery of further *Plecotus* species (in Sardinia and northern Italy) questions the validity of some *Plecotus auritus* or *P. austriacus* records, potentially corresponding to *P. macrobullaris* in the north and *P. sardus* in Sardinia.

The use of bat detectors only makes it possible to identify a subset of the species occurring in Italy based on recordings from free-flying bats. This approach is still relatively recent and rapidly advancing. Regrettably, no fully standardised procedure is available to date, and inexperienced operators, incorrect procedures or both may have led to unreliable presence data. Therefore, our approach here was especially conservative, and we did not include most bat detector data in our analysis. Few exceptions were made for species easier to identify from their echolocation calls, as long as data were obtained by advanced technology (time expansion) and methods (sound analysis). Many papers lacked the methodological details needed to assess data quality – in fact in some cases no distinction was made between bat detector and capture records. For some regions, especially in the south, records were fewer than elsewhere in Italy. This is not due to intrinsic faunal paucity but rather the consequence of there being fewer bat workers in these areas. One of our aims was to highlight such gaps to encourage efforts to improve the available knowledge.

2.3.1 *Species recorded in Italy before 1980*

RHINOLOPHUS BLASII Peters, 1866

Blasius' Horseshoe Bat

Family

Rhinolophids *(Rhinolophidae)*.

Measurements

BL (44) 46-54 (56) mm; TL (20) 23-30 mm; FAL (42) 45-49 (50) mm; LD-IV-P1 (6,8) 8-9 (9.6) mm; LD-IV-P214-15 (19) mm; EH (14) 16-21 mm; WS 270-310 mm; CBL (15.8) 16.4-17 (17.8) mm; CM^3 6.4-7 mm; W 10-16.5 g.

Geographical range

African-tropical-Mediterranean taxon, recorded from SE Europe, through SW Asia, east to Pakistan, as well as in NE and central-southern Africa. Few Italian historical records (1850-1920), of unknown reliability for some regions. The only reliable records concern the north-east of Italy, the most recent dating back to 1927 (Val Rosandra, Trieste).

Migration

Regarded as sedentary. Maximum movement recorded between winter and summer roosts 10 km.

Habitats

Recorded from sea level up to 1,000 m a.s.l. Foraging habitats with woody vegetation (trees or shrubs). Day roosts, including reproductive sites and hibernacula, represented by natural or artificial underground habitats.

Diet

Based on Lepidoptera, Coleoptera and other insects.

Reproductive behaviour

Nurseries numbering up to 300 females. Gives birth in June-July, at some sites in August. One young.

Relationships with other bat species

May roost together with *Rhinolophus euryale* at maternity sites.

Conservation status

LR: nt (Hutson *et al.*, 2001). At lower risk, near threatened. Probably the rarest European rhinolophid. Negative population trends observed in Romania.

MYOTIS DASYCNEME (Boie, 1825)

Pond bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 57-68 (73) mm; TL (39) 46-51 (53) mm; FAL (41) 44-48.5; (49.2) mm; EH (15) 16-19 mm; WS 200-320 mm; CBL 15.7-17.4 mm; CM^3; 6-6.5 mm; W 14-20 (23) g.

Geographical range

Siberian-central European taxon, found from NE France (western range limit) through central Europe (northern limit in S Sweden and Estonia) to central Siberia. Outside this range, scattered records, including one in Manchuria and another in Italy. The latter was a female caught in 1881 in Trento and conserved in the Florence Museum “La Specola” bat collection.

Migration

Facultative migrant, longest movement recorded 350 km.

Habitats

Recorded from sea level up to 1,000 m a.s.l. Prefers landscapes including large areas of wetland (especially still waters) and forest. Wetland is the typical foraging habitat. Summer roosts in buildings (especially roofs and attics), hollow trees and bat boxes. Hibernates in underground habitats or buildings (cellars); some records concerning hollow trees also available.

Diet

Preys on small Diptera (especially chironomids), Lepidoptera and Coleoptera.

Reproductive behaviour

Mating from beginning of autumn to spring. In Denmark and Holland, maternity colonies number from a few to 500 females, and sometimes include males too. Parturitions in June: one young, exceptionally two. Female sexual maturity in the second year of life. Maximum lifespan recorded: 20 years

Relationships with other bat species

Summer colonies mixed with *Vespertilio murinus*, *Pipistrellus nathusii*, *Nyctalus noctula* and *Myotis daubentonii*.

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable).

One of the rarest European bats, the largest populations recorded in Denmark and Holland. Slight positive population trends observed in the last decades. In Italy most probably recorded as vagrant.

2.3.2 *Species recorded in Italy in 1980-2006*

RHINOLOPHUS EURYALE Blasius, 1853

Mediterranean horseshoe bat

Family

Rhinolophids *(Rhinolophidae)*.

Measurements

BL 43-58 mm; TL (18) 22-26 (30) mm; FAL (43) 45-51 (54.9) mm; LD-IV-P1 6-8,5 mm; LD-IV-P2 (15.9) 18-19 (20.5) mm; EH 18-24 mm; WS 290-320 mm; CBL (15.4) 16-17.8 mm; CM^3 6.2-6.4 (6.6) mm; W (6) 8-17.5 g

Figure 2.1 - Presence of Mediterranean horseshoe bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence in some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area)

Geographical range

Turanian-European-Mediterranean species, found in S Europe, SW Asia (from Near East to Turkmenistan and Iran) and NW Africa. Seems to be absent from the northernmost Italian regions (Figure 2.1).

Migration

Regarded as sedentary, longest movement documented is 134 km.

Habitats

Recorded from sea level up to ca 1,000 m a.s.l.; prefers low altitudes. Thermophilous, prefers Mediterranean habitats characterised by karstic processes and abundant (broadleaved) tree or shrub cover. Forages within or near woodlands, both on the wing and by perch hunting. Summer day roosts, including maternity ones, in natural or artificial underground habitats, rarely in buildings.

Diet

Based on Lepidoptera and other insects

Reproductive behaviour

Mating from the end of July, sometimes protracted into winter.

Maternity colonies of 50-400 females, often frequented by males. Births from mid-June to mid-July: one young.

Relationships with other bat species

In summer, roosts may be shared with *Rhinolophus ferrumequinum, R. mehelyi, R. blasii, Myotis myotis, M. emarginatus, M. capaccinii* and *Miniopterus schreibersii*.

Conservation status

VU: A2c (Hutson *et al.*, 2001).

Threatened with extinction (vulnerable).

Strong decline reported for northern regions (France, Switzerland, Slovakia) which may have led to local extinction. In France, a 70% estimated population decline occurred between 1940 and 1980.

Regarded as widespread and not threatened in Spain, but in Portugal, where few colonies are known, is considered highly threatened. Lanza (1959) defined the species as frequent in Italy, especially in central and southern Italy.

RHINOLOPHUS FERRUMEQUINUM (Schreber, 1774)

Greater horseshoe bat

Family

Rhinolophids
(Rhinolophidae).

Measurements

BL (50) 56-71 mm; TL (30) 35-43 mm; FAL (50) 53-61 mm; EH 20-26 mm; WS 330-400 mm; CBL (19) 20-22 mm; CM^3 8-9.5 mm; W 17-34 g.

Geographical range

Central Asian-European-Mediterranean species, found in central Europe (up to S England), most of the Mediterranean Basin, and east through the Himalayan regions to China, Korea and Japan. Recorded in all Italian regions (Figure 2.2).

Figure 2.2 - Presence of greater horseshoe bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006.

Migration

Sedentary. Distance between summer roosts and hibernacula 15-60 km, rarely longer. Longest movement recorded in a bat's lifetime: 320 km.

Habitats

Found from sea level up to 2,000 m a.s.l. Prefers areas below 800 m a.s.l characterised by habitat mosaics such as pastures interspersed with hedgerows and broadleaved woodland, as well as wetland.

Day roosts, including maternity roosts and hibernacula, represented by underground sites or buildings (large attics, cellars); rarely in tree cavities.

Diet

Mainly based on large insects captured either on the wing or often by perch hunting. Prey generally caught when flying at low height, more rarely taken from ground. Commonest prey includes Lepidoptera *(Noctuidae, Nymphalidae, Hepialidae, Sphingidae, Geometridae* and *Lasiocampidae)* and Coleoptera *(Scarabeidae, Geotrupidae, Silphidae* and *Carabidae)*. Cockchafers are seasonally important in the diet.

Reproductive behaviour

Mating occurs mainly in autumn, more rarely during hibernation, and possibly as late as the beginning of spring.

Maternity colonies mainly ranging from a few dozens up to 200 adults (females along with some males in their second or third year of life). Births from mid-June to the beginning of August: normally one young. Females do not give birth every year and rarely before they are four years old.

Males sexually mature from the end of second year of life, mainly when three years old. Maximum lifespan recorded: 30 years.

Relationships with other bat species

Occasionally preyed upon by raptors (Strigiformes, Accipitriformes). May associate in roosts with other species, i.e. *Rhinolophus euryale, R. mehelyi, Myotis emarginatus, Miniopterus schreibersii.*

Conservation status

LR: nt (Hutson *et al.*, 2001). Lower risk, near threatened.

Outside Italy, there have been cases of local extinction (part of England, Holland, Israel). Population decline observed in Austria, Belgium, Germany, Bulgaria, France and Switzerland. In the U.K., a general decline was observed in the ’60s and ’80s, but currently population size seems stable. In 1939, Gulino and Dal Piaz wrote that “this is a common species, widespread in the whole Italian territory” and that “the species is easy to observe, often in large numbers”. Data currently available are not sufficient to reveal population trends in the whole country, but investigations carried out in some regions show a considerable decline.

RHINOLOPHUS HIPPOSIDEROS (Bechstein, 1800)

Lesser horseshoe bat

Family

Rhinolophids *(Rhinolophidae)*.

Measurements

BL 35-45 (50); TL (18) 21-23 (33) mm; FAL (34) 37-42,5 mm; EH (13) 15-19 mm; WS 192-254 mm; CBL 13-15.2 mm; CM^3 5-5.9 mm; W (3) 6-9 (10) g.

Figure 2.3 - Presence of lesser horseshoe bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Turanian-European-Mediterranean taxon, found in central and S Europe (north up to Ireland and England), central-southern Asia (east to Kashmir), and N and NE Africa.

Recorded in all regions of Italy (Figure 2.3).

Migration

Sedentary. Summer and winter roosts often 5-10 km apart. Longest movement documented 153 km.

Habitats

Recorded from sea level up to 2,000 m a.s.l. Hunts in broadleaved forest or mosaic landscapes including forest, open areas and wetland. Day roosts, including maternity roosts and hibernacula, are represented by underground habitats or – especially for reproduction – buildings.

Diet

Mainly made up of small insects (Diptera, Lepidoptera and Neuroptera) and spiders. Nematocera dipterans especially important, including many wetland species. Prey caught on the wing, generally up to 5 metres above ground, or taken from substrate (foliage or ground). Perch hunting also documented – especially during reproduction.

Reproductive behaviour

Mating is thought to occur mainly in autumn, but also observed in winter. Maternity colonies generally of 10-100 adult females (occasionally made up of several hundred females) also joined by fewer male juveniles. Births in June-July: one young.

Sexual maturity reached by both sexes in 1-2 years. Maximum lifespan: 21 years.

Relationships with other bat species

Occasional predation by owls. Often shares day roosts, including maternity roosts and hibernacula, with other bats *(Rhinolophus ferrumequinum, Myotis myotis, M. emarginatus)* but never mixes with them in clusters.

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable).

Population decline observed in the last 50 years in several European countries (England, Belgium, Luxemburg, Germany, Poland, France and Switzerland); local extinction also reported (Holland). In Italy, Lanza (1959) described the species as “widespread”. Current information available on a regional scale for some areas shows a range contraction in the last decades.

RHINOLOPHUS MEHELYI Matschie, 1901

Mehely’s horseshoe bat

Family

Rhinolophids *(Rhinolophidae)*.

Measurements

BL (49) 55-64 mm; TL (21) 23-29 (32) mm; FAL (46) 49-54 (55) mm; LD-IV-P1 7.0-8.5 mm; ; LD-IV-P2 17.2-19.8 mm; EH (18) 20-23 (24) mm; WS 310-340 mm; CBL (16.1) 16.5-17.5 (18.6) mm; CM^3 (6.2) 6.7-7.4 mm; W 10-18 g.

Figure 2.4 - Presence of Mehely’s horseshoe bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions (especially in the south) is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Mediterranean taxon, found in S Europe, Africa north of Sahara and SW Asia (east to W Iran).

In Italy recorded only in Sardinia (the only region where large numbers are found) and Sicily, where only occasional sightings awaiting confirmation are reported (Figure 2.4).

Migration

Probably sedentary; longest movement documented 94 km.

Habitats

Found from sea level up to 1,200 m a.s.l. Prefers warm areas below 500 m a.s.l. Hunts in woody vegetation (woodland, scrubland).

Day roosts, including maternity roosts and hibernacula, are represented by underground sites

Diet

Includes moths and other insects caught on the wing.

Reproductive behaviour

Little information is available on mating time. According to some authors mating occurs in spring. Births in June: one young.

Sexual maturity reached at of 1-3 years of age in females, 2-3 in males.

Maximum life span recorded: 12 years.

Relationships with other bat species

In colonies, may mix with *Myotis blythii*, *M. myotis*, *M. capaccinii*, *Miniopterus schreibersii* and *Rhinolophus euryale*.

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable). Declining in several countries. Close to extinction in France, population has decreased in the Iberian Peninsula, where however it is still relatively more abundant.

MYOTIS BECHSTEINII (Kuhl, 1817)

Bechstein's bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 45-55 mm; TL (30) 35-45 (47) mm; FAL 39-45 (47) mm; EH (21) 24-26 mm; TrL 10-12 mm; WS 250-290 mm; CBL (16.1) 16-17.4 mm; CM^3 (6.2) 6.6-7.4 mm; W 7-13.6 g.

Geographical range

Southern and central-European taxon. Recorded in all Europe, the northern limits being represented by S Sweden and Great Britain, Anatolia, Caucasus and Iran. The rare records available for Italy suggest that the species is present in all regions, possibly with the exception of Sardinia (Figure 2.5).

Figure 2.5 - Presence of Bechstein's bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Probably sedentary. Longest move documented 53.5 km.

Habitats

From sea level up to 1,800 m a.s.l., strictly associated with forests, prefers mature broadleaved (oak or beech) forests. Some records in urban parks. Forages within forest or along its edges. Summer day roosts in hollow trees; alternatively, may use bat boxes or rarely buildings.

Hibernates in very wet underground habitats, sometimes in tree cavities or lower parts of buildings.

Diet

Mainly based on Lepidoptera, Diptera and Coleoptera, also non-volant arthropods gleaned either from foliage or ground.

Reproductive behaviour

Mating from autumn to spring. Maternity colonies of 5-30 females. In spring-summer males roost separately from females. Births in June-July: one young, exceptionally two.

Maximum lifespan ascertained: 21 years.

Relationships with other bat species

Occasionally preyed upon by owls. In summer, may cluster together with *Myotis nattereri*.

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable).

Regarded as very rare throughout its range, except in optimal habitats. Bone deposits dating back to ca 3,000 years ago, found in Great Britain, show that the species was once much commoner than today.

MYOTIS BLYTHII (Tomes, 1857)

Lesser mouse-eared bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (54) 58-70 (76) mm; TL (45) 54-60 (73) mm; FAL (50.5) 52-59 (63.5) mm; EH (20) 21-23 (26) mm; TrL 9.5-13 mm; WS 350-408 mm; CBL (19.3) 20-22 mm; CM^3 8-9.7 mm; W 15-28 g.

Figure 2.6 - Presence of lesser mouse-eared bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Central Asian-European species, found in S Europe, the southernmost regions of central Europe, part of central Asia and eastwards to the Himalayan chain, part of Mongolia and China. Present in all Italian regions except, almost certainly, Sardinia (Figure 2.6).

Migration

Generally regarded as sedentary – but a 488-km movement is reported in the literature.

Habitats

In Europe, from sea level to ca 1,000 m a.s.l. Foraging occurs in grassy habitats: steppes, meadows (especially with tall grass), pastures, etc.

Maternity colonies either in buildings or relatively warm underground habitats. Hibernates in underground habitats.

Diet

Based on insects gleaned from tall grass, mainly orthopterans (Tettigoniidae). Further significant diet components are larval Lepidoptera and melolonthid beetles.

Reproductive behaviour

Mating in autumn, and perhaps during hibernation. Maternity colonies from few dozen to several thousand bats. Births from the end of May to all June: one young.

Maximum lifespan ascertained: 30 years.

Relationships with other bat species

Occasionally preyed upon by owls.

Often mixes with *Myotis myotis* and *Miniopterus schreibersii* at maternity roosts, sometimes also associates with rhinolophids.

Diet quite distinct from the sibling *M. myotis*, thanks to different foraging micro-habitat selection.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern). Population declines recorded in various European countries and central Asia suggest recent range contraction.

Data from single colonies in Europe all show strongly negative trends. In Romania, a maternity colony numbering 4-5,000 bats in 1974 dropped to 150-200 bats in 1979. On the brink of extinction in Israel. The very scarce data available for Italy do not make it possible to assess the species conservation status. Single cases relative to NW Italy maternity colonies monitored over time (where *M. blythii* associates with *M. myotis*) show a concerning decline.

MYOTIS BRANDTII (Eversmann, 1845)

Brandt's bat

Family

Vespertilionids *(Vespertilionidae)*.

Figure 2.7. - Presence of Brandt's bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Taxonomy

Until 1970 this taxon was regarded as a subspecies of *mystacinus*.

BL 45-55 mm; TL (30) 35-45 (47) mm; FAL 39-45 (47) mm; EH (21) 24-26 mm; TrL 10-12 mm; WS 250-290 mm; CBL (16.1) 16-17.4 mm; CM^3 (6.2) 6.6-7.4 mm; W 7-13.6 g.

Measurements

BL 39-51 mm; TL 32-44 mm; FAL 31-39.2 mm; EH (12) 13-15 (17) mm; WS 190-240 mm; CBL 13-14.4 mm; CM^3 5.7-5.9 mm; W 4-7 (9.5) g.

Geographical range

Asian-European taxon, found in most of Eurasia, from the western range limit represented by Great Britain and eastern France east to Korea and Japan. The species distribution in Italy is poorly known, partly due to the difficulty of telling this species apart from the sibling *M. mystacinus* in the field. The only recent records for this species, relying upon species identification based on morphological features, concern the Abruzzo, Lazio and Molise National Park, central Italy (Issartel, 2001; D. Russo, *pers. com.*) (Figure 2.7).

Migration

Sedentary or occasionally migrating species. Exceptionally long movement of 618 km recorded.

Habitats

Found from sea level to 1,800 m a.s.l. Forages in forest, scrublands, wetland.

Summer roosts in buildings, tree cavities and bat boxes.

Hibernates in natural or artificial underground habitats, more rarely in cellars.

Diet

Mainly based upon dipterans, Lepidoptera being secondary prey. Further frequent food items are arachnids and neuropterans.

Reproductive behaviour

Mating from autumn to spring. Maternity colonies made up of 20-60 females (males roost separately at this time), sometimes up to hundreds of bats. Births in June-July: one young, exceptionally two.

Females probably sexually mature from their second year of life.

Maximum lifespan recorded: 41 years.

Relationships with other bat species

There are reports on maternity colonies mixed with *Pipistrellus nathusii* and *P. pipistrellus vel pygmaeus.*

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Widespread and common in northern Europe, the species is probably rare and patchily distributed in central and southern Europe.

MYOTIS CAPACCINII (Bonaparte, 1837)

Long-fingered bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (43) 47-53 (54) mm; TL (34) 35-38 (42) mm; FAL (37) 39-44 mm; EH 14-16 mm; TrL 6.5-7.5 mm; WS 230-260 mm; CBL 12.9-15 mm; CM^3 5.4-6 mm; W 6-15 g.

Geographical range

Central Asian-Mediterranean species, found in Mediterranean areas of Europe N Africa and, in SW Asia, east to Iran and Uzbekistan. Recorded in most Italian regions (Figure 2.8)

Figure 2.8 - Presence of long-fingered bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Mainly sedentary or short-distance (40-50 km) migrant.

Habitats

In Italy it is found from sea level up to 825 m a.s.l.

Dwells in woody vegetation associated with woodland, the latter its preferred foraging habitat, almost exclusively in Mediterranean contexts (thermophilous) characterised by karstic phenomena (cave-dweller).

In France, species decline was associated with the alteration of rivers and riparian vegetation. Roosts in natural or artificial underground habitats, more rarely in underground sectors of buildings.

Diet

Mainly based on Diptera, Neuroptera and Tricoptera. Recent work showed that it may also prey upon water larvae of dipterans and small fish.

Reproductive behaviour

Maternity colonies of 100-1,000 females – in Albania a nursery numbered ca 10,000 females. Gives birth in May-June: one young, exceptionally two.

Relationships with other bat species

Studies carried out in France, where the species is declining due to habitat alteration, showed it tends to be replaced by *Myotis daubentonii*. May mix in colonies together with *Rhinolophus ferrumequinum*, *R. mehelyi*, *R. euryale*, *Myotis myotis*, *M. blythii*, *M. daubentonii* and *Miniopterus schreibersii* (the latter seems to represent the most typical association).

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable). The species is currently regarded as very rare and in serious decline, at least in its northern range. Only one maternity roost known for France, eight in Spain (a further five disappeared recently). In Switzerland it is officially regarded as extinct, but recent findings in Italy, close to the Swiss border, leave hope it still survives in that country.

Defined as "infrequent in Italy, especially in the north, but not rare in the south" in 1939 by Gulino and Dal Piaz – a judgement also confirmed by B. Lanza in 1959. Especially in relation with the central geographical position occupied by Italy within the species' range, a check of *M. capaccinii's* conservation status in the country is most urgent.

MYOTIS DAUBENTONII (Kuhl, 1817)

Daubenton's bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (40) 45-55 (60) mm; TL (27) 31-44 (48) mm; FAL 33-41 (42) mm; EH (11) 13-15 mm; TrL 6.5-7.5 mm; WS 240-275 mm; CBL 12.8-14.6 mm; CM^3 5-5.7 mm; W (4) 7-10 (17) g.

Geographical range

Asian-European species, found in all European countries and, in Asia, east to Japan. Latitudinal limits are represented by 60°N and 45°N (western sector of range) and 25°N (eastern). Present in most Italian regions (Figure 2.9).

Figure 2.9 - Presence of Daubenton's bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Distances covered between winter and summer quarters generally less than 100 km, but movements of 257 km and 304 km are also documented.

Habitats

In Italy, found from sea level to over 1,500 m a.s.l.

Originally a forest bat, prefers landscapes including forest and wetland, the latter being the typical foraging habitat.

Maternity roosts in hollow trees, bat boxes, buildings – often close to water (bridges, docks), underground habitats. Single bats found in nests of sand martin (*Riparia riparia*) or among rocks on cave floors.

Hibernates in underground habitats, pits and cellars, in all cases in very wet conditions.

Diet

Mainly based on aquatic dipterans. Especially chironomids (adult insects as well as pupae), occasionally young fish.

Reproductive behaviour

Mating from autumn to the beginning of spring. Maternity colonies made up of 20-50 females (but occasionally several hundred bats), sometimes also frequented by adult males – more often these form small separate groups in this period.

Births in June-July: generally one young, exceptionally two. Males are sexually mature when 15 months years old, females mainly at two years of age (rarely one). Maximum lifespan ascertained: 28 years.

Relationships with other bat species

Occasionally preyed upon by owls.

May share roosts with: *Rhinolophus euryale*, *Myotis nattereri*, *Pipistrellus* spp., *Plecotus auritus*, *Nyctalus* spp.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Population size records for central and N Europe, where *M. daubentonii* is quite common, show either stable or increasing colony sizes (but some nurseries have declined). It is unclear whether the increase is real or due to concentration of bats following loss of suitable roosts.

MYOTIS EMARGINATUS (Geoffroy, 1806)

Geoffroy's bat

Family

Vespertilionids *(Vespertilionidae).*

Measurements

BL 41-54 (58) mm; TL (34) 38-46 (48) mm; FAL 36-41 (43.5) mm; EH (14) 16-17 mm; TrL 8-10 mm; WS 220-250 mm; CBL 14-16 mm; CM^3 6-6.8 mm; W (5.9) 7-15 g.

Figure 2.10 - Presence of Geoffroy's bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Turanian–European-Mediterranean species, extending to Arabian peninsula. Found in S and central Europe (northwards to the latitude 52°N), SW and central Asia and N Africa. Most Italian regions are included in the range (Figure 2.10).

Migration

Mainly sedentary, longest movement documented 105 km.

Habitats

From sea level to ca 1,800 m a.s.l. Favours low or intermediate altitudes and mild climates. Main foraging areas in forest interspersed with wetland, but may also dwell in open areas, urban parks and gardens.

Thermophilous summer roosting habits; especially in the northern sector of range roosts in warm attics – in the south is often a cave-roosting species. Maternity roosts occasionally in tree cavities. Hibernates in underground habitats.

Diet

Mainly based on diurnal dipterans (flies) and spiders gleaned from vegetation, stable walls or ground.

May also hunt on the wing, mostly within 5 m above ground, occasionally over water or near streetlamps, where it feeds on several prey types (Neuroptera, Diptera, Hymenoptera, Lepidoptera, Coleoptera).

Reproductive behaviour

Mating in autumn, possibly also in winter. Maternity colonies of 20-200 females or more, with records of 1,000 females (males roost separately at this time). Births in June-July: one young, exceptionally two.

Females may mate in their first year of life, but it is unclear whether this actually leads to pregnancy.

Maximum lifespan recorded: 18 years.

Relationships with other bat species

May form maternity colonies in association with rhinolophids.

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable).

The species is rare and shows a discontinuous presence especially in the northern range, where population declines have been noted.

MYOTIS MYOTIS (Borkhausen, 1797)

Greater mouse-eared bat

Family

Vespertilionids
(Vespertilionidae).

Taxonomy

Recent work has shown that all bats from northern Africa (Morocco, Algeria, Tunisia), formerly regarded as *M. Myotis*, in fact belong to a separate species, and the same would hold for those from Corsica and Sardinia (Castella *et al.*, 2000; Ruedi e Arlettaz, *in press*).

Figure 2.11 - Presence of greater mouse-eared bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area). Note, however, that Sardinian records should be attributed to the newly described species *Myotis punicus*, *M. myotis* being in fact absent from the island.

Measurements

BL (65) 67-79 (84) mm; TL (40) 45-61 mm; FAL (54) 58-66 (68) mm; EH (24) 26-31 mm; TrL 11-13 mm; WS 350- 450 mm; CBL (21.5) 22-24.8 mm; CM^3 9.8-10.6 mm; W (16) 28-40.7 g.

Geographical range

European-Mediterranean species, its range includes: central, E and S Europe (up to S England), most Mediterranean islands, Near East, possibly east to W Turkistan. All Italian regions are included in the range, but Sardinian populations most probably belong to the recently described *M. punicus* (see “Taxonomy”). (Figure 2.11).

Migration

Occasional migrant: there are cases of movements between winter and summer roosts of about 50 km (few above 100 km), but also movements of over 100 km (in one case over 400 km). Longest movements are thought to be dispersal flights.

Habitats

Mainly found from sea level up to 700 m a.s.l., but occasionally recorded up to 2,200 m (this record probably refers to a migrant bat). At the Abruzzo, Lazio and Molise National Park (central Italy), presence recorded up to ca 1,700 m a.s.l. (D. Russo, *pers. com.*).

Forages in forest ecosystems with rare undergrowth and open habitats (pastures and freshly cut meadows), when close to forest and offering enough food.

Maternity roosts in buildings or underground habitats. Single bats in tree cavities or bat boxes. Hibernates at underground sites.

Diet

Mainly based on non-volant arthropods gleaned from bare ground, mainly Carabidae, and secondarily larval Lepidoptera, Gryllotalpidae, Gryllidae, Melolonthinae, Tettigoniidae and Staphylinidae.

Reproductive behaviour

Mating in late summer-autumn, more rarely winter. Maternity colonies range from a few dozen to hundreds, sometimes thousands of females. Births in May-June: normally one young, exceptionally two. Males reach sexual maturity at the age of 15 months, females even earlier yet few actually reproduce in their first year of life.

Maximum lifespan: 22 years.

Relationships with other bat species

Occasionally preyed upon by owls.

Mixes frequently at maternity sites with *Myotis blythii*, *M. capaccinii*, *Miniopterus schreibersii* and occasionally rhinolophids. In spite of its very close resemblance to its sibling *Myotis blythii*, this species has a markedly different diet, corresponding to separate foraging micro-habitat preferences.

Conservation status

LR: nt (Hutson *et al.*, 2001). Lower risk, near threatened. Relative to past situation, range contractions have been noted, especially in the north. Data available on single colonies show that in the ’60s and ’70s populations declined in many European countries (France, Czech Republic, Poland, Switzerland, Austria), locally estimated at 85-90% (Germany) and in some cases leading to local extinction (England, northern Belgium, Holland, Israel). Thanks to both protection and favourable climate trends, population increases have been observed locally (areas of Poland and Germany). In Italy, Gulino and Dal Piaz (1939) wrote that the species was “very common”. Although no detailed population data are available for the country, the fall in numbers observed in several colonies and the disappearance of others, once numerous, highlight that the species is declining in Italy too.

MYOTIS MYSTACINUS (Kuhl, 1817)

Whiskered bat

Family

Vespertilionids *(Vespertilionidae)*.

Taxonomy

Recent studies showed that some bats formerly classified as *M. mystacinus* collected in Greece, Hungary and France (where *M. mystacinus* is also present) belong to a separate sibling species, named *Myotis alcathoe*. Moreover, the description of the new taxon *Myotis aurascens*, of very similar morphology, complicates further field identification of bats from the "*mystacinus*" group.

What follows, especially as far as geographical distribution is concerned, might well be contradicted by future findings on range and ecology of the newly described species.

Figure 2.12 - Presence of whiskered bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Measurements

BL 35-48 mm; TL 30-43 mm; FAL 32-36 (37.7) mm; EH 12-17 mm; WS 190-225 mm; CBL 12-13.3 (13.6) mm; CM^3 4.5-5.1 mm; W (3) 4-8 g.

Geographical range

North African-European-Asian species, occurring in all European regions except Iceland, in Morocco and central Asia, Iran, Himalayan region and part of China, east to Korea and Japan. The recent description of *M. alcathoe*, however, will require validation of this range.

Records for Italy are not sufficient for a detailed range description. Here this species has been repeatedly confused with *M. brandtii*. However, the available information suggests that the species occurs in the whole country (Figure 2.12).

Migration

Sedentary or occasional migrant. One exceptionally long movement (625 km) recorded in France.

Habitats

Found from sea level up to over 2,000 m a.s.l. Forages more frequently than *M. brandtii* in urban settlements (gardens, parks, near street lamps). Also common in forest habitats, open areas and wetland. Summer roosts in buildings, tree cavities or bat boxes.

Hibernates in natural or artificial underground habitats

Diet

Mainly based upon dipterans (especially Tipulidae), arachnids and moths, either caught on the wing within 6 m from ground or gleaned from vegetation or soil.

Reproductive behaviour

Mating from autumn to spring. Maternity roosts include 20-70 females, occasionally also joined by a few males. Gives birth in June-July: one young, exceptionally two.

Females are sexually mature from the age of 15 months, but there are reports of reproduction in their first year of life.

Maximum lifespan recorded: 23 years.

Relationships with other bat species

Occasionally preyed upon by owls. Sometimes roosts with other bat species, such as *Pipistrellus* spp., *Plecotus auritus, Myotis brandtii.*

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Within its geographical range, this species becomes progressively rarer from north to south.

MYOTIS NATTERERI (Kuhl, 1817)

Natterer's bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (37) 45-52 (55) mm; TL (32) 37-47 (49) mm; FAL 35-43 (46) mm; EH (14) 16-18.3 (20) mm; TrL 10-11.2 mm; WS 220-300 mm; CBL 14-15.6 mm; CM^3 5.8-6.3 mm; W 5-12 g.

Geographical range

Central Asian-European taxon, found all over Europe up to the northern limit of latitude 63°N, in the near East, Turkmenistan and NW Africa. Although scarce, information on species presence in Italy suggests that the species occurs in the whole country, with the possible exception of Sardinia (Figure 2.13).

Figure 2.13 - Presence of Natterer's bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Sedentary, but one long movement (157 km) documented.

Habitats

Found from sea level to 2,150 m a.s.l. Preferred foraging habitat forest, often associated with wetland, but may also forage in urban parks and structurally complex landscape mosaics with extensive hedgerow networks.

Roosts in tree cavities, buildings, bridges, rock crevices and bat boxes.

Hibernation sites in very wet underground habitats (caves, cellars).

Diet

Largely relies on diurnal dipterans and other arthropods captured near vegetation or other substrates when prey rests in the night. Secondary prey represented by insects (neuropterans, nocturnal dipterans) caught on the wing. Many prey species are typically forest arthropods.

Reproductive behaviour

Mating in autumn, possibly in winter and start of spring. Maternity colonies of 20-80 females, sometimes up to 100-200 bats. Male occurrence in such colonies negligible.

Births in June-July: one young, exceptionally two.

Maximum lifespan recorded: 20 years.

Relationships with other bat species

Occasionally preyed upon by owls. In summer, roosts may be shared with genera *Rhinolophus*, *Myotis* and *Plecotus*.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern). Rare throughout S Europe. Defined in 1939 as “uncommon in Italy” by Gulino and Dal Piaz.

MYOTIS AURASCENS Kusjakin, 1935

Steppe whiskered bat, Eastern whiskered bat

Family

Vespertilionids *(Vespertilionidae).*

Measurements

Unavailable.

Taxonomy

Another cryptic species from the *mystacinus* group. In their taxonomical revision, Benda and Tsytsulina (2000) regarded *M. aurascens* as a good species on the basis of a detailed skull and tooth morphological analysis. However, the species rank was not confirmed by Mayer and von Helversen (2001) on a molecular basis.

The validity of this species is debated.

Figure 2.14 - Presence of steppe whiskered bat in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

The only bat reported for Italy (Benda and Tsytsulina, 2000) is a female from Mount Altissimo di Nago, Monte Baldo (TN), held in the collection of Senkeberg Museum, Frankfurt am Main (Germany) (Figure 2.14).

Migration

Unknown.

Habitats

Unknown.

Diet

Unknown.

Reproductive behaviour

Unknown.

Relationships with other bat species

Unknown.

Conservation status

Not assessed (recently described *taxon*).

MYOTIS PUNICUS Felten, 1977

Maghrebian mouse-eared bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 59-77 mm; TL 47-62 mm; EH 22-27; FAL 53-65 mm; W 18-30 g.

Geographical range

Northern African – Mediterranean species, found in the SW Mediterranean, from Straits of Gibraltar to Sahara, including Tunisia and Malta.

In Italy, probably confined to Sardinia (Figure 2.15).

Figure 2.15 - Presence of Maghrebian mouse-eared bat in Italy. Grey: regions including at least one confirmed record from 2000. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Few data available; in general, no evidence of long-distance movement (inter-island movements between Malta and Gozo have been recorded).

Habitats

Unknown.

Diet

Unknown.

Reproductive behaviour

Unknown.

Relationships with other bat species

Unknown.

Conservation status

Not assessed (newly described *taxon*).

PIPISTRELLUS KUHLII (Kuhl, 1817)

Kuhl's pipistrelle

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 40-47 (50) mm; TL 30-40 mm; FAL 31-36 (37) mm; EH 12-13 mm; TrL 5.5-6 mm; WS 210-240 mm; CBL 12-13.4 mm; CM^3 4.8-5 mm; W 5-10 g.

Geographical range

Turanian-Mediterranean species, found in S and southern-central Europe (northernmost presence in France, occasional records in Germany and Great Britain), N and E Africa, S Asia, the eastern limit being represented by NE India. Present in all Italian regions (Figure 2.16).

Figure 2.16 - Presence of Kuhl's pipistrelle in Italy. Grey: regions including at least one confirmed record in the period 1980-2006.

Migration

Probably sedentary.

Habitats

Found from sea level to almost 2,000 m a.s.l., but preferred areas below 700 m a.s.l.

Forages in a range of habitats, including urban settlements, where it is the commonest bat. Hunts frequently near street lamps, trees or over water.

Roosts in tree cavities and rock crevices, but these are optimally replaced by spaces in buildings (housing of roll-down shutters, cracks in walls, spaces beneath metal panels and other narrow spaces), bat boxes and holes made to lodge explosives in mines and quarries.

Diet

Prey caught on the wing: small Diptera, Lepidoptera, Tricoptera, Coleoptera, Hemiptera.

Reproductive behaviour

Mating in late summer and August.

Maternity roosts with numbers ranging from a few to over 100 adult females (rarely several hundred bats), only occasionally frequented by adult males. Births in June-July: mainly two young, more rarely one. Sexual maturity reached in female's first year of life.

Maximum lifespan ascertained: 8 years.

Relationships with other bat species

Occasionally preyed upon by owls.

In the Valle d'Aosta region found in hibernation together with *Pipistrellus pipistrellus vel P. pygmaeus*, inside holes made to lodge explosives in abandoned mines.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Still abundant in many areas; some records suggest both range and population size might be expanding (probable range expansion in France and Switzerland). Given its marked synanthropy, probably less sensitive to environmental alteration than other bats.

PIPISTRELLUS NATHUSII (Keyserling & Blasius, 1839)

Nathusius' pipistrelle

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (42.2) 46-56 (58) mm; TL (30) 33-40 (44.6) mm; FAL 31-37 mm; EH 10-14 mm; TrL 6-7 mm; WS 220-250 mm; CBL (12.1) 12.3-13.4 mm; CM^3 4.4-5.3 mm; LD-V (42) 43-48 mm; W 6-15.5 g.

Figure 2.17 - Presence of Nathusius' pipistrelle in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Turanian-European species, found in Europe (above all in central Europe; northernmost regions are Scotland and southern Finland), the Near East and Transcaucasia. Available records suggest the species occurs in northern and central regions of Italy, probably either scarce or not present in the south, almost certainly absent from Sardinia (Figure 2.17).

Migration

Long-distance migrant. Longest movement recorded 1,905 km.

Habitats

Found from sea level to over 2,000 m a.s.l., altitudes presumably reached during migration.

Favours lower elevations. Mainly a forest bat, forages in forest clearings and along edges, in both conifer and broadleaved forests – the latter being preferred, especially along rivers or nearby. Summer roosts in tree cavities, bat boxes and buildings. Hibernation in tree cavities, wall or rock cracks, occasionally inside buildings (in crevices).

Diet

Prey caught on the wing: small Diptera (especially chironomids), Lepidoptera, Tricoptera, Coleoptera, and Hemiptera.

Reproductive behaviour

Mating in late summer and autumn. Maternity colonies from few to over 100 adult females, occasionally joined by adult males. Births in June-July: mainly two young, more rarely one. Sexual maturity reached by females in first year.

Maximum lifespan ascertained: 7 years.

Relationships with other bat species

Occasionally preyed upon by owls. Records of mixed colonies including *Pipistrellus pipistrellus* and/or *Myotis brandtii*, more rarely *Vespertilio murinus*, *Pipistrellus kuhlii*, *Myotis dasycneme* and *Nyctalus noctula*.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

PIPISTRELLUS PIPISTRELLUS (Schreber, 1774)

Common pipistrelle

Family

Vespertilionids *(Vespertilionidae)*.

Taxonomy

The recent description of its sibling species *(Pipistrellus pygmaeus)*) may change several aspects of knowledge available for *P. pipistrellus* because much information – especially that on geographical distribution – may in fact refer to either species.

Measurements

BL (32) 36-52 mm; TL (20) 24-36 mm; FAL 27-32 (35) mm; EH 9-13.5 mm; TrL 4.5-5.5 mm; WS 180-250 mm; CBL 11-12.3 mm; CM^3 4-4.8 mm; LD-V 36-41 mm in males and 42 mm in females; W 3.5-8.5 g.

Figure 2.18 - Presence of common pipistrelle in Italy. Grey: regions including at least one confirmed record in the period 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area). For this species, many records relative to the time before *P. pygmaeus* was recognised as a separate species will need validation because they potentially refer to *P. pipistrellus s.l.* (=*P. pipistrellus/P. pygmaeus*).

Geographical range

Central Asian-European species, found all over Europe except northernmost areas (north limit represented by parallel 63°N), in Maghrebian Africa, Libya and Asia through SW regions (northern limit ca 45°N, southern limits 35°N in the SW sector, 25°N in the E sector), east to NW China.

Migration

Probably sedentary, although some animals may cover long distances. A move of 1,123 km is reported.

Habitats

From sea level up to ca 2,000 m a.s.l. At least in NW Italy commoner in mountains than lowland.

Originally a forest species, it is highly versatile ecologically. Forages in a variety of habitats (forests, farmland, wetland, urban areas) and is among the most anthropophilous bat species.

Roosts in buildings, rocks and tree cracks; at least in the warm period, also in bat boxes.

Diet

Prey caught on the wing: small Diptera, Lepidoptera, Tricoptera, Coleoptera, Hemiptera.

Reproductive behaviour

Mates in late summer and spring. Maternity colonies made up of a few dozen females, but may reach up to several hundred bats. Births in June-July: mainly two young, more rarely one. Sexual maturity reached in female's first year of life.

Maximum lifespan ascertained: 16 years.

Relationships with other bat species

Occasionally preyed upon by Strigiformes and Falconiformes.

Colonies may include other bat species: other species from the genus *Pipistrellus*, *Myotis brandtii*, *M. mystacinus*, *M. dasycneme*, *B. barbastellus* and, more rarely, *Vespertilio murinus*, *Nyctalus* and *Plecotus*; frequently associated with *Pipistrellus nathusii* and *Myotis brandtii* at maternity roosts.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Abundant and widespread throughout its range. In the U.K., some decline in maternity colony numbers over recent decades.

PIPISTRELLUS PYGMAEUS (Leach, 1825)

Soprano pipistrelle

Family

Vespertilionids *(Vespertilionidae)*.

Taxonomy

Recently described species, for which the data available (especially concerning geographical distribution) are still limited. To date, fully reliable species recognition relies on molecular or bioacoustical analysis (echolocation calls peak at a frequency ca 10 kHz higher than those of *P. pipistrellus*).

Figure 2.19 - Presence of soprano pipistrelle in Italy. Grey: regions including at least one confirmed record since 1998. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Measurements

BL 28-32 mm; FAL 29-31 mm; EH 8.5-9.5 mm; LD-V 38-45 (48) mm; LD-IV-P1 8-8.5 mm; LD-IV-P2 6.5-7.5 mm; W 4-7 g.

Geographical range

P. pygmaeus is found, in sympatry with *P. pipistrellus*, in most of Europe; in Italy, so far documented for the south (Campania, Lazio and Abruzzo) Lombardy and Sardinia (Russo and Jones, 2000; D. Russo, *pers. com.*; figure 2.19). Also reported for Norway, Greece, Spain and Portugal.

Migration

Probably sedentary.

Habitats

Less dependent on human-created habitats, especially for foraging. Prefers foraging in wetland. In southern Italy, frequently observed also in broadleaved forests, especially at low and medium altitudes. In general, more selective than *P. pipistrellus* in foraging habitat choice.

Diet

Little data available. In the U.K., forages on Diptera (chironomids and ceratopogonids).

Reproductive behaviour

Mating in late summer and autumn. Probably similar to *P. pipistrellus*. Males emit social calls structurally different from those produced by *P. pipistrellus*.

Relationships with other bat species

Unknown.

Conservation status

Not assessed.

NYCTALUS LASIOPTERUS (Schreber, 1780)

Greater noctule

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (78) 84-104 mm; TL (51) 55-65 (66) mm; FAL (62) 63-69 (70.5) mm; EH 21-26 mm; TrL 7-8.5 mm; WS 410-460 mm; CBL 20-23.6 mm; CM^3 8.5-9.2 mm; W 41-76 g.

Geographical range

Turanian-European taxon, found in S and central Europe, the northern limit being represented by parallel 55°N, in N Africa (Morocco, Libya) and Asia east to Uzbekistan, through Caucasus, N Iran (Caspian Sea coasts) and Kazakhstan. Might be present in all Italian regions (Figure 2.20).

Figure 2.20 - Presence of greater noctule in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Probably migrant, but no banding data are available

Habitats

From sea level to middle-altitude mountainous areas (up to 1,350 m a.s.l. in beech woodland of Tuscany and Calabria), may occasionally reach higher elevations – *ca* 2,000 m a.s.l. – during migration (record elevation 1,923 m, Col de Bretolet pass, French-Swiss Alps).

Typically forest species, also found in conifers, but broadleaved forest is preferred.

Roosts in trees all year round. Alternatively, may use bat boxes, rock crevices and rarely buildings.

Diet

Preys on large moths and coleopterans, caught in open areas or above canopy. Recently, predation upon birds has been reported, especially important during migration peaks of the latter.

Reproductive behaviour

Mating between end of September and beginning of October. Colonies of up to ca ten bats. Births in June-July: two young, more rarely one.

Relationships with other bat species

May share roosts with other vespertilionids, i.e. N*yctalus noctula* and, less frequently, *N. leisleri*, *Pipistrellus pipistrellus* and *P. nathusii*.

Conservation status

LR: nt (Hutson *et al.*, 2001). Lower risk, near threatened.

In general, few scattered data on species presence are available. In Europe, presence reported for 120-130 sites and records generally correspond to single bats or small numbers.

NYCTALUS LEISLERI (Kuhl, 1817)

Leisler's bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 48-75 mm; TL 35-48 mm; FAL (37) 40-47 mm; EH 12-16.5 mm; TrL 6-8 mm; WS 260-320 mm; CBL 14.7-16.1 mm; CM^3 5.8-6.3 mm; W 11-20 g.

Geographical range

Turanian-European species, found in all Europe (northern limit ca latitude 56°N), in N Africa, SW Asia (to NW India). Found in most northern and central Italian regions, Campania and Sardinia (Figure 2.21).

Figure 2.21 - Presence of Leisler's bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Migration

Long-distance migrant (NE-SW), longest one-way move recorded 1,567 km.

Habitats

In Italy, found from sea level to over 2,000 m a.s.l. (peak altitudes probably reached on migration). Mainly a forest bat, may nonetheless show a tendency towards synanthropy.
Tree cavities are the preferred roost type (both in summer and winter); where unavailable, may use bat boxes and buildings (wall cracks, housing of roll-down shutters).

Diet

Catches prey on the wing, mainly small Diptera, Lepidoptera and Tricoptera.

Reproductive behaviour

Mating in August and September. Males occupy a roost and defend a harem of up to ca 10 females. Maternity colonies numbering 20-50 females, but in Ireland (where this species shows the highest population densities) there are numerous colonies of hundreds of bats.

Births in June: one or two young.

Maximum lifespan recorded: 9 years.

Relationships with other bat species

Occasionally preyed upon by owls. There are cases of mixed colonies with *N. noctula*, *N. lasiopterus, Myotis bechsteinii*, *Myotis daubentonii* and *Pipistrellus pipistrellus vel P. pygmaeus.*

Conservation status

LR: nt (Hutson *et al.*, 2001). Lower risk near threatened.

Difficult to survey, there is no information on current population trends in Italy. Because of its tree-dwelling habits, in natural habitats it is highly sensitive to intensive forestry removing suitable trees.

NYCTALUS NOCTULA (Schreber, 1774)

Noctule

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 60-84 (88) mm; TL (38) 41-60.6 mm; FAL (45) 48-58.5 mm; EH (10.5) 16-21 mm; TrL 6-8.5 mm; WS 320-400 mm; CBL (16.9) 17.4-19.9 mm; CM^3 6.7-7.5 (8.3) mm; W (16.7) 19-40 (46) g.

Figure 2.22 - Presence of noctule in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Central Asian-European species, found in all European countries as far north as 60°N, in Maghrebian Africa and in Asia: Near East, Turkmenistan, SW Siberia, Himalayan regions and part of the Far East (Japan, S China, N Vietnam and, possibly, N Thailand and the Malayan peninsula). In Italy probably present in all regions, with the possible exception of Sardinia and Sicily (Figure 2.22).

Migration

Long-distance migrant, on average estimated to cover 270 km per night. Longest movement known 1,546 km.

Habitats

Mostly found at low or medium elevations, from sea level to 500-1,000 m a.s.l.; during migration may occur higher up (French-Swiss Alps: 1,923 m a.s.l.).

Mainly a forest bat, may exhibit anthropophilous tendencies, and especially in central Europe may often roost in buildings as an alternative to tree cavities. Also found in bat boxes, hollow concrete poles and narrow spaces in buildings.

Forages in open spaces, above vegetation or more frequently over still water.

Diet

Based on insects caught and eaten on the wing, both large and small (the latter probably detected and seized from swarms). Main prey: Tricoptera, Diptera, Lepidoptera and Coleoptera.

Reproductive behaviour

Mates in late summer or autumn. Maternity colonies of 20-50 up to a hundred bats, occasionally joined by adult males. Births in June-July: mainly two young, more rarely one or exceptionally three.

Females give birth from their second year of life.

Maximum lifespan ascertained: 12 years.

Relationships with other bat species

Occasionally preyed upon by owls. Cases of mixed colonies with *Pipistrellus nathusii*, *P. pipistrellus* and *Vespertilio murinus.*

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern). Still regarded as widespread and abundant, but local decline recorded, due to loss of wetland (Holland) or forestry (Sweden).

HYPSUGO SAVII (Bonaparte, 1837) *(=Pipistrellus savii)*

Savi's bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (40) 43-52 (54) mm; TL 31-43 mm; FAL 30-37 (38) mm; EH (10) 12-15 (17) mm; TrL 4.5-6 mm; WS 220-250 mm; CBL (11.9) 12.3-13.6 (14.2) mm; CM3 4.3-5.2 mm; W 5-10 g.

Figure 2.23 - Presence of Savi's bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Central Asian-Mediterranean species, found in S Europe (Mediterranean), part of central and E Europe, NW Africa, central Asia and eastwards to NE India and possibly N Japan.

Present in most Italian regions (Figure 2.23).

Migration

Possibly an occasional migrant, but no data are available.

Habitats

Found in a variety of habitats, including urban areas, from sea level up to over 2,000 m a.s.l.. In mountainous areas, prefers warmest valleys.

Rupiculous. Roosts in cliff crevices or more rarely in crevices in underground habitats. Also reported in tree cavities and beneath loose bark. Narrow spaces in buildings provide similar conditions: found in wall cracks, space beneath shutters, tiles, roof cladding, wall-hung objects.

Diet

Foraging flights both low (over water, near tree crowns or street lamps) and at some dozen metres from ground. Preys upon small insects, especially Diptera, Lepidoptera, Hymenoptera and Neuroptera.

Reproductive behaviour

Mating in August-September.

Maternity colonies numbering 5-70 bats. Births in June - July, generally two young (more rarely one).

Females are sexually mature at one year of age.

Relationships with other bat species

Occasionally preyed upon by owls.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Until recently, regarded as rarer than it is due to methodological limitations to surveys. In Italy it is frequent: in Turin the commonest bat found in buildings after *P. kuhlii*. However, the available data are not sufficient to carry out a detailed conservation status assessment.

EPTESICUS NILSSONII (Keyserling & Blasius, 1839)

(=Amblyotus nilssonii)

Northern bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (45) 54-64 (68) mm; TL (35) 37-48 (50) mm; FAL (37) 38-43 (44) mm; EH (12) 13-18 mm; TrL 5-6 mm; WS 240-280 mm; CBL 14-15.2 (15.8) mm; CM^3 5-6 mm; W (6.5) 8.5-12.5 (18) g.

Figure 2.24 - Presence of northern bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Asian-European taxon, found in N, S and central Europe (this is the only bat also found at latitudes above the Arctic Polar Circle, the northernmost record referring to 70°25'N), absent from Great Britain and Ireland and almost completely absent from Palaearctic Asia (except Near and Middle East), present eastwards in Korea, Japan and, southwards, NW China (except Tibet), Kashmir and Nepal. The scarce records available for Italy show that its presence is limited to the Alps (Figure 2.24).

Migration

Sedentary. Longest movement recorded 450 km.

Habitats

In the mildest areas of its range (central Europe), favours the low and medium altitudes of mountainous landscapes, whereas in colder regions (N Europe) frequents lowland. Altitude ranges from sea level to 1,000 m a.s.l in S Sweden; in the Alps, found up to ca 2,300 m a.s.l. (the highest maternity colony was found at 1,600 m a.s.l.).

Open space forager, also hunting along forest edges, in wetland and in urban settlements, near street lamps.

Roosts in rock or wall crevices, occasionally in tree cavities and in woodpiles. Especially maternity roosts also in buildings (space under roof, cracks in wooden elements, spaces between walls or behind shutters, beneath cladding, etc.).

Diet

Based on insects caught on the wing, especially Diptera (Chironomidae, Tipulidae), Lepidoptera, Neuroptera, Hemiptera.

Reproductive behaviour

Limited information is available on mating and age of sexual maturity; 1-3 year old females often fail to give birth. Maternity colonies of 10-80 females, some of which not pregnant. Males separate from females in spring and summer, i.e. before mating. Births from mid-June to mid-July: 1-2 young.

Maximum lifespan ascertained: 15 years.

Relationships with other bat species

Occasionally preyed upon by owls.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

The commonest bat in the Scandinavian region. Abundance decreases southwards, but there is no evidence of population decline.

EPTESICUS SEROTINUS (Schreber, 1774)

Serotine

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 62-80 (82) mm; TL (39) 46-54 (66) mm; FAL 48-56 (58) mm; EH (12) 14-22 mm; TrL 7.5-9.5 mm; WS 315-380 mm; CBL 18-21.8 mm; CM^3 7-8.6 mm; W 14-33 (35) g.

Figure 2.25 - Presence of serotine in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Central Asian-European-Mediterranean species, found from W (including S England, northern limit 56°N), central and E Europe to the Near East, southern regions of former Soviet Union, Iran, Iraq, Afghanistan, northern part of Indo-Himalayan region, and E to China and Korea. Also occurring in the Maghreb and Libya.

All Italian regions included in the species range (Figure 2.25).

Migration

Probably sedentary; longest movement documented 330 km.

Habitats

In Europe, found from sea level up to *ca* 1,800 m a.s.l. Favours low or medium altitude. Various foraging habitats: forest edges, farmland with significant hedgerow availability, and, in urban areas, parks, gardens and near street lamps.

Summer roosts mainly in buildings (between roof beams, wall cracks, spaces beneath cladding), more rarely in tree cavities or bat boxes.

Winter roosts in buildings or underground habitats.

Diet

Preys upon several insect groups: Coleoptera (including large species, mainly non-volant or rarely flying), Lepidoptera, (Sfingidae, Noctuidae), Odonata, Orthoptera, Diptera, Hemiptera, Hymenoptera.

Diet also includes spiders and, occasionally, Gastropods, confirming the species' substrate-gleaning habit.

Reproductive behaviour

Mates in late summer or autumn – possibly also in winter. Maternity colonies may contain up to a few hundred bats, more commonly 10-50 females, rarely including some adult males.

Females sexually mature when they are 1-2 years old.

Maximum lifespan ascertained: 21 years.

Relationships with other bat species

Occasionally preyed upon by owls. May roost together with *Pipistrellus kuhlii*, *P. nathusii* and *Nyctalus noctula*.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

VESPERTILIO MURINUS Linnaeus, 1758

Parti-coloured bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL 48-64 mm; TL (30) 37-44.5 (47) mm; FAL 39-47 (50.3) mm; EH (12) 14-16.5 (18.8) mm; TrL 5.5-8.5 mm; WS 265-330 mm; CBL 13.9-15.8 mm; CM^3 5-6.1 mm; W 10.7-17 (23) g.

Figure 2.26 - Presence of parti-coloured bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Geographical range

Asian-European species, found in N (northern limit 65°N), central and S Europe, absent from Great Britain, Ireland and the Iberian Peninsula. In Asia occurs east to Manchuria, and south to Iran, Afghanistan and N Pakistan. In Italy it is known only for NE regions. Recently, a male was caught in Milan (De Carli and Fornasari, *pers. com.*) (Figure 2.26).

Migration

Long-distance migrant, movements recorded range from 18 up to 1,780 km.

Habitats

Also found above 2,000 m a.s.l., but areas preferred are those at medium altitude.

Found in different habitats: forest, steppes, farmland, urban areas. Hunts on the wing, in straight flight paths at 10-40 m above ground, sometimes near street lamps.

According to some authors, originally a rupiculous bat. Known summer roosts are mainly buildings (especially in wall crevices or beneath claddings), more rarely in tree cavities, bat boxes and exceptionally inside rock or straw piles.

Hibernates in buildings, more rarely at underground sites.

Diet

Mainly based on small or very small insects, caught on the wing. Especially when hunting near street lamps, may catch larger prey, including moths and beetles.

Reproductive behaviour

Mates especially in autumn, sometimes at the onset of winter. Maternity colonies mostly number 10-50 females (occasionally over 100); males roost separately in this period, either singly or sometimes in numerous groups (the record male aggregation numbered 267 bats).

Births in June-July: mostly two, occasionally three young in central Europe, one or two in Scandinavia and Denmark.

Sexual maturity probably reached in the first year of life.

Longest lifespan recorded: 12 years.

Relationships with other bat species

Occasionally preyed upon by owls. May roost together with several bat species: *Nyctalus noctula*, *Pipistrellus pipistrellus*, *P. nathusii*, *Myotis daubentonii*.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

BARBASTELLA BARBASTELLUS (Schreber, 1774)

Barbastelle

Family

Vespertilionids *(Vespertilionidae)*.

Figure 2.27 - Presence of barbastelle in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Measurements

BL 44-60 mm; TL (36) 38-52 (60) mm; FAL (31) 36-44 (47.5) mm; EH 14-18 mm; TrL 9-9.5 mm; WS 240-290 mm; CBL 12-14.8 mm; CM3 4.6-4.9 mm; W 6-14.2 g.

Geographical range

European-Mediterranean species, probably occurring in all European countries up to the northern limit of 60°N and east ca to longitude 30°E (Ukraine), including southwards Crimea, Turkey, and Caucasus. Also reported for Morocco, Canary islands and possibly Senegal.

All Italian regions are included in the species range (Figure 2.27).

Migration

Mainly sedentary, occasionally movements for dispersal or migration. Longest movement recorded 290 km.

Habitats

Found from sea level up to *ca* 2,000 in the Alps and 2,260 m a.s.l. in the Pyrenees. In the Abruzzo, Lazio and Molise National Park (central Italy), maternity roosts recorded up to ca 1,700 m a.s.l. (D. Russo, *pers. com.*). It is thought to prefer medium altitude areas.

Mainly foraging in forest, often associated with wetland, also recorded in urban parks.

Summer roosts in tree cavities (often beneath loose bark of dead or decaying trees, or in cracks) or, alternatively, buildings (in alpine huts, roosts often behind window shutters left open which probably “mimic” the condition found beneath tree bark). Hibernates in underground habitats, at low temperatures (2-5°C).

Diet

Almost exclusively made up of small moths, also regularly includes tricopterans – this confirms foraging in wetland.

Reproductive behaviour

Mates in late summer or autumn, sometimes during winter. Maternity sites contain up to 100 females, more frequently 5-30 bats. Males separate in spring and summer (before mating time), roosting solitarily or in small groups.

Births from mid-June: one, more rarely two young.

Females sexually mature in their second year of life.

Relationships with other bat species

In winter, may hibernate along with other species, especially *Pipistrellus pipistrellus.*

Conservation status

VU: A2c (Hutson *et al.*, 2001). Threatened with extinction (vulnerable).

Relatively more common in central Europe, it is regarded as one of the rarest bat species. Population declines observed across most of the range. Probably extinct in Holland.

PLECOTUS AURITUS (Linnaeus, 1758)

Brown long-eared bat

Family

Vespertilionids *(Vespertilionidae)*.

Taxonomy

Following the recent description of the new long-eared species *Plecotus macrobullaris* and *Plecotus sardus*, a substantial revision of knowledge of the *Plecotus* genus is in progress, which may lead to changes in the information reported below. The species *Plecotus microdontus* described by Spitzenberger *et al.* (2002) is now regarded as a synonym of *P. alpinus* (Kock, 2002); for both, the name *P. macrobullaris* (Spitzenberger *et al.*, 2003) has been proposed.

Figure 2.28 - Presence of brown long-eared bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).
Many past records, obtained before new long-eared bat species (and especially the very similar P. macrobullaris) were described, await validation and may be cautiously classified as *P. auritus s.l.* (=*P. auritus/P.macrobullaris*).

Measurements

BL (38.8) 42-53 (55) mm; TL (32) 37-55 mm; FAL (34); 37-42 mm; EH 31-41 (43) mm; TrL 14.7-17.4 mm; WS 240-285 mm; THL (5.8) 6.5-8.4 mm; CBL (13.2) 14-16.3 mm; DB 4-4.2 mm; CM^3 5.2-6 mm; W (4.6) 6.5-9.2 (12) g.

Geographical range

Asian-European species, found in all European regions (north to latitude 64°N ca.) and in Palaearctic Asia, where it is present east to Japan and south to the Himalayan region.

Recent records for Italy include northern and central regions, and Sardinia (Figure 2.28).

Migration

Sedentary species, longest movement documented 90 km.

Habitats

In Italy, it is found from sea level to over 2,000 m a.s.l. Mainly a forest bat, also hunts near single trees or in open areas. Maternity colonies in tree cavities, bat boxes or buildings, where it may occupy both open rooms (hanging on the ceiling) or narrow spaces (cracks or fissures in the ceiling, space behind hanging paintings, etc.)

Hibernates in underground habitats (often near the entrance), buildings (cellars) or tree cavities.

Diet

Highly specialised in lepidopterans and secondarily large dipterans, *P. auritus* catches prey on the wing or gleans it from foliage (such as resting diurnal insects). Small prey ingested in flight, larger ones carried to a perch and dismembered there. Beneath the perches usually frequented, it is common to find non-ingested parts, especially moth wings.

Reproductive behaviour

Mating occurs mainly in late summer-autumn, possibly also during hibernation. Maternity colonies mostly small, 5-50 adult females (rarely more), occasionally joined by adult males.

Births in June-July: one young, rarely two.

Maximum lifespan ascertained: 30 year

Relationships with other bat species

Occasionally preyed upon by owls. In some cases, congregates at roosts together with the sibling *P. austriacus.*

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

P. auritus is quite frequent in N Europe, rarer in the south of the continent.

PLECOTUS AUSTRIACUS (Fischer, 1829)

Grey long-eared bat

Family

Vespertilionids *(Vespertilionidae)*.

Figure 2.29 - Presence of grey long-eared bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).
Many past records, obtained before new long-eared bat species were described, await validation and may be cautiously classified as *P. auritus* s.l. (=*P. auritus/P.macrobullaris*)

Taxonomy

Following the recent description of the new long-eared species *Plecotus macrobullaris* and *Plecotus sardus*, a substantial revision of knowledge of the *Plecotus genus* is in progress, which may lead to changes in the information reported below. The species *Plecotus microdontus* described by Spitzenberger et al. (2002) is now regarded as a synonym of *P. alpinus* (Kock, 2002); for both, the name *P. macrobullaris* (Spitzenberger *et al.*, 2003) has been proposed.

Measurements

BL 41-58 (60) mm; TL 37-55 (57) mm; FAL (35) 37-45 mm; EH 31-42 mm; TrL 15.7-20 mm; WS 255-300mm; THL 4.7-6.3 mm; CBL 15-17.2 mm; DB 4.4-5 mm; CM3 5.4-6.5 mm; W 5-14 g.

Geographical range

Turanian-European-Mediterranean species, found in central (north up to parallel 53°N ca) and S Europe, Mediterranean and tropical Africa and, in Palaearctic Asia, east to Kashmir, Mongolia and W China. Present in most Italian regions (Figure 2.29).

Migration

Regarded as sedentary, longest move 61 km.

Habitats

Quite thermophilous, in Europe prefers low or medium altitudes. More frequently found in synanthropy than *P. austriacus*, also occurring in farmland and urban settlements.

In Switzerland, absent from forests, in Mediterranean areas found in shrubland and *Quercus ilex* woodland. In the Abruzzo, Lazio and Molise National Park (central Italy) found in mature beech forests together with the more abundant *P. auritus* (D. Russo, *pers. com.*).

Maternity sites mostly in buildings (hanging from ceiling or in narrow spaces), but summer roosts also offered by underground sites or, more rarely, tree cavities and bat boxes.

Hibernates mainly in underground habitats, more rarely in buildings or tree cavities.

Diet

Mainly based upon tympanate moths (especially Noctuidae), secondarily dipterans. Like *P. auritus*, this species may use feeding perches.

Reproductive behaviour

Mating in autumn. Maternity colonies generally small, made up of 10-30 adult females, rarely exceeding 100 bats. Births in June: one young.

Maximum lifespan ascertained: 25 years.

Relationships with other bat species

Occasionally preyed upon by owls. May form mixed colonies with *Plecotus auritus*, *Myotis myotis* and *Rhinolophus hipposideros*.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Regarded as relatively rare in central and N Europe, more frequent in the south. Population declines recorded in the ‘70s, in the northernmost sector of the range, are thought to be due to adverse weather conditions.

PLECOTUS MACROBULLARIS (Kuzjakin, 1965)

Alpine long-eared bat

Family

Vespertilionids *(Vespertilionidae)*.

Measurements

BL (48.4) 51.2 (55.4) mm; FAL (39.8) 40.8 (42.2) mm; EH (14) 16-21 mm; TrL (15.2) 16.5 (17.7); THL (6.0) 7.4 (7.6); W (7.0) 8.4 (9.5) g.

Geographical range

Newly described species for which providing a reliable range is not yet possible. In Italy (Figure 2.30) there are records from Friuli Venezia Giulia, Trentino Alto Adige, Veneto, Lombardy, Piedmont and Liguria (Spitzenberger *et al.*, 2002; 2003; Chirichella *et al.*, 2003; Trizio *et al.*, 2003; Kiefer e von Helversen, 2004; Trizio *et al.*, 2005).

Figure 2.30 - Presence of alpine long-eared bat in Italy. Grey: regions including at least one confirmed record from 2001. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area, especially due to the very recent species discovery).

Migration

Similar to *P. auritus*, probably sedentary.

Habitats

The few data so far available suggest habitat preferences comparable to those of *P. auritus.* However, *P. macrobullaris* would prefer lower altitude.

Diet

Unknown.

Reproductive behaviour

Maternity colonies of a size similar to those of *P. auritus:* 10-30 adult females. Births in June-July: so far, only one young recorded

Relationships with other bat species

Currently unknown.

Conservation status

Not assessed (newly described *taxon*).

PLECOTUS SARDUS Mucedda *et al.*, 2002 N.S.

Sardinian long-eared bat

Family

Vespertilionids *(Vespertilionidae).*

Measurements

BL 45 mm; LCo 51 mm; FAL 40.9-42.3 mm; EH 37.5-39 mm; CBL 15.9 mm; CM^3 5.75 mm; W 6.5-9.5 g; DB 4.75 mm; LD-V 56 mm; THL 6-6.4; TrL 18-19.8; Tragus width 6-6.5.

Figure 2.31 - Presence of Sardinian long-eared bat in Italy. Grey: regions including at least one confirmed record from 2002 (Sardinia). The currently available records, all from Sardinia, suggest the species is exclusive to the Corsican-Sardinian area.

Geographical range

As far as is known, the species seems endemic to Sardinia (Figure 2.31).

Migration

Unknown, but probably sedentary – limited seasonal movements recorded.

Habitats

So far found at low-medium elevations, in forest. Very few maternity colonies observed in karstic caves or buildings; very few hibernacula, in buildings. Hunting strategies unknown.

Diet

Unknown.

Reproductive behaviour

Currently unknown – presumably similar to that of *P. auritus.*

Relationships with other bat species

Unknown.

Conservation status

Not assessed (newly described *taxon*).

MINIOPTERUS SCHREIBERSII (Kuhl, 1817)

Schreiber's bat

Family

Miniopterids (*Miniopteridae*).
Family recently separated from *Vespertilionidae* (Tiunov, 1989; Lanza and Agnelli, 1999).

Figure 2.32 - Presence of Schreiber's bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area).

Measurements

BL (48) 50-62 (65) mm; TL (46) 56-64 mm; FAL (42) 45-48 mm; EH 10-13.5 mm; TrL 5.2-6.2 mm; WS (208) 305-350 mm; CBL (13.6) 14.5-15.5 mm; CM^3 5.6-6.3 mm; W 8-17 g.

Geographical range

Sub-cosmopolitan (Southern European-Mediterranean-Ethiopian-Far Eastern-Australian) species. From S Europe, southern part of central Europe eastwards to Japan, most of China and the Far East, through Caucasus and SW Asia; also in New Guinea, Solomon Islands (Bougainville Island included), Australia, Bismarck archipelago, main Mediterranean islands (including Maltese islands), Mediterranean and sub-Saharan Africa, Madagascar and Comoros.

Present in most Italian regions (Figure 2.32).

Migration

Sedentary in some southern areas characterised by a mild climate, elsewhere migrates, sometimes over great distances. Longest movement recorded 833 km.

Habitats

Favours areas of low to medium altitude, from those along the coast to medium altitudes in mountainous landscapes (reported up to ca 1230 m a.s.l. in the Abruzzo, Lazio and Molise National Park, central Italy; D. Russo, *pers. com.*).

Forages both in forest and open habitats (areas covered with herbaceous vegetation, steppes). Roosts in either natural or artificial underground habitats all year round; more rarely (in the warm period of the year and especially in the northern sector of the range) in buildings.

Diet

Specialised in food similar to that of *Barbastella barbastellus,* i.e. especially moths. Diet includes also non-volant components, such as lepidopteran larvae and spiders.

Reproductive behaviour

Unlike other European bats, in which egg fertilisation is delayed to spring, in this species fertilisation immediately follows autumn mating, but the embryo either slows down or interrupts its development in winter and leads to late spring parturition (i.e. at the same time of year as the other temperate bat species)

Large, often huge maternity colonies made up of several hundred to thousands of females, often including many males. Gives birth between the end of May and July: one young, more rarely two.

Maximum lifespan ascertained: 16 years.

Relationships with other bat species

Occasionally preyed upon by owls. May associate at roosts with rhinolophids *(Rhinolophus ferrumequinum, R. euryale, R. mehelyi)* and vespertilionids *(Myotis blythii, M. capaccinii, M. emarginatus, M. myotis).*

Conservation status

LR: nt (Hutson *et al.*, 2001). Lower risk, near threatened. Although large colonies still exist, the species is facing a decline, especially in the north of its range. In recent years, mass mortality due to unknown causes recorded at several maternity roosts in southern Europe (concerning especially juveniles).

TADARIDA TENIOTIS (Rafinesque, 1814)

European free-tailed bat

Family

Molossids *(Molossidae)*.

Measurements

BL 80-92 mm; TL 44-57 mm; FAL 57-65 mm; EH 27-31 mm; TrL 6-6.5 mm; WS 408-440 mm; CBL 20.9-24 mm; CM^3 9-9.5 mm; W 25-50 g.

Geographical range

Central Asian-Mediterranean species, found in the Mediterranean, most of the Middle East, the Himalayan area, several regions of S and E China, Korea and Japan.

Present in most Italian regions (Figure 2.33)

Figure 2.33 - Presence of European free-tailed bat in Italy. Grey: regions including at least one confirmed record in 1980-2006. Unrecorded presence for some regions is not necessarily due to actual species absence (may depend on insufficient research effort in the area)

Migration

Probably sedentary or partly migrant.

Habitats

From sea level up to over 2,000 m a.s.l., from the coast to Alpine valleys.

Rupiculous species, roosts in rock crevices. Alternatively, in urban areas selects cracks in building walls, especially high up; sometimes roosts inside housing of roll-down shutters.

Diet

Flies high up (often several hundred meters above ground), and feeds mainly on lepidopterans, coleopterans and dipterans.

Reproductive behaviour

Poorly known. Probably mates in late winter-spring. Maternity colonies mostly small, made up of 5-50 adult females, sometimes over a hundred bats. Births in June-July: one young. Females sexually mature in the first year of life.

Maximum lifespan ascertained: over 10 years.

Relationships with other bat species

Occasionally preyed upon by raptors.

Conservation status

LR: lc (Hutson *et al.*, 2001). Lower risk (least concern).

Regarded as a species characterised by low population densities.

3. LEGAL FRAMEWORK

E. Patriarca

3.1 **International and national laws**

The first Italian law protecting bats was the Regio Decreto 5 June 1939, no. 1016 (Royal Decree), *Testo Unico delle norme per la protezione della selvaggina e per l'esercizio della caccia* (Norms for game protection and hunting). It established that "killing or capturing bats of all species is forbidden in all cases" (art. 38).

In Italy, regulations protecting bats are currently covered by the *Legge quadro in materia di fauna e attività venatoria*, L. 11 February 1992, no. 157 (Basic Law on wildlife and hunting activity), as well as by documents concerning some of the main international conventions adopted by the country (Bern Convention, 1979; Bonn Convention, 1979; Rio de Janeiro Convention, 1992) and the EC Habitats Directive (92/43/EEC).

Since bats may be regarded as an environmental component, their protection is also legally established by the national law on environmental damage (D. LGS. 3 April 2006, no. 152), enforcing the Directive 2004/35/EC.

Developments concerning this topic can be expected following the 21 April 2004 EC/2004/35 Directive by European Parliament and Council, setting out the responsibility for preventing and restoring environmental damage. This may be applied to bats because it covers all species in Annexes II, IV of 92/43/ EEC Directive, as well as habitats used by Annex II species, reproductive and resting sites of Annex IV species and Annex I habitats, including crucial bat habitats. EU Member States are required to enforce the Directive by 30th July 2007.

3.1.1 *Protection laws*

L. 11 February 1992, no. 157

The *Legge quadro in materia di fauna e attività venatoria*, L. 11 February 1992, no. 157 does not refer explicitly to bats. However, its provisions may be applied to such mammals because bats are generically part of the fauna protected by the law, and include species mentioned in international directives too. Since bats are mammals "characterised by populations temporarily or permanently occurring in the wild in the national territory (art. 2, comma 1), being species other than those explicitly not protected by the law (art. 2, comma 2) as well as not subject to hunting (art. 18)", they are protected by the following provisions (art. 21, comma 1; art. 30, comma 1): they cannot be killed, captured, kept in captivity, or traded.

Exceptions are made for scientific research (see par. 3.1.3), rescue and rehabilitation (according to the law, regional rules should be applied in such cases: art 4, comma 6) or for wildlife management actions (art. 19).

Violations are regarded as a penal offence and prosecuted (art. 30), sanctions being particularly severe for “especially protected species”. Although bats are not listed among especially protected mammals (art. 2, comma 1, letter *a*), they are nonetheless covered by this definition because they include species defined by European Union directives or international conventions as “threatened” (art. 2, comma 1, letter *c*). In this respect, two major international initiatives are especially important: the Bern Convention and the 92/43/EEC Directive.

“Vulnerable and threatened” species are considered of special concern by the Bern Convention (art. 1, comma 2), listing in Annex II (strictly protected animal species) species in need of a more rigorous protection, including those threatened with extinction. All bat species other than *Pipistrellus pipistrellus* are included. More recently, the 92/43/EEC Habitats Directive has pooled threatened and vulnerable species together with rare or endemic species in the “Species of Community Importance” category, listing in Annex IV those requiring rigorous protection. All European bats feature in the list, several of which (Table 3.1) also figure in the Directive’s Annex II, covering species whose protection requires the designation of Special Areas of Conservation.

Table 3.1 Bat species of community interest (currently occurring in Italy, or documented by historical records) whose protection requires the designation of Special Areas of Conservation (92/43/EEC Habitats Directive).

Rhinolophus blasii	*Myotis bechsteinii*
Rhinolophus euryale	*Myotis blythii*
Rhinolophus ferrumequinum	*Myotis capaccinii*
Rhinolophus hipposideros	*Myotis dasycneme*
Rhinolophus mehelyi	*Myotis emarginatus*
Barbastella barbastellus	*Myotis myotis*
Miniopterus schreibersii	

Hence, even though indirectly, Law 157/92 does invoke strict protection of bats. However, it only deals with protection of *individuals*, and not roosts or habitats. This omission gives rise to considerable concern, since Law 157/92 is supposed to enforce the Bern Convention (art 1, comma 4), which highlights the importance of bat roosts and habitats, in the Italian territory. Nonetheless several national and international laws covering the protection of roosts and habitats may help circumvent this limitation (D.P.R. 357/97 and further modifications and implementation, Bat Agreement, L. 349/86).

Bonn Convention, Bat Agreement and L. 27 May 2005, no. 104

The "Convention on the Conservation of Migratory Species of Wild Animals" (Bonn, 23rd June 1979), to which the European Community is a party (Decision 82/461/EEC), was enforced in Italy by Law 25 January 1983, no. 42. In a previous version, the Convention did not mention European bats, which were not listed in its Annexes. In the course of subsequent meetings of the Parties (Bonn, 1985; Nairobi, 1994), the following bats were added to Annex II: *Tadarida teniotis* (with reference to its global range) and European populations of migrant species in the families *Rhinolophidae* and *Vespertilionidae.*

The Convention aims to conserve migratory species on a global scale, defined as entities of which significant parts leave periodically, or predictably, one or more national boundaries. Annex II lists all migratory species showing a dubious conservation status, about whose protection and management the Convention's Parties are required to make specific agreements

With reference to bats, one of the first agreements stipulated within the Convention's general framework was the "Agreement on the Conservation of Bats in Europe" (London, 4th December 1991), subsequently (Bristol, 2000) renamed "Agreement on the Conservation of Populations of European Bats". This is most often called (and hereafter referred to as) the "Bat Agreement". The document's name was changed following an "extensive" interpretation of the protection needs of bats in Europe. Species occurring in the European continent are in fact considered with respect to their whole geographical range, including both European and non-European countries. Moreover, the Bat Agreement covers both migratory and sedentary species, exposed to the same threats and often sharing the same roosts.

Bat species currently targeted by the Agreement are those known for Europe except those exclusive to Macaronesia. Such species are explicitly listed in Annex 1 to the Agreement, which has already been updated, mainly to recognise new acquisitions in taxonomy. The Agreement became operative in 1994, being ratified by a first group of Nations. In Italy, it was ratified in 2005 (L. 27 May 2005, no. 104).

All Parties are required to:

- Prohibit deliberate capture, captivity or killing of bats; exceptions can be made on the basis of specific authorisations issued by national authorities;
- Identify important sites for bat conservation, including roosts, and protect them from alteration and disturbance;
- Make efforts to identify and protect important foraging areas;

- Adequately consider the importance of bat habitats when making decisions in the field of environmental protection;
- Undertake important actions for bat protection and promote public awareness of this issue;
- Designate a consulting institution for bat conservation and management, with special reference to the issue of bats in buildings;
- When necessary, start further conservation actions to safeguard endangered bat populations and inform the Meeting of the Parties of such actions;
- Promote research on bat conservation and management, inform the other parties and coordinate with them such activity;
- When deciding on pesticides to be adopted, take into account potential effects on bats; replace highly toxic chemicals used for timber structure treatment with safer products.

More detailed regulations on the above aspects are described in an Action Plan and in Resolutions adopted by the Agreement Meeting of the Parties (see par. 3.2.3).

Bern Convention

The "Convention on the Conservation of European Wildlife and Natural Habitats" (Bern, 19th September 1979), to which the European Community is also a party (Decision 82/72/EEC), came into force in Italy with Law 5th August 1981, n 503. Annex II of the Convention (including strictly protected fauna species) mentions all European bats except *Pipistrellus pipistrellus*. With reference to such species, Parties are obliged to promote all necessary laws and regulations for habitat protection (art 4, comma 1), with special attention to wintering, feeding and breeding areas of migratory bats (art 4, comma 3).

For species listed in Annex II the following actions are prohibited (art. 6, points a, b, c, e):

- all forms of deliberate capture and keeping and deliberate killing;
- deliberate damage to or destruction of breeding or resting sites;
- deliberate disturbance, particularly during the period of breeding, rearing and hibernation,
- possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof.

Pipistrellus pipistrellus is mentioned in Annex II (protected fauna species) along with species to be protected by temporarily or locally prohibiting exploitation, or by regulating trade, detention or transportation of both live and dead specimens (art 7). For this as well as other bat species, in cases when exceptions are legally made, it is forbidden to adopt non-selective capture or killing tools, or those locally determining the disappearance or disturbance to species (art. 8). When the Convention was drawn up, *Pipistrellus pygmaeus* had not yet been distinguished from *P. pipistrellus*. To date, the problem of verifying the status of these two distinct taxa and their protection needs has not been dealt with in updating the Convention Annexes.

Exceptions to the rules so far described may be made for the following aims (art 9, comma 1):

- for the protection of flora and fauna;
- to prevent serious damage to crops, livestock, forests, fisheries, water and other forms of property;
- in the interests of public health and safety, air safety or other overriding public interests;
- for the purposes of research and education, of repopulation, of reintroduction and necessary breeding;
- to permit, under strictly supervised conditions, on a selective basis and to a limited extent, the taking, keeping or other judicious exploitation of certain wild animals and plants in small numbers.

The Convention has designated a Standing Committee to supervise its correct application (art 13). Parties have to report on the exceptions made under the above points (art. 9, comma 2). Among its tasks, the Committee has to make recommendations to the Contracting Parties concerning measures to be taken for the purposes of this Convention (art 14). Several recommendations have been made which are significant for bat protection. Recommendation No. 43 (1995), dealing with conservation of threatened mammals in Europe, invites parties to adopt new Action Plans or implement existing ones to protect species listed in Annex A, among which the following bats are mentioned: *Rhinolophus euryale, R. ferrumequinum, R. hipposideros, R. mehelyi, Myotis blythii, M. emarginatus, M. myotis* and *Miniopterus schreibersii* (the last species is mentioned with reference to Russian populations). All other bat species are mentioned in Annex B. It is recommended that Parties evaluate the need to produce analogous action plans by monitoring actions aimed to establish their conservation status.

More recently, following two Action Plans issued by the Council of Europe on *Rhinolophus ferrumequinum* and *Myotis dasycneme*, the Standing Committee has produced Recommendations No. 72 and No. 73 (1999) for the Parties taking into account these tools in creating or implementing national action plans for these species.

Recommendation No. 36 (1992), on the conservation of underground habitats, invites the Parties to identify underground sites of a high biological value and adopt appropriate management and protection measures for them (designed to restore better environmental conditions). In this context, explicit mention is made of winter and summer bat roosts, whether natural (caves) or artificial (mines, quarries), as well as of measures taken to mitigate disturbance at such sites (placing appropriate barriers at entrances to prevent human access while allowing bats to safely cross them).

Further recommendations, potentially relevant to bat conservation yet not explicitly referring to it, have been made by the Standing Committee to promote conservation of other habitats or fauna. For example, Recommendations R (88) 11 on ancient natural and semi-natural woodlands and R (88) 10 on the protection of saproxylic organisms and their biotopes highlight the importance of keeping old, decaying or rotted trees in forests, as well as other actions, all highly important to forest bat conservation.

The Standing Committee also worked to stimulate the creation of a pan-European network of Areas of special conservation value, also identifiable on the basis of their value for bats, named the *Emerald Network* (Recommendation No. 16, 1989; Resolution No. 3, 1996). However, following the 92/43/EEC Habitats Directive, the Standing Committee has pointed out that EU Member States should follow the rules set by the Directive and that in those Countries *Emerald Network* sites are covered by the Natura 2000 network (established by the Habitats Directive: Resolution No. 5, 1998).

<u>92/43/EEC Habitats Directive and D.P.R. 8 September 1997, no. 357 – D.P.R. 12 March 2003, no. 120</u>

The Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, commonly called the "Habitats Directive", came into force in Italy with the D.P.R. (Decree of President of Republic) of 8 September 1997, no. 357, modified and integrated by the D.P.R. of 12 March 2003, no. 120. Subsequently 97/62/EC Council Directive of 27 October 1997 (which approved an update of Annexes I, II) was ratified with an Environment Ministry Decree (20 January 1999). This made no modifications as far as bats are concerned. The Directive primarily aims to promote the conservation of European biological diversity.

Being listed in Directive Annex IV (Annex D of D.P.R. no. 357/97), all bat species must be regarded as species of community interest requiring strict protection. The following actions impacting on such species are forbidden:

- all forms of deliberate capture or killing of specimens of these species in the wild;
- deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;
- deterioration or destruction of breeding sites or resting places.

For these species, Member States shall prohibit the keeping, transport and sale or exchange, and offering for sale or exchange, of specimens taken from the wild, except for those taken legally before this Directive was implemented in the country by the D.P.R. no. 357/97. Exceptions to such rules may be made following authorisation by the Environment Ministry (Ministero dell'Ambiente e della Tutela del Territorio) after a technical opinion has been provided by the Istituto Italiano per la Fauna Selvatica (INFS), as long as no valid alternatives exist, and provided that the exception will not affect maintenance of a satisfactory conservation status of the species populations within its geographical range. Exceptions should be justified by needs such as (D.P.R. no. 357/97 art. 11, comma 1):

- protection of flora, fauna and natural habitats;
- to prevent serious damage to crops, livestock, forests, fisheries, water and other forms of property;
- the interests of public health and safety, air safety or other overriding public interests;
- purposes of research and education, of repopulation, of reintroduction and for the necessary breeding;
- to permit, under strictly supervised conditions, on a selective basis and to a limited extent, the taking, keeping or other judicious exploitation in small numbers.

Every two years the Ministry has to report to the European Commission on the exceptions made (art. 11, comma 3). Scientific advice on report preparation is provided by the *Istituto Nazionale per la Fauna Selvatica*. The report must include:

- species for which exceptions have been made and reasons for these;
- methods, systems and tools authorised for capture or killing and reasons for the authorisation;
- time and places of interventions;
- monitoring measures applied and relative results.

As far as bat research involving capture or suppression is concerned, the Institutions responsible for the projects will have to ensure the collection of the above information and communicate it to the national authorities in charge of reporting to the EC (i.e. *Ministero dell'Ambiente e della Tutela del Territorio* and *Istituto Nazionale per la Fauna Selvatica*).

Besides the strict protection required by the above aspects, 13 bat species, either currently present or historically recorded in Italy, also feature in Directive Annex II (Annex B of D.P.R. no. 357/97) (Table 3.1). For such species, the designation of Special Areas of Conservation (SAC) is expressly required (D.P.R. no. 357/97, art. 3). Such protected areas have to be identified by following the procedure set in art. 3 of D.P.R. no. 357/97, i.e. referring to selection criteria described in Annex III of Directive (Annex C of D.P.R. no. 357/97). In such areas, necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which SACs are designated.

Such sites play a critical role in maintaining or restoring the species' favourable conservation status because they include "the physical or biological elements essential to the species survival and reproduction" (D.P.R. no. 357/97, art. 2, point m). It should be noted that the Directive does not require such habitats to be natural ones – a relevant point for bat protection, given that bats often use artificial habitats such as buildings or mines to meet their biological needs. The Directive defines *habitat of a species* "an environment defined by specific abiotic and biotic factors, in which the species lives at any stage of its biological cycle" (D.P.R. no. 357/97, art. 2, point f). Hence, even a completely artificial site, such as a building which houses an important breeding colony, may be proposed as a SAC.

There is a clear correspondence between the Habitats Directive and Bern Convention. Along with the EC Birds Directive, the 92/43/EEC Directive represents the legal framework under which the rules set by Bern Convention are applied within the European Union. Specifically, the 92/43/EEC Directive implements conservation recommendations concerning species and habitats already addressed by the Bern Convention, through the realisation of the Natura 2000 Network of protected areas. Regrettably, in Italy no sanctions are explicitly stipulated in national law for disturbance of bats or their resting sites, with the exceptions of offences classifiable as environmental damage (see below discussion on L. 349/86).

The Rio de Janeiro Convention

The Convention on Biological Diversity, ratified in Rio de Janeiro on 5th June 1992, was approved by the European Commission through the Council Decision 93/626/EEC and came into force in Italy through Law

14 February 1994, no. 124. One of the Convention's main purposes is to preserve biological diversity, and for this aim Parties are required to produce, or adapt (if already existing), national strategies, plans or programmes. The Convention does not include species lists, but specifies the characteristics which are needed to identify species of interest, such as the conservation status of threatened taxa (Annex I). Therefore, bats certainly represent a biodiversity component which must be targeted for conservation and management according to the Convention's aims. A recent Rio - Bonn Convention joint framework has been implemented, addressing forestry and biodiversity; this is taken into account by the Bat Agreement Action Plan (see par. 3.2.3).

2004/35/EC Directive and D.LGS. 3 April 2006, no. 152

The 2004/35/EC Directive of the European Parliament and of the Council dated 21 April 2004, establishing responsibility for preventing and repairing environmental damage, includes among the definitions of "environmental damage" "all damage resulting in significant negative effects on the establishment, or maintenance, of a favourable conservation status of protected species and natural habitats" (art. 2, par. 1, letter a). All bat species occurring in Italy are covered by this definition because it includes (art. 2, par. 3, letters a, b):

- species in Appendices II and IV of 92/43/EEC Habitats Directive;
- species habitats in Appendix II of 92/43/EEC Habitats Directive;
- reproduction or resting sites of species in Appendix IV of 92/43/EEC Habitats Directive;
- natural habitats in Appendix I of 92/43/EEC Habitats Directive, including habitats playing key ecological roles for bats.

The Directive is enforced in Italy by the D. LGS. 3 April 2006, no. 152, which states (part six): "Norms concerning safeguarding with compensation for damage to the environment". In this case, the "protected species and natural habitats" are those mentioned in L. 157/92 and D.P.R. 357/97 (consequently covered by the above mentioned Habitats Directive).

Directive Appendix I (Appendix IV of D.LGS. 152/2006) lays down the criteria for assessing the extent of damage. They may be easily applied to damage to bat colonies. For instance, the loss of a reproductive colony may be quantified by mentioning the number of bats in the colony and the number of remaining reproductive colonies in the area, as well as recalling the relevant scientific background on the species reproductive biology (e.g. maximum distances between maternity sites needed to maintain viable populations).

The range of applications concerns the professional activities listed in the Directive Appendix III, or all other professional activities, in the case of criminal or blameful behaviour. The objectives to be pursued and the criteria to be applied in making good the environmental damage are also described (Directive Appendix II, corresponding to Appendix III of D.LGS. 152/06).

3.1.2 *Provisions for monitoring*

Several laws highlight the importance of monitoring the status of threatened species, including bats. The Bern and Rio de Janeiro Conventions both require that the Parties adopt all necessary measures to carry out such monitoring within their planning, development and conservation policies (Bern Convention art. 3 and 11; Rio Convention, art. 7). Specifically, some of the Recommendations approved by the Bern Standing Committee emphasise on the one hand the adoption or implementation of national Action Plans in order to improve the conservation status of several bat species, and on the other status assessment for the remaining species by specific monitoring work (Recommendation no. 43, 1995). The same institution has recommended that parties draw up an inventory of the most important underground sites for bats and their characterisation in terms of species diversity and biological role (hibernation, reproduction) and ecological function with respect to migration (Recommendation no. 36, 1992).

The Bonn Convention emphasises the need for trans-boundary collaboration to preserve migratory species (art II, comma 3). It also invites the Parties to stipulate an agreement on periodical assessments of species conservation status, and, more generally, research on their ecology (art V, especially comma 4, points a, b, c, d, l). Finally, it delegates the Scientific Committee (instituted by the Meeting of the Parties) to recommend and coordinate research work (art VIII, comma 5, point b). On the basis of the Agreement on the Conservation of Populations of European Bats, the Parties have to locate the most important bat conservation sites and, more generally, to promote and (as far as possible) coordinate research plans aimed to bat conservation and management. Such activities are set out in an Action Plan periodically updated by the Agreement's Meeting of the Parties (see par. 3.2.3)

So far, Italy has done little to put these recommendations into practice, at least as far as bats are concerned.

Law 157/92 covers the issue of research on fauna very generically.

Among the tasks of the *Istituto Nazionale per la Fauna Selvatica* (INFS) mentioned by this law are "surveying the environmental heritage represented by wildlife, studying its state, evolution and relations with other environmental components; developing plans for restoring or improving animal communities and habitats to improve wildlife conditions in the country, and carrying out and coordinating ringing for scientific aims within the Italian territory" (art. 7, comma 3).

Local institutions such as Regions and Provinces are responsible for plans on game hunting and wildlife (art. 10), whereas the management organs of the *Ambiti Territoriali di Caccia* (territorial hunting areas) promote and organise survey activities of environmental resources and wildlife population size (art. 14, comma 11). No information is given on which faunal components should be considered. Because art. 1 of Law 157/92 specifies that the law enforces the Bern Convention as well as other international laws within the national territory, bats would be expected to feature within the fauna deserving such planning and surveys. However, to date the above mentioned authorities have almost totally ignored bats.

A turning point in this scenario may be represented by the application of the 92/43/EEC Directive. The law enforcing it on the national territory (D.P.R. no. 357/97, modified and completed by D.P.R. no. 120/03) includes more effective rules, explicitly addressing bats and providing well-defined and homogeneous deadlines for the entire national territory. Specifically, art. 7 states that after consulting the Agriculture Ministry (*Ministero delle Politiche Agricole e Forestali*) and the INFS, the Environmental Ministry *(Ministero dell'Ambiente e della Tutela del Territorio*) will produce a decree establishing guidelines for monitoring, removal of individuals and exceptions made for protected species according to the law.

On the basis of such guidelines, the regions and the autonomous provinces of Trento and Bolzano have to adopt measures to protect and monitor conservation status of species of community interest (including all bat species). Such Institutions also have to report annually on the outcome of monitoring to the Environmental Ministry, which in turn has to inform the European Commission by reporting periodically (every six years) on the application of the law (art. 13).

In addition all bat species (mentioned in Annex D of law) are subject to the following rules (art. 8, comma 4):

"Regions and the autonomous provinces of Trento and Bolzano have to carry out a continuous monitoring of captures or accidental killing", submitting an annual report to the Environmental Ministry.

Comma 5 adds that on the basis of the information collected, the Ministry will “promote research and recommend conservation measures necessary to avoid a significantly negative impact on the species considered”. Because of power delegation, monitoring requirements specified in articles 7 and 8 also involve provincial institutions.

Finally, it is obvious that bats, and especially the species listed in Annex B of the Law, should be a priority for conservation-based research in the areas that are actually or potentially part of the Natura 2000 Network. Knowing the ecological requirements of these species is one of the crucial prerequisites to developing correct site management (art. 4, comma 2), as well as one of the main factors to be taken into account when carrying out Incidence Assessment work for all proposed plans or projects involving these protected areas (art. 5). These aspects too should be covered in the annual report submitted to the Environmental Ministry by the administrative organs of Regions or autonomous provinces, as well as in the report submitted by the Ministry to the European Commission every six years.

3.1.3 *Procedure for the authorisation of capture, tagging and captivity of bats*

According to law 157/92, the Regional authorities, after consulting the *Istituto Nazionale per la Fauna Selvatica* (INFS), may authorise the sole scientific institutions of Universities and National Research Council, and Museums of Natural History, to carry out “capture and use for scientific aims” of mammals, as well as removal of their newborns (art. 4, comma 1). The same law sets the rules for captures for the purpose of ringing. As anticipated, INFS is charged with “carrying out and coordinating scientific ringing over the entire national territory” (art. 7, comma 3). Current laws specifically dealing with ringing, however, are only referred to birds (art. 4, comma 2, generically referring to “captures for ringing”, completes the legal framework dealt with by comma 1 and likewise addresses birds). The current legal framework makes no mention of bat ringing, so this activity should be authorised following the same procedure generically adopted for captures aimed for scientific research.

Regional laws have ratified the rules set by the Law 157/92. However, because of subsequent national laws (L. 15 March 1997, no. 59, Decrees (D.l.) 4 June 1997 no. 143, 31 March 1998 n, 112, 18 August 2000 no. 267), several obligations in the field of wildlife management have been transferred from the central State to the single Provinces. Hence, except for a few Regions, applications for authorisation should be submitted to the provincial authorities rather than the regional ones. However, because

Table 3.2 - Summary of main laws and regulations on bat protection and monitoring

Legal requirement	Target species	Source
Killing, capture, captivity or trade forbidden.	All	L. 157/92; Bern Convention (L. 503/81); 92/43/EEC Directive (D.P.R. 357/97); Bat agreement (L. 104/2005).
Alteration or destruction of resting or reproductive sites forbidden.	All	L. 157/92; Bern Convention (L. 503/81); 92/43/EEC Directive (D.P.R. 357/97); Bat agreement (L. 104/2005).
Disturbance to bats forbidden, especially during hibernation or reproduction.	All	L. 157/92; Bern Convention (L. 503/81); 92/43/EEC Directive (D.P.R. 357/97); Bat agreement (L. 104/2005).
Preparation of a report illustrating exceptions to above cases	All	L. 157/92; Bern Convention (L. 503/81); 92/43/EEC Directive (D.P.R. 357/97); Bat agreement (L. 104/2005). (*1).
Protection by designation of pSCIs, SCIs or SACs; adoption, within such areas, of conservation measures.	*Rhinolophus blasii*, *R. euryale*, *R. ferrumequinum*, *R. hipposideros*, *R. mehelyi*, *Barbastella barbastellus*, *Miniopterus schreibersii*, *Myotis bechsteinii*, *M. blythii*, *M. capaccinii*, *M. dasycneme*, *M. emarginatus*, *M. myotis*.	L. 157/92; Bern Convention (L. 503/81); 92/43/EEC Directive (D.P.R. 357/97); Bat agreement (L. 104/2005). (*2).
Monitoring conservation status, inventorying roosts, adoption of action plans or improvement of existing conservation measures.	All	92/43/EEC Directive (D.P.R. 357/97, D.P.R. 120/03) (*2); Bat Agreement (L. 104/2005); Recommendations of the Bern Convention Standing Committee No. 36, 43, 72, 73
Monitoring accidental captures or killing.	All	92/43/EEC Directive (D.P.R. 357/97 (*2);

(*1) Such laws establish that the Environmental Ministry will submit a report to the Bern Convention Standing Committee and the European Commission every two years on the exceptions authorised. The subjects of such exceptions must in turn report annually to the Ministry and the INFS.
(*2) According to such laws, the Environmental Ministry has to report every six years to the European Commission. Regions and autonomous Provinces of Trento and Bolzano will submit an annual report to the Ministry on the cited rules. Other provincial institutions are involved in dealing with such tasks because of power delegation.

bats are protected within the whole EC thanks to the 92/43/EEC Directive, a further licence from the Environmental Ministry is required. After hearing the INFS advice, the Ministry may authorise exceptions to be made to species of community interest (including bats), such as capture, captivity or sacrifice of specimens (D.P.R. no. 357/97, art. 11, comma 1 point e, comma 2). Among the reasons for such exceptions, there are "educational or research aims, re-stocking or reintroduction" (D.P.R. no. 357/97, art. 11, comma 1, point d).

To sum up, the current procedure includes licences to be issued by both regional and provincial organs and the Ministry, after taking INFS advice. This is provided on the basis of a technical report submitted by the applicant, covering well-defined aspects (see Table 3.3). To speed up the process, it is convenient to apply at the same time to local authorities, Ministry and INFS, attaching the technical report to the application. After evaluating the correctness and the merit of methods and aims of the project, INFS will give its scientific advice to both Ministry and local authorities. These will then issue the licence. This procedure might be insufficient when working within protected (national, regional or provincial) areas. In such cases, authorities can refer to regional laws if relevant, and to the rules set for the protected areas considered according to art. 11 of L. 6 December 1991, no. 394 (i.e. the national law on protected areas).

Table 3.3 - Contents of technical report to be attached to the application for the issue of a bat capture licence for scientific purposes.

1. Project title
2. Brief description of project (cite study area, aims, methods and duration of study)
3. Correspondence of project to rules set by the law on bat monitoring and conservation (note A)
4. If applicable – role of the project within the general framework of activities coordinated on a national/international scale (B).
5. Position and affiliation (Institution, Organisation, Firm) of project leader
6. Position and affiliation (Institution, Organisation, Firm) of person responsible for capture (if different from project leader)
7. Position and personal information on capture operators
8. Vernacular and scientific name of species to be captured
9. For each species, number of subjects to be captured (or maximum number planned) and if applicable their sex and class age
10. Geographical location, province where captures are planned
11. Time of year when captures are planned
12. If applicable – specific situations for which a capture stop is planned (C)
13. Description of capture methods and tools – when possible relevant literature

should be cited

14. Bat handling methods – when possible relevant literature should be cited
15. When tagging is planned, description of tagging methods (D)
16. Capture aims and use of captured subjects (immediate release, temporary captivity (E), suppression (F))
17. If suppression is planned, describe general and local conservation status of the species, maximum number of subjects to be captured, expected impact of removing subjects on wild population status (G)
18. If specimens are to be released in the wild, state release place.

NOTES

(A). Specifically, highlight the significance of project with respect to requirements of D.P.R. 357/97 and 120/03.

(B). Highlight project correspondence with Action Plans (I.U.C.N., Bat Agreement, Council of Europe) or other national or international projects.

(C) E.g. inside the roost at hibernation or reproduction time.

(D) If banding is planned, apply to INFS for bands suitable for target species, with an unequivocal serial code. Serial numbers of bands applied should be immediately communicated to INFS (along with species, site and date of banding) to make it possible to store information in a national database and subsequent reporting on the activities carried out as an exception. See also par. 4.5.3.

(E) Keeping bats in captivity should be planned only when research is highly important to understand main conservation aspects and provided suitable housing facilities (including sufficient flight space) are available. Duration of captivity should be short (in any case less than 3 months) and allow for subsequent release of bats at the original site. Such cases do not include captivity aimed to rehabilitate injured bats which may need longer periods.

(F) E.g. for species recognition based on the examination of external morphology and measurements; for taxonomic identification carried out by examining external morphology, taking biometrical measurements and biopsy samples (specify species, numbers of bats involved and type of biopsy); for radiotracking studies (provide information on tags used, tag application procedure followed and permanence time of bats); for ringing; for all other kinds of tagging, etc.

(G) Suppression may be accepted only when indispensable for a research programme of outstanding significance and no valid alternatives are available

Researchers responsible for projects are requested to submit an annual report on the results of their activities and provide information about any problems that occurred during field work. The annual report should include study areas and periods, methods adopted, numbers of bats captured for each species and activity type, as well as bats accidentally injured or killed by capture or handling. The person responsible should declare in the initial capture application their intention of reporting annually on such aspects. As far as banding is concerned, the applicant should ask INFS to provide appropriate bands for the target species, and ensure immediate communication of capture data relative to each ring serial code employed.

3.2 **International Action Plans**

3.2.1 *General I.U.C.N. recommendations*

The I.U.C.N./S.S.C. *Chiroptera Specialist Group* has published a Microchiropteran Action Plan (Hutson *et al.*, 2001). The general conservation guidelines recommend including, at a national level, the protection principles defined by the international laws (Bonn and Rio de Janeiro Conventions, and – for the countries involved – Bern Convention and 92/43/EEC Directive). The document recommends that existing information be re-examined and new data acquired on bats included in the I.U.C.N. Red List, covering species threatened with extinction, as well as developing Action Plans to ameliorate their conservation status. When planning research activity, priority should be given to threatened species in the study areas for which insufficient information is available. The document also recommends ascertaining local conservation status of species not included in the Red List, and carrying out conservation policies supporting locally rare or threatened species while preserving a favourable conservation status for the others, first of all taking into account endemisms.

Research topics in need of development addressed by the document include: application of bioacoustics to monitoring, foraging requirements, population trends and viability, role of bats in ecosystem functioning, and ecological requirements for roost selection (necessary to both effectively manage existing sites and create new sites). For taxa of problematic definition, it is hoped that revision work will be carried out based on modern techniques of taxonomic investigation. As far as habitat protection is concerned, it is highlighted that ecological needs of bats should be considered by local policies and planning tools. Specifically, databases of underground sites are needed, including information on site suitability for bats and factors affecting it. Bat sites should be subject to long-term monitoring. Further technical details are given in the IUCN Cave and Karst Conservation Guidelines (Watson *et al.*, 1997). Finally, the document emphasises the importance of disseminating information and promoting public awareness of bat conservation.

3.2.2 *Specific Action Plans*

The Microchiropteran Action Plan covers 20 species. These are not necessarily the most threatened ones: they have been selected because well known and representative of the wide range of conservation problems affecting bats. Two such plans are devoted to species occurring in

Italy, *Rhinolophus ferrumequinum* and *Miniopterus schreibersii;* another concerns *Myotis dasycneme*, whose presence in Italy is only registered in one record dating back to the second half of the nineteenth century. For *Rhinolophus ferrumequinum* and *Myotis dasycneme*, further specific Action Plans are available, issued by the Council of Europe as an initiative stemming from the Bern Convention. The following list summarises the research and monitoring issues, with conservation implications, recommended by the *R. ferrumequinum* and *M. schreibersii* Action Plans. For further information see the full texts of the documents (Ransome and Hutson, 2000; Hutson *et al.*, 2001).

Rhinolophus ferrumequinum

- Population trend survey and monitoring: counts at hibernacula and reproductive roosts. For the latter, a standardised study design is recommended.
- Observations on maternity colony structure and effect of climate on a selected sample of reproductive colonies.
- Feeding ecology: diet (little information available especially on southern European populations), foraging habitat selection.
- Effects of environmental changes on populations (biomagnification of pesticides or heavy metals, land use change, etc.).
- Interspecific interactions between bat species (especially competition).
- Genetic studies: population genetic variation, reproductive strategies, dispersal.

Miniopterus schreibersii

- Movements/migration and ecological requirements during such phases.
- Population trend surveying: counts carried out on a selected sample of hibernacula and maternity roosts. Analysis of effects of land use change on population dynamics and size .
- Feeding ecology: diet, foraging habitat selection.
- Reproductive biology and implications for conservation.
- Genetics: verification of taxonomic status.

3.2.3 *The Bat Agreement Action Plan*

Within the enforcement of the Bat Agreement, coordinated by a Secretariat through periodical Meetings of the Parties and an Advisory Committee, an Action Plan has been developed designed to implement effective bat conservation strategies. This is updated on the occasion of each Meeting of the Parties. The Action Plan includes legal measures as well as research and monitoring initiatives coordinated on an international level.

The following section summarises all aspects considered in the 2003-

2006 Action Plan:

1) Legal requirements

- To enforce and put into practice art. III of the Bat Agreement, the parties will adopt legal measures, or improve those already existing (see 3.1.1).

2) Population surveys and monitoring

- The Parties should improve the information available on bat geographical range and population trends within their respective territories, improve experimental protocols, recognise and emphasise the importance of long-term monitoring. Given the difficulty of obtaining data on all bat species, the following are those for which it is most urgent to start collecting data: *Rhinolophus ferrumequinum, R. hipposideros, Myotis blythii, M. bechsteinii, M. capaccinii, M. dasycneme, M. myotis, Eptesicus nilssoni, E. serotinus, Nyctalus noctula, Miniopterus schreibersii.* Advice on the most appropriate survey methods are given in the Eurobats document MoP2.5 (Resolution no. 2) and, concerning *R. ferrumequinum* and *M. dasycneme*, in the corresponding Action Plans (see 3.2.2). On the basis of the experience obtained in each nation, by 2006 the Advisory Committee will produce guidelines on bat monitoring methods.
- The Advisory Committee will complete the acquisition of information on migration routes of European bats, especially those obtained from the project on *Myotis dasycneme* and *Pipistrellus nathusii*. By 2006, it will also give recommendations to optimise future research efforts and migratory species conservation.
- As established in the Agreement, the Parties should complete and disseminate the results of studies on the ecology of priority species. The Parties are currently requested to work especially on seven Mediterranean species, three identified as deserving special attention *(Rhinolophus euryale, Myotis capaccinii* and *Miniopterus schreibersii)*. Research should cover: survey protocols, reproductive strategies, foraging habitats and diet, migrations/moves, roosts, health problems.
- The Parties should identify species working as bioindicators of forest habitats, this aspect being especially important to carry out sustainable forestry.

3) Roost

- By 2006, the Advisory Committee should publish guidelines on conservation and management of underground roosts.
- The Advisory Committee should collect and disseminate information on the methods adopted to protect roosts other than underground,

priority being assigned to those located inside buildings of outstanding cultural value.

- The Parties should produce or complete inventories of main underground roosts (both natural and artificial, including those in buildings) and communicate the data in time to conclude the general inventory work by 2006.

4) Foraging habitats

- The Parties should carry out work designed to locate main foraging areas close to breeding colonies of national or international significance. The Advisory Committee should inform the Parties on the best methods to conduct such investigations.
- When programming management or landscape planning (especially when these involve foraging areas or linear landscape elements providing landmarks for commuting between roosts and foraging sites), the Parties should take into account the need to protect bat habitats. National guidelines on this issue have to be prepared. The Advisory Committee is asked to prepare a general outline to help in the production of national documents.

5) Information/public awareness promotion

- The Parties are responsible for the dissemination/ public awareness of bats and their conservation.

6) Pesticides

- The Parties have to carefully take into account the impact of remedial timber treatment on bats, especially when new products are tested.
- The Advisory Committee must deal with the impact of anti-parasite drugs used for livestock farming on bats and produce a report by 2006.

7) International co-operation

- The Parties and all states within the geographical range of the Bat Agreement should cooperate in carrying out the above actions.
- The Secretariat and the Advisory Committee must act to include bat conservation among the issues of sustainable forestry during the upcoming Ministerial Conferences on the Protection of Forests in Europe.

For some of the above aspects, further points are detailed in specific Resolutions agreed by the Meeting of the Parties. For their conservation significance, it is worth emphasising Resolutions 4.3 (providing guidelines on protection and management of important underground bat habitats) and 4.4. (dealing with bats and sustainable forestry), both produced during the Fourth Session of the Meeting of the Parties (Sofia, 2003). The former requires that besides inventorying all important underground sites, the Parties will adopt all measures necessary for their legal protection and, where appropriate, set up physical barriers to avoid unauthorised access to sites. Under Resolution 4.4, at the next Meeting the Parties will report on the following points: forestry and land use practices threatening forest bats; efforts made to increase sustainability of forestry; improvement schemes for bat conservation in forests; location, management and improvement of key elements (e.g. wetland, old trees, roost trees) and areas (e.g. wet forests, mature forest stages) for forest bats.

Furthermore, it is worth mentioning also resolution 4.7 (on wind turbines and bat populations), following the more general resolution 7.5 (on wind turbines and migratory species) adopted by the Meeting of the Parties of Bonn Convention. The document recommends assessing the potential impact of wind turbines on bats, specifically taking bats into account when planning the location of wind farms with respect to migration routes and critical areas for bats.

For more detailed information and updates see http://www.eurobats.org/

4. Survey techniques and methods

D. Russo

4.1 **Bat counts**

One of the basic (but by no means the simplest!) aims of a conservation-oriented bat study is to provide estimates of population size for a bat species occurring in a certain area. This information is crucial to establish which species are most threatened and to analyse the trend over time, objectives commonly featuring in international directives and national laws (see par. 3.1.2). In some cases, it is useful to estimate relative abundance from data collected by mistnetting in foraging areas or by acoustic surveys; such aspects are dealt with below (par. 4.8). In this context, we will examine the methodological aspects of roost counts, representing the commonest survey type in bat studies, as well as the objective of a nationally-coordinated monitoring activity in Italy (see Appendix 1).

4.1.1. *Roost counts*

The term “roost” is used to indicate a site used by bats to rest, mate, give birth, nurse the young or hibernate. Roost counts are useful above all for estimating bat population size in a given area. Many species are highly gregarious and some roosts are home to thousands of bats (Kunz, 1982). Bats may be counted either by entering the roost (Kunz, 1982; Agnelli *et al.*, 2001) or by staying outside and observing their evening emergence (Swift, 1980; Agnelli *et al.*, 2001). The former approach has a much bigger impact on bats in terms of disturbance. Once the main bat roosts (i.e. those used by large colonies) have been located, bat numbers may be counted – or estimated, depending on the situation – to obtain a reliable assessment of population size in the study area.

Excellent situations are often represented by bat nurseries, as well as by main hibernacula (roosts where bats overwinter). Synchronous counts (or, at least, counts made within a short period of time) at several roosts may avoid the risk of performing double counts, especially outside the hibernation time – i.e. when movements across roosts may be quite frequent. Bat density may be expressed by summing colony sizes ascertained at the roosts surveyed in a given region and dividing this figure by the surface area of the region surveyed (Kunz *et al.*, 1996).

4.1.1.1 Locating roosts

A good knowledge of roost occurrence in the area of interest is needed to make the most of the above techniques. Locating roosts requires a careful survey of the area under investigation. Local inhabitants, or cavers, can often provide excellent information, especially for locating buildings or caves used by bats.

The presence of bats at a site is often revealed by droppings or prey remains; these are especially conspicuous at roosts other than hibernacula. Non-specialists may easily confuse bat droppings (Figure 4.1) with those of rodents. Unlike the latter, however, bat droppings are made up entirely of tiny chitinous fragments of arthropod exoskeletons. In rare cases, droppings of *Myotis daubentonii* (e.g., Brosset, 1975; Siemers *et al.,* 2001) and *Myotis capaccinii* (Biscardi *et al.,* 2001) may contain fish remains, whereas those of *Nyctalus lasiopterus* may include fragments of bird feathers (Dondini and Vergari, 2000; Ibáñez *et al.*, 2001).

Unlike rodent faeces, those of bats are generally not scattered, but found concentrated on the ground corresponding to where the bats roost. In some circumstances, species such as *M. daubentonii* hang under bridges along rivers during pauses from hunting (*night-roosting*). In these cases, droppings adhere to the surface where bats have hung (D. Russo, *pers. obs.*).

The occurrence of droppings also reveals the presence of bats inside holes or crevices. Once droppings on the floor are noticed, the corresponding opening on the ceiling is likely to represent the roost entrance. In this way, it is easy to locate day roosts of *M. daubentonii*, often crevices in bridges (D. Russo, *pers. obs.*).

Figure 4.1 – Bat droppings are easily identified because they are almost entirely made up of arthropod prey remains, making them particularly brittle (photo by D. Russo).

Prey remains (legs, wings, etc.) may be found in both day and night roosts. *Plecotus* bats and rhinolophids dismember larger prey items, particularly moths, and remains (especially wings) accumulate on the ground corresponding to where they hang to deal with their prey (Jones, 1990; Schober and Grimmberger, 1997; Swift, 1998).

When inspecting a potential roost site it is possible that no bats, or signs of their presence, are found. In this case it is advisable to visit the site again in a different period of the year. In fact sites may be used by bats just for part of the year, because certain features (structure, micro-climate, etc.) are most suitable during hibernation or during the activity period (i.e. in the warm season).

Tree roosts may be revealed by a dark stain along the trunk or branch from the occupied cavity. However, in some cases such traces are in fact produced by rotted matter percolating down from cavities in the tree during rain. On the other hand, many bat roosts show no such signs. Structurally ephemeral roosts, such as the space beneath loose bark, are especially difficult to discover. In some cases, generally concerning old hollow trunks, droppings may accumulate at the base of the trunk and be readily visible. The nurseries of the common noctule (*Nyctalus noctula*) are revealed immediately prior to emergence when these bats emit conspicuous high-pitched vocalisations. This vocal activity generally peaks during the hour preceding emergence, although calls are produced all day long once the young are born (D. Scaravelli, *pers. com.*). Loud, audible calls are also emitted by roosting free-tailed bats *Tadarida teniotis* (Zava and Lo Valvo, 1991).

Radiotracking may be effectively employed to reveal roosts in buildings, rock crevices or trees (see below). Especially when several investigators equipped with bat detectors are available, bats may be back-tracked at dawn to their day roosts (Boonman, 2000). The operation is made simpler by the fact that bats often congregate and keep flying around the roost before entering it. This approach proves useful to locate roosts both in trees and also in buildings.

4.1.1.2 Bat counts inside the roost

When adopting this technique, useful for cave- and house-dwelling species which do not roost in crevices, it is important to minimise disturbance. For instance, it must not be used when the young have been born. If adults are scared by the presence of an observer, their sudden take off may accidentally make non-volant juveniles fall to the ground, seriously prejudicing their survival. If the objective is to count juveniles at a reproductive site, one should wait outside the roost until the adults have emerged and then enter for as short a time as possible, making the count before adults return (Kunz *et al.*, 1996). Repeated bat counts inside a nursery roost may force the colony to abandon the site even before the young have been born.

Counts at hibernacula may also affect bats. Even non-tactile disturbance (i.e. the mere presence of the investigator inside the hibernaculum) may cause arousal from lethargy, determining a larger consumption of fat reserves (Thomas, 1995). This consumption may be considerable: for example, in *Myotis lucifugus*, it corresponds to 108 mgs of fat, providing the energy necessary to survive 68 days in torpor (Thomas *et al.*, 1990). When performing such counts, the investigator has to keep silent and employ a weak, "cold" light source, to avoid affecting roost micro-climate (not for example the acetylene lamps commonly fixed to cavers' helmets). Red filters mounted on lamps may make the impact of light less harmful to bat colonies (Thomas *et al.*, 1979).

Small colonies, especially of bats which are not associated in clusters, may be easily counted by eye. Large clusters are far more problematic (Agnelli *et al.*, 2001): in such cases, counts may be performed from photographs taken of the colony. If bats do not form multi-layer clusters, counts from photos are relatively easy; otherwise, only the individuals exposed will be counted, providing a *minimum* colony size. Single bats may be marked on digital photos with a graphic software package to facilitate the counting operation (Agnelli *et al.*, 2001). For especially large clusters, colony size can be estimated by assessing the number of bats in one or more parts of the clusters, and then extrapolating the number of bats present to the entire cluster surface. If, due to variation in clustering density, different numbers of bats are estimated for several surface samples of the cluster, maximum and minimum values may be calculated and used to obtain an estimated range of colony size (Agnelli *et al.*, 2001).

Taking photos will inevitably increase disturbance, so care is recommended. If the colony is made up of several species, the operation is obviously more difficult. It is the investigator's responsibility to assess the feasibility of this approach in terms of technical limits (possibility of identifying species from a distance, risk of confusion due to the co-occurrence of several species, accuracy of the record, etc.) and ethical problems (disturbance to bats) posed by the specific situation. Hibernating bats may only be counted by inspecting the roost. To limit disturbance, it is advisable to carry out as few counts as possible, even just one per year (Thomas, 1995). The best period for this is the coldest winter month (generally January). To obtain trends over different years, it is necessary to repeat the count in the same period every year.

4.1.1.3 Evening emergence counts

This approach is far less invasive than the one described above, and may be applied to all roosts other than hibernacula when exits are few and easily surveyed. One or more investigators will wait near the roost exit(s) before bats leave the site, and count them on roost emergence. The number of people involved will have to be sufficient to check all available exits (Kunz *et al.*, 1996; Shiel and Fairley, 1999). The method may be applied whenever the bat silhouette is easily distinguished against the sky, but is more problematic when the background is vegetation (Kunz *et al.*, 1996). Counting species roosting in cliffs or rocks emerging from the sea, such as *T. teniotis*, may require the use of a boat (Zava and Lo Valvo, 1991). Repeated counts may help determine the actual colony size, to compensate for number variation across days. Bats remaining inside the roost, and especially non-volant juveniles, are overlooked. There are generally few adults which do not leave the roost. If no considerable risks of disturbance are foreseen, the total colony size may be recorded by combining the emergence count and a site inspection following emergence to count the bats still inside.

For a successful emergence count, species should be unambiguously identified and bats returning to the roost during emergence should be counted and subtracted from the total colony size recorded. Bats often return to the roost at around emergence time on account of behaviour known as "light sampling" (Erkert, 1982), when they sample light conditions and decide on the best moment to leave. In such cases, bats make short flights, often circling a few metres away from the roost, and re-enter.

Tally counters such as those used to count wildfowl may help record the number of emerging bats. For colonies of less than a few hundred bats this method provides accurate results (Swift, 1980). However, for colonies larger than 500 bats, the accuracy seriously diminishes (Kunz, 1982; Barlow, 1999).

Bat detectors may help in counting the emerging bats, especially at low light levels. Moreover, they may help tell different species apart if their calls are easily distinguishable. A simple heterodyne bat detector will greatly help, say, in distinguishing between *Rhinolophus euryale* and *Myotis emarginatus* sharing a roost. Because rhinolophids and vespertilionids emit clearly different calls, the former will be told apart from the latter by listening to the unmistakable warbling sound of their calls detected at ca. 100 kHz.

Bat detectors linked with a data logger may be used to assess activity automatically, i.e. even in the absence of an observer: in this case, all passes will be recorded. Clearly, not only will bats actually emerging be counted, but also those performing light sampling or returning to the roost. Moreover, clustered emergence will make counting problematic. This approach may be useful in particular to provide a relative activity index (Thomas and La Val, 1988).

Night scopes or infra-red videocameras may greatly help counts (Sabol and Hudson, 1995; Debernardi and Patriarca, 1999). Relatively cheap hand-cameras offering a so-called night-shot function are available today, and may be successfully employed for emergence counts. Bat numbers may be conveniently recorded viewing the tape in the laboratory, slowing down the sequence or stopping it when necessary. Moreover, a bat detector may be connected to the audio input of the videocamera, to acoustically highlight the emergence of each bat. When studying emergence behaviour, data are often expressed as the number of bats emerging per minute or every five minutes. The emergence time of the median bat is often assumed as a reliable indicator of emerging behaviour and allows for comparisons between different colonies, times and species (Oxford *et al.*, 1996; Barlow, 1999; Shiel and Fairley, 1999). Repeated counts during the season may be used for investigating emergence data in relation to sunset time and other environmental variables (cloudiness, light level, ambient temperature). Such studies offer interesting opportunities for amateur researchers working on bats (Richardson, 1985).

If the colony is made up of one species only and evening emergence involves only one or few exits, photo-electric beams connected to a data logger may be positioned by each exit. When a bat crosses the light beam, an electric signal is generated and recorded by the data logger. Two or several such beams may help count returning bats too and avoid double counts (Thomas and La Val, 1988). One problem difficult to obviate is that of birds such as sparrows and pigeons using buildings (attics) where bats roost are also counted. Clustered emergence of bats may be counted as a single object crossing the beam, leading to underestimation of colony size (Thomas and La Val, 1988). Under good conditions, however, this method allows detailed information to be collected on time patterns, colony size and emergence activity. Advantages include full 24-hour recordings and the possibility of recording data in the absence of an operator.

4.2 **Bat capture and handling**

4.2.1 *Why capture?*

For several bat species, identification is only fully reliable when a bat is examined in the hand. Only in this way will it be possible to observe discriminant morphological features and take-diagnostic measures. When surveying an area to obtain a species inventory, captures are much more effective than acoustic techniques for detecting species which emit calls that are weak, prone to severe atmospheric absorption (*Plecotus* spp., *Rhinolophus* spp.), or difficult to identify (e.g. several *Myotis* species). Species flying high up, such as *Nyctalus* spp., are difficult to capture but generally easy to detect with a bat detector. However, a well set mistnet may also prove effective in catching them (see e.g. Rachwald, 2001, for *N. noctula*). Of course, captures are necessary when the object of the operation is obtaining data concerning morphology, biometry, genetics, biomechanics or parasitology, or to fit the bat with a tag, ring, etc.

4.2.2 *Capture tools*

In some cases, bats may be simply caught by hand in the roost, if their position is accessible and especially if the operation does not mean disturbing other subjects (Agnelli *et al.*, 2001). The animals should be removed by gently lifting them up towards the point where their feet are attached. By doing so, the bat's legs will not be pulled or stretched, and toes or nails will not be harmed. We give recommendations about how to handle bats below. In most cases, however, a capture tool is needed.

4.2.2.1 Hand-nets

Especially when capturing at roosts (see below), a hand-net may be useful, particularly if mounted on a telescopic pole. The nets used for butterflies are generally suitable (Agnelli *et al.*, 2001) because they avoid the bat getting tangled. For this reason, the hand-nets used by fishermen should be avoided. Once a bat is caught, the hand-net should be rotated so that the opening is placed vertically. In this way the trapped animal will not escape. The bat has then to be removed immediately. It may be convenient to lay the net on a horizontal surface, such as the ground, and carefully insert a hand through the opening to extract the bat (if the hand-net is opened before the bat is securely held in the hand, it may well escape). Hand-nets should only be used to catch static bats, such as those hanging from the ceiling. Never use them to catch bats in flight: although this is technically possible (Churchill, 1998), there is a high risk of hitting the flying bat with the net frame or pole, injuring or even killing it (Finnamore and Richardson, 1999).

4.2.2.2 Funnel-and-bag traps, bag traps

Also known as cone-traps (Finnamore and Richardson, 1999), these tools are very useful to catch bats leaving the roost when they exit through a small opening (such as in some buildings or tree cavities). A "funnel", or a cylinder of variable size, may be made out of polythene sheets stuck together with adhesive tape. One of the extremities of this structure is mounted on a metal frame (such as that of a hand-net) and positioned around the roost exit. At the opposite side, a cotton bag will be placed to contain the bats crossing the funnel. When a bat leaves the roost, it is led by the funnel to the bag. A slightly different tool is represented by the bag-trap (Gaisler, 1979; Agnelli *et al.*, 2001). In this case the part to be placed near the roost exit is made of a rigid frame sustaining a set of nylon threads. The bats hit the threads and slide into the bag placed below. In all cases, all bats caught must be removed immediately.

4.2.2.3 Mistnets

Mistnets used for bats are similar to those employed by bird netters, although they are thinner to make them less conspicuous to bats' highly sensitive echolocation system (Kunz and Kurta, 1988). The material employed for bat nets is generally nylon or terylene. Thread diameter ranges from 50-70 denier (denier = mass expressed in grams of 9,000 m of fibre). Threads are made of two thin elements woven together. Mesh size (= distance between two diagonal corners in the mesh of a stretched net) is generally 32-38 mm. Some manufacturers measure mesh size as the distance between two consecutive nodes in the mesh. In such cases, the range will correspond to 16-19 mm. It is advisable to ask which definition of mesh size is adopted by the manufacturer before ordering a net. Prior to selling such nets, many manufacturers require a copy of the capture licence (issued according to the laws of the country in question).

The net is supported by a multi-element frame of thick horizontal and vertical threads. The horizontal ones sustain pockets (generally four in bat nets; Finnamore and Richardson, 1999). Nets available from several providers may be specifically made for bats. They have reduced pockets to facilitate extraction of caught bats. Several net sizes are available. Lengths preferred by bat specialists are 6, 9, 12, or 18 m, depending on capture situations. Net height is generally 2-2.6 m. When a flying bat hits the net, it falls into the pocket, which opens on impact. Nets are erected by attaching their vertical sides, provided with cotton or nylon loops, to a pair of vertical poles (best if telescopic). Poles may be fixed to the ground by means of ropes secured to tent pegs or trees, rocks, etc.

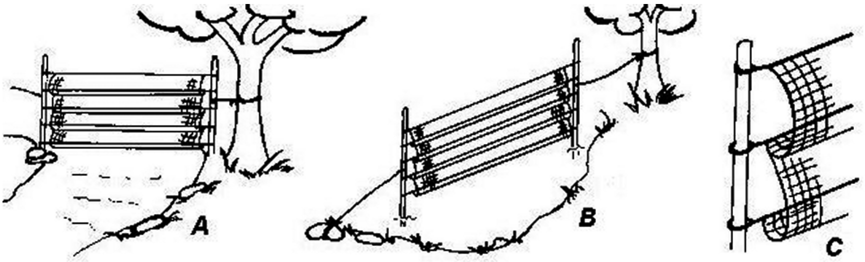

Figure 4.2 - How to erect a mistnet: a – net set across a stream; b – net set up along a stream bank; c – close-up of a mistnet pocket (drawings by R. Chirichella).

Mistnets are most often used to catch bats in foraging areas, at drinking sites or along favourite commuting routes (such as sites close to roosts). Bats in small colonies may be caught with a mistnet on roost emergence. The use of mistnets in foraging areas and the correct way of extracting the bats are dealt with below.

Mistnets are relatively cheap, easy to transport and may be adapted to different situations; moreover, they may cover large surfaces. Their main disadvantages lie in the fact that the bats may get tangled up, making extraction difficult, stressful or even harmful (Finnamore and Richardson, 1999). Moreover, nets may be easily damaged by a biting bat (Figure 4.3).

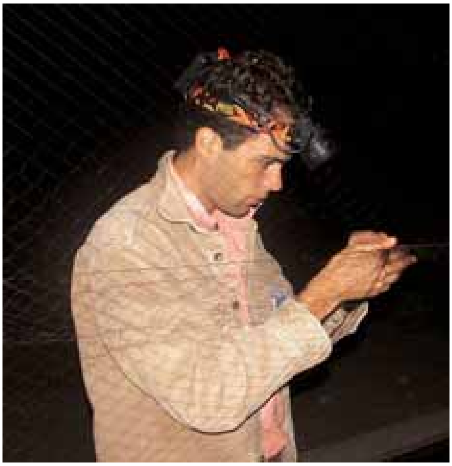

Figure 4.3 - Extracting a bat from a mistnet needs attention to avoid the bat being stressed or injured. Headlamps are useful to leave both hands free to handle the bat (Photo by G. Jones).

4.2.2.4 Harp-traps

Harp-traps are made of two parallel metal or wooden frames positioned vertically, generally supported by legs (Kunz and Kurta, 1988). Each frame sustains a set of vertical and parallel nylon threads (fishing line). A fabrics bag is placed beneath the frames (Fig. 4.4.). The bag opening is provided with two sheets of slippery material (such as polythene or waxy fabrics) needed to trap the bats inside the bag. The two sheets are folded inside the bag and are very slippery for bats, whereas the remaining inner bag walls are covered with rough fabrics on which bats may climb. When a flying bat hits the threads, it falls into the bag. Then it either stays on the bottom or climbs up the bag wall until it stops beneath one of the folded sheets. These have to be lifted cautiously to extract the bat.

Figure 4.4 - A harp-trap set near a bat roost exit. Flying bats hit the nylon threads and fall into the bag, from which they can be easily removed (Photo by G. Maglio).

The bag may end up containing many bats. It is advisable to remove bats periodically to avoid them finding a way to escape or overcrowding (some bats may bite and seriously injure others). If several bags are available, the one containing the bats may be replaced with another to remove the bats trapped without interrupting the capture. Harp-traps are very useful especially when catching bats on roost emergence, whenever this is through a small opening. Although several sizes are available, they may not cover areas as large as those covered with mistnets. They may be successfully employed along narrow flight corridors (Finnamore and Richardson, 1999), or in dense vegetation, and in forest may be raised with ropes and pulleys to catch at canopy height. Harp-traps are far less stressful for bats, and less easily detected even by the highly manoeuvrable species which are very sensitive to obstacles such as rhinolophids and hipposiderids (Kingston *et al.*, 2000). Capture success depends upon the bat's speed and body mass, as well as on the thread tension. The latter may be adjusted using screws connected to the tool's frame. When threads are too tense, bats may bounce back off them, while loose threads often get crossed. EUROBATS (Resolution 4.6. of Fourth Session of 2003 Meeting of Parties) recommends leaving some space free when setting traps near underground roosts (caves, tunnels) so that the exit is not completely blocked. Likewise one should avoid setting the trap on flight paths traversed by birds or bats at high speed.

Harp-traps cover only a small surface, making them less effective at open sites. Moreover, they are expensive and not easy to build. Finally, although they are easy to dismantle for transportation, they are quite cumbersome.

4.2.3 *Capture situations and techniques*

Capturing bats is inevitably invasive and should be carried out only by experienced operators licensed according to national laws (see paragraph 3.1.3). It is good practice to capture bats only when necessary, i.e. when other, less invasive methods are not sufficient or suitable. Of course we refer to temporary capture, because killing bats is almost always unacceptable in terms of ethics and conservation, as well as pointless from the scientific point of view. The only exceptions are specimens collected as essential reference samples, as long as these are for museums granting durable and correct preservation, and full access to specialists. Two different capture situations are described: at roost sites, and in foraging areas.

4.2.3.1 Captures at roost sites

These are often problematic, especially when the roost is used by large numbers of bats, or when reproductive colonies are present. As mentioned above, bats may either be caught on evening emergence, or inside the roost in the daytime. The former option is preferable because bats are less disturbed. In the breeding season (May to August) do not enter the roost, because this would cause stress to adult bats, harm juveniles and in general elicit a negative reaction in bats which may even result in site abandonment. If it is necessary to enter the roost (e.g. to count non-volant juveniles or set up measurement tools), do so after the adults have emerged. Stay inside only for the time it takes to accomplish your task, and be certain to leave before the adults get back.

Bats may be captured inside the roost by hand or with a hand-net mounted on a telescopic pole to reach the subjects roosting high up. Never capture during hibernation. As mentioned above, even a mere visit to a hibernating colony needs care to avoid their arousal – inevitable when a torpid bat is captured (Speakman *et al*., 1991). Hand-nets may also be of use to catch a few bats exiting through a narrow opening, or a roost exit located high up such as in tree cavities, crevices in a wall, a small window, etc.

In most cases, it is preferable to set up mistnets, or even better, harp-traps, outside the roost (or, if possible, at a distance from its exit). It may also be possible to catch in the neighbourhood of the roost rather than close to the exit. This will reduce disturbance (Bontadina *et al.*, 2002). The capture tool employed should not cover the entire exit, but leave some free space. Capture should only take place once, or at most a few times, in the same year. Mistnets may be used only when dealing with small colonies, otherwise the likely outcome is dozens of bats getting tangled at the same time, leading to an unmanageable situation and a high risk for bat safety. Although harp-traps cover a smaller surface, they are much better in these situations. Unlike mistnets, harp-traps may be easily removed if the number of bats exiting the roost is too large to manage. The above-mentioned funnel-and-bag traps are most suitable for capturing bats at roosts characterised by a small exit, such as crevices or tree cavities. From experience of capturing *Chalinolobus tuberculatus* exiting tree cavities in New Zealand forests, Sedgeley and O'Donnell (1996) conclude that harp-traps had no influence on bat behaviour (i.e. number of days a given roost was used, or emergence time).

Sometimes it may be necessary to catch a few subjects to identify the species occurring at a roost, especially if bat detector-aided identification has proved problematic. If preliminary bat detector work has suggested the presence of one species only, then a single subject may be captured for reliable identification, minimising disturbance.

4.2.3.2 Captures at foraging or drinking sites, or along flight paths

In such situations, either mistnets or harp-traps may be used, although the former are much more popular because they grant a higher capture success. We will limit our discussion to mistnets. Proceed as follows:

1. Once a mistnet is erected, the investigator may wait near one of the poles. Do not make noise or keep lights turned on. A bat detector set on frequency division may help reveal approaching bats (put headphones on to avoid unnecessary noise). Check the net continuously to avoid the bats getting so tangled that extraction is difficult. Be ready to extract the bats quickly: once in the net, they may move a lot and bite, so in a short time they will be stressed and difficult to free. Moreover, bats may cause large holes in unattended nets and escape, or fall victim to predators.
2. A head lamp is indispensable to illuminate the bat in the net and leave the hands free. Should extraction be too difficult, use small scissors to cut a few threads. Once a bat is in the net, first work out from which side it got in. Then move to that side and open the net pocket contain-

ing the bat. Should the bat be so high up in the net as to make handling difficult, lower the net to reach the bat comfortably and extract it. There are no rules valid for all situations. In general, gently hold the bat with one hand, and free the bat's feet first (they are generally the last part of the bat to enter the net), then the wings, and finally the head. As each of these parts is freed, the hand keeping the bat still should hold them to avoid them getting tangled again. The wings are generally the most difficult part to extract, and great care must be taken to avoid harming the bat. If a wing is tangled, try to unfold it to open the meshes blocking it: this will help show how the wing got tangled and facilitate extraction. Lowering the tension of the net area where the bat is tangled will be of help. Let the bat bite a cotton bag, a glove or similar (Kunz and Kurta, 1988): this will help you work better. Should the bat bite you, do not pull it and avoid incautious movements which may harm the bat. If you want the bat to stop biting your finger, blow on its muzzle (sometimes this is the only way to free a cotton bag it is biting!). Wear gloves if possible, especially when working with larger species. Some bat workers do not feel at ease wearing gloves because it complicates handling. At least wear one thin glove on the hand used to hold the bat, especially when working with large species (such as *Rhinolophus ferrumequinum*, *Nyctalus* spp., *Eptesicus* spp., *Myotis myotis*, *Myotis blythii*, *T. teniotis*); bites may be painful and may also transmit disease.

3. Mistnets may be placed in a variety of situations and habitats. Experience is needed to recognise the more promising spots. Best catches are generally obtained over rivers, lakes and ponds, which are main foraging habitats (Vaughan *et al.*, 1997a). They are also frequented for drinking by bats foraging elsewhere. Avoid setting up the net in open space. A surrounding vegetation tunnel may hide the net and lead the bats to it. Nets may be successfully erected beneath bridges crossing rivers. However, make sure no crevice or cavity in the bridge is home to a bat colony, otherwise at emergence time the net will fill with bats, making extraction problematic. To avoid bats passing beneath the net, leave its lower edge close to the water, but also leave enough space to avoid tangled bats going underwater and drowning. Be aware that the water level may change overnight. Wear wellingtons to avoid getting wet while reaching a caught bat. Make sure the water is shallow enough to reach all sectors of the net comfortably. In rivers and streams, look out for water turbulence, wit the risk of falling – moving in the dark and walking on slippery surfaces, muddy or rocky substrates does not make things easier!

Two or more mistnets may be attached to the same poles one above the other to reach greater heights and increase capture rates for species flying higher up. When netting at riparian sites, the net is generally placed across the river bed. Nets may also be erected near riparian vegetation, where several species forage and may be caught. Forest trails, corridors and edges may offer good chances of capture. Is some cases, two nets may be placed in a "V" shape: one net will deviate the bat's trajectory, the other will catch it. This effect may be enhanced using three nets in a "Z" shape. To catch bats beneath forest canopy, so-called canopy nets may be employed. These are raised to tree branches by means of ropes and pulleys. For details on how to use nets in forest, see Diks *et al.* (1995). Preliminary bat detector surveys of the area where one intends to set the net will help identify main flight paths and improve setting up the net. Experience is crucial to enhance success.

4. Nets should be erected at sunset; it is best to open them when diurnal bird activity is low to avoid bycatches, but before early flying bats are active. In Italy, these are especially *Pipistrellus kuhlii*, *P. pipistrellus* and *Hypsugo savii*. Mount the mistnet when it is still light, and close it with strings. It will then be easy to open the net at the right moment. Bat activity is often bimodal: a first activity peak starts soon after dusk, and continues over 2-3 hours. Then activity decreases, sometimes dramatically, before a second peak, shortly before dawn, generally smaller than the first (Gaisler, 1979; Erkert, 1982; Rachwald *et al.*, 2001).
   Capture success is strongly influenced by environmental conditions. When ambient temperature decreases, so does insect prey density, and hence bat activity. This effect is apparent below 10°C. Rain affects bat activity. Russo and Jones (2003) found that increased wind speed corresponds to a marked decline in *M. daubentonii* and *M. capaccinii* activity. In some neo-tropical regions, moon phase influences bat activity (and in turn capture success), the latter being lowest on moonlit nights (Morrison, 1978; Fleming and Heithaus, 1986), on account of the higher predation risk. Recent work carried out in the US (Negraeff and Brigham, 1995), U.K. (Vaughan *et al.*, 1997a) and Italy (Russo, 2001; Russo and Jones, 2003) has failed to observe this relationship. Reiterated captures at the same site may result in reduced capture success. In fact, bats may locally learn to avoid the nets.
5. For the sake of completeness, it is worth mentioning that nets may also be used in a "dynamic" way. They may be dropped from a bridge and manoeuvred by two people sustaining the poles, with at least one

other person ready to extract the bats from the nets. In other circumstances, one net pole may be fixed to the ground and the other manoeuvred by an operator who keeps the net surface horizontal (Kunz *et al.*, 1996; Finnamore and Richardson, 1999). When an approaching bat tries to cross the area, the operator will flick the net and catch it. Another person should be ready to free the bat. A further option consists in having both poles manoeuvred by operators. Net flicking is useful in open habitats. Care must be taken not to hit the bats with the poles.

4.2.3.3 Experimental design and analysis of mistnetting data

In general, mistnetting facilitates several kinds of research, such as making species inventories, assessing relative abundance or community diversity at different spatial scales (Kurta and Teramino, 1992; Lumsden and Bennett, 1995; Moreno and Halffter, 2000), describing activity patterns over time (Rachwald *et al.*, 2001) and examining the effect of variables such as elevation, distribution by sex and age class (Grindal *et al.*, 1999; Cryan *et al.*, 2000).

In many cases it is necessary to compare data collected at different sites or in several habitats. To make observations comparable, capture effort should be standardised across capture sites (Grindal *et al.*, 1999; Rachwald *et al.*, 2001). Several methods have been proposed (Moreno and Halffter, 2000). The simplest way is to keep the number and size of nets equal at each site and use them for the same amount of time (Barlow, 1999; Rachwald, 1992). Alternatively, the overall capture effort may be kept constant. Capture effort may be calculated by multiplying net surface by capture time: if all nets have the same height, in practice the time may be simply multiplied by total net length, with capture effort expressed as m x h (Medellín, 1993). Nets should be placed in the same configuration over all sampling nights. If sampling is repeated at a given site and the bats caught are not tagged, repeated captures of the same bat cannot be ruled out (this problem may be circumvented by employing temporary marking). Capture success is related to the time of night (Rachwald, 2001), so it is also advisable to control for time of capture across sites. Moreover, bat activity may vary over several weeks, flawing the analysis. Unless sampling is carried out over a few, consecutive days, sampling sites should be visited in a random order to overcome this problem. Moreno and Halffter (2000) proposed the application of species accumulation curves to species inventory work or diversity assessment. In this way it is possible to objectively evaluate the completeness of the inventory obtained, estimating the minimum sampling effort required.

Markedly different weather conditions may affect bat activity, and in turn capture rates. ANCOVA (ANalysis of COVAriance) may adjust for this effect, making capture rates comparable across sites or habitats. In this case, parameters such as wind speed or ambient temperature may be entered in the analysis model as covariates. Generally, no such problems arise when paired sampling is used. To see whether bat habitat use differs between two neighbouring habitats, two identical mistnets may be employed simultaneously for an equal sampling time (nets will be placed far enough apart to avoid mutual interference with capture success). Likewise, to examine resource partition in highly structured forests, identical nets may be placed simultaneously at heights corresponding to canopy and undergrowth, or even at several different heights (Barlow, 1999). As long as variables are well controlled, paired sampling may be used to assess temporal trends. For example, Jones *et al.* (2001) highlighted a decrease in bat species richness and abundance on Puerto Rico Island (Caribbean Sea) following hurricane Georges. In that case, paired samples – compared by a Wilcoxon sign test – were obtained by mistnetting at the same sites before and after the hurricane struck the area. Various statistical books specifically devoted to ecological monitoring may help the reader select the most appropriate inferential approach to data analysis in relation to the specific sampling protocol adopted.

4.3 **Bat boxes**

The introduction of bat boxes (artificial shelters for bats) is primarily an active conservation action, because they provide extra roosting opportunities for bats (Fig. 4.5). This is all the more important when bat boxes are located in areas offering few or no tree cavities suitable for roosting, such as artificial conifer plantations, young coppice or arable land. Here we shall not go into either the structural aspects of bat boxes (several models are available, differing above all in design and construction material, which affects the likelihood of the box being used) or positioning (height above ground, aspect, relation to site characteristics, etc.). Such aspects are largely covered by specialised work (see e.g. Stebbings and Walsh, 1991).

For the researcher, bat boxes are very useful in carrying out work on bat distribution, ecology and behaviour. They may be used even in simple species observation to survey the presence of otherwise overlooked species (such as *Myotis bechsteinii* or *Pipistrellus nathusii*). The species which most often make use of bat boxes are those tending to roost in trees (such as the above mentioned *M. bechsteinii*, *Nyctalus* spp., *Plecotus auritus*, and *M. daubentonii*) and also several of those with more general roost selection habits, such as *P. pipistrellus*. Bat boxes offer good opportunities to investigate territoriality, roost fidelity, emergence behaviour, demography, and even diet. In fact it is easy to collect and analyse droppings accumulating inside the box. Once the roosting bats are identified, these can be confidently attributed to a specific species.

Figure 4.5 - A simple wooden bat box used in the Delta de l'Ebro Natural Park (Catalunia, Spain). Large numbers of *P. pygmaeus* and several *P. nathusii* roost in boxes such as the one illustrated. Bat boxes prove especially useful for research on occurrence, ecology and behaviour of forest species (Photo by D. Russo).

Of course, in terms of occupation likelihood, the higher the number of bat boxes the better. Both correct placement and periodical inspection of boxes are demanding, labour intensive operations. As a rule of thumb, Walsh and Catto (1999) mention that a project employing 100 boxes is much more likely to provide statistically significant results than one involving 20-30 boxes. Another consideration is that although in some circumstances bats start using boxes from the first season they are set up, this is not generally the case – sometimes significant results have only been obtained 2 or 3 years after placement.

4.4 **Handling, measuring and identifying bats**

We saw above how bats should be extracted from traps such as mist-nets or harptraps. We shall now deal with how they should be handled and measured, and how to recognise sex, age class and species.

4.4.1 *Handling bats*

A captured bat should be put in a numbered cotton bag fastened with string. Bags containing bats must not be left in a place accessible to predators, and in any case you must avoid keeping bats in the bags for too long. Each bag must contain *only one* specimen, otherwise they can bite and seriously injure one another (especially likely for some species!). If kept outdoors, or in low ambient temperatures, bats may get torpid: this will complicate the release phase. It is best to keep the bats in a warm place and wait until they are fully active to release them. Releasing a partially torpid bat exposes it to the risk of falling to the ground and predation.

Figure 4.6 - Handling *Tadarida teniotis:* a gentle pressure of thumb and first finger will avoid the risk of being bitten by the bat (Photo by P. Debernardi).

Bags should be securely fastened and hung up – do not place the bag on a surface or the bat will move about and attempt to escape. Droppings and urine accumulate in bags, so it is advisable to wash them often. Moreover, droppings may be collected from bags for further diet analysis (making it possible to correlate diet with bats of known sex, age class, reproductive status and biometry).

A bat may be held in the palm (Figure 4.6) by wrapping the fingers around its body and holding its head between thumb and first finger. A *delicate* first finger pressure will open the bat's mouth for tooth inspection, if desired. This way of holding a bat, with folded wings, makes it easy to measure forearm length and unfold and examine a wing. Practically all the small or medium-sized species occurring in Italy may be handled in this way without risk of being bitten (when large species are handled, it is recommended to wear a light glove). There are several alternatives to this manner of handling. In all cases, squeezing the bat or holding it by its wings may cause serious injury and must be avoided.

4.4.2 *Identifying species, taking measurements and collecting samples*

Bats are generally identified to species from a set of qualitative or quantitative variables (e.g. Schober and Grimmberger, 1997). The recent interest in bat molecular studies is revealing the existence of sibling species, so for some *taxa* reliable morphological criteria have yet to be identified. The sibling *M. myotis* and *M. blythii* may be identified by applying reliable qualitative and quantitative criteria, including discriminant functions (Arlettaz, 1995; Arlettaz *et al.*, 1997). European bats from the genus *Plecotus*, until recently considered as two species (*P. auritus* and *P. austriacus*) told apart on the combined use of diagnostic criteria (Maddalena and Moretti, 1994; Swift, 1998), have in fact also been shown by molecular analysis to comprise more sibling species (Kiefer and Veith, 2001; Spitzenberger *et al.*, 2001, 2002; Mucedda *et al.*, 2002), and our knowledge of this genus is changing rapidly. While some morphological identification criteria set for *Pipistrellus pygmaeus* and *P. pipistrellus* have been proved unreliable, others are more promising though they need to be validated on a broader geographical scale (Häussler *et al.*, 2000; Helversen and Holderied, 2003). These two species may easily be identified by either molecular or bioacoustical approaches (Jones and Parijs, 1993; Barratt *et al.*, 1997; Russo and Jones, 2000).

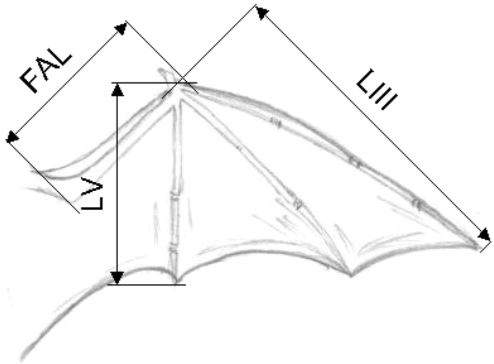

Figure 4.7 - Measuring forearm length (FAL), third (LIII) and fifth (LV) digits. To measure FAL, hold the bat as shown and position calliper tips so that they just touch the forearm. LV should be measured by completely unfolding the wing (taking care not to harm the bat) and letting calliper tips touch finger end and wrist (at the thumb's insertion point). Likewise, LIII should be measured from finger tip to wrist (drawing by R. Chirichella)

The commonest measurements taken from a bat (Figure 4.7) are forearm length (Figure 4.8), length of digits III and IV (all in mm), and body mass (in g). For some species (e.g. *Plecotus* spp.), further measurements may prove diagnostic, including length of thumb and its claw, ear height, tragus height and foot length (Figures 4.9 and 4.10). Head to body and tail lengths are less commonly taken (Figure 4.11). Forearm length (distance between elbow and wrist) should be taken from the folded wing using a precision calliper (±0.1 mm). The calliper should be closed so that both elbow and wrist are gently touched, but care must be taken not to force the delicate forearm bone. Once the calliper is set for the measurement, the bat's wrist should still be able to gently slide against the calliper's inner surface. Self-blocking callipers are especially useful to avoid accidentally forcing the forearm.

In some cases, further measurements are needed, such as ear pinna height (e.g. for *M. myotis/blythii*; Arlettaz, 1995), tragus width, and

Figure 4.8 - Measuring *Tadarida teniotis* forearm by a self-blocking calliper (Photo by P. Debernardi).

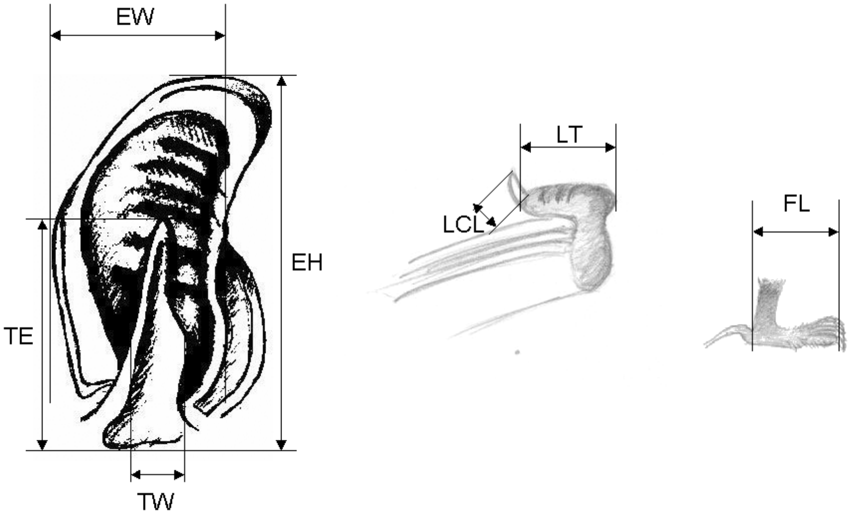

Figure 4.9 - For some species (e.g. *Plecotus spp.*) taking further measurements besides those commonly obtained may aid identification. The following may be useful: ear height (EH), tragus height (TH), tragus width (TW), ear width (EW), thumb length (TL), thumb claw length (TCL), and foot length (FL) (drawing by R. Chirichella).

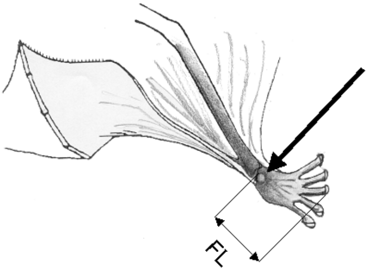

Figure 4.10 - Detail of foot pad (arrow). Its position helps in taking an accurate measurement of foot length FL (drawing by R. Chirichella).

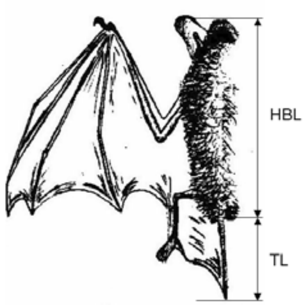

Figure 4.11 - Measurement of head-body length (HBL) and tail length (TL). The former is rarely taken from living bats. To take such measurements, the bat body should be kept stretched; HBL = distance from anus to muzzle tip; TL = distance from anus to tail tip (Drawing by R. Chirichella).

thumb (or its claw) length (such as for *Plecotus* identification; Maddalena and Moretti, 1994; Swift, 1998). When hand-held, *M. myotis* and *M. blythii* tend to lay back their ears, requiring particular attention when measuring ear length. Ear and tragus widths should both be measured where these structures show their maximum size. Thumb length should be measured by stretching the thumb and measuring the distance between the bases of claw and basal joint respectively. A graduated lens may help in taking this measurement (M. Mucedda, *pers. com.*). Foot length is generally measured from the base of the middle toe claw to talon. Spotting the exact point of talon from which to take this measure may prove difficult. A good reference point is provided by the foot pad, always well visible and hence useful to correctly position the calliper (A. Martinoli, *pers. com.*; Figure 4.10).

Body mass may either be measured with a Pesola spring or a digital scale; in most cases, the precision required is ±0.1 g. Use a bag to hold the bat when measuring body mass. The bag should be small enough to prevent the bat moving during measurement (Barlow, 1999). The bag weight will be subtracted from the value recorded to obtain the bat's body mass. As mentioned, bats often defecate or urinate when in bags. Hence, the bag may change its weight during the time taken to process several bats and it is advisable to check its weight periodically to obtain reliable net values for the bats weighed.

Body mass changes markedly in relation to sex, age, reproductive status and amount of fat reserves: these factors should be taken into consideration when elaborating body mass data (Barlow, 1999). The so-called *Body Condition Index* may be used to check body size and allow for comparisons of body condition. The simple version is given by 100 x (body mass/forearm length) expressed in g/mm. BCI may be used to make comparisons within, or across, species (Jones, 1991; Russo *et al.*, 2001).

In eco-morphological studies, wing variables are very important (Norberg and Rayner, 1987). Wing profile may be traced as follows (Barlow, 1999). The bat should be placed with its ventral side on drawing paper (but a large field notebook will also do). Stretch a wing and gently flatten it on the paper. The corresponding leg and tail membrane should be fully stretched too. Use a pencil to trace the silhouette of head, wing and half tail membrane (down to tail tip). Wing variables may be determined after Norberg and Rayner (1987). It is advisable to have the same person take the tracings in all cases, to avoid differences between operators (Barlow, 1999).

For molecular work, biopsy punches may be used to sample a small (3-4 mm in diameter) skin fragment from wing or tail membranes. The sample should be immediately stored in a tube containing a preserving solution. The operation does no harm to the bat, and cicatrisation is generally completed in 2-4 weeks (Hutson and Racey, 1999; A. Martinoli, *pers. com.*). Bat membranes, ears, head and feet often host ectoparasites. They may be collected with forceps (use a magnifying lens if parasites are not visible to the naked eye) and stored in 70-80% ethanol. Appendix II shows a typical form to record data collected during capture operations.

Bats found dead may have high scientific value and should be preserved (either as skin or in alcohol). Details on preservation are given in Handley (1988). If the specimen is in poor condition, at least prepare the skull, whose features are diagnostic for species identification (Lanza, 1959). Skulls may also be retrieved in roosts (especially caves) or sometimes extracted from owl's pellets (Speakman, 1991; Bellini and Agnelli, 1999; Scaravelli and Aloise, 1999).

4.4.3 *Determining sex, age class, reproductive condition and moult stage*

Sexing bats is immediate, because the penis is obvious in males (Racey, 1988). Bats may generally be easily recognised as either juveniles or adults. To tell the two age classes apart, a wing should be unfolded and trans-illuminated with a light source such as a torch. In juveniles, cartilaginous epiphyseal plates – parts not yet replaced by bone – may be spotted in finger bones. These parts are easily noticed because they are less opaque, so more light shows through them (Anthony, 1988). As the bat becomes older, the cartilage is replaced by bone tissue, and ossification is completed in 60-75 days (Hutson and Racey, 1999). However, juveniles still retain peculiarly tapered finger joints, while those of adults are knobby. This criterion may generally be applied to bats merely a few months old. In some *Myotis* species, such as *M. daubentonii*, there is a chin-spot (Richardson, 1994) which is inkjet black in juveniles in their first year of age, and then turns grey or disappears. In the first year of life, wings appear especially clean, soft and slightly sticky. Some authors refer to tooth wear as a criterion to distinguish between different age classes. For instance, Bontadina *et al.* (2002) categorised age in *Rhinolophus hipposideros* also looking at this feature. However, tooth wear is often hard to detect and requires a good deal of experience to be correctly interpreted. For the sake of completeness, we can mention that counting tooth cement incremental lines from tooth transverse sections examined under a light microscope, once regarded as a precise (albeit ethically unacceptable) way to determine the age of bats, is now considered quite unreliable (Batulevicius *et al.*, 2001).

In both juvenile and sexually immature adult males, the *cauda epididymis* is covered with a pigmented sheet of peritoneum (*tunica vaginalis*), and the epididymides appear dark through the skin (Hutson and Racey, 1999). In sexually active males, testes increase in size during spermatogenesis. Following seasonal spermatogenesis, sperm accumulates in the *cauda epididymis*, which are swollen and well visible through the interphemoral membrane. Consequently, the *tunica vaginalis* appears extended and the melanocytes separate, making the epididymides appear white (Hutson and Racey, 1999). At least in the genus *Pipistrellus*, Hutson and Racey (1999) pointed out that after the initial separation of melanocytes, these generally do not return to the initial density, so that reduced pigmentation in association with the extension of the epididymides is a good indicator of sexual maturity.

In hibernating bats, both testes and epididymides may not be visible due to considerable fat reserves (Hutson and Racey, 1999). In females, pregnancy is evident in its last phases and may be diagnosed by a gentle abdomen palpation. Nulliparous females have small nipples covered with fur, whereas females who have already given birth show large, keratinised nipples, generally covered with few or no hairs. Female rhinolophids show so-called "false nipples" in the pelvic position, a further indicator of reproductive condition (Gaisler, 1963; Ransome, 1991). They develop at the first parturition, and are used by newborns to cling to their mother's body. In *R. ferrumequinum* such structures persist after the first pregnancy (generally taking place in the female's third year, though sometimes it may occur in the second year or be delayed by one or more years). However, they may slightly reduce their size from the subsequent winter, especially if the bat fails to reproduce for one or more years (Ransome, 1991). In lactating females, both mammary glands and nipples are swollen. The mammary area is not covered with hairs, and a *gentle* pressure at the nipple base will squeeze out milk (Hutson and Racey, 1999). In temperate climates like that found in Italy, bats moult only once a year (in tropical species this may happen twice), generally in late spring in males and young females. In lactating females, however, moult may be delayed until lactation is over (Lanza *et al.*, 2002). The process starts with a conspicuous loss of hairs between shoulder blades, which may then extend to the neck.

4.5 **Bat tagging**

4.5.1 *General considerations*

The application of tags making bats identifiable either at a distance or in the hand is necessary in all studies involving individual recognition. A number of techniques are available, the main differences relating to the type of study objectives and duration of tag. In recent years radio-tag miniaturisation has made it possible to use radiotracking in bat studies (see par. 4.6). When a subject only has to be identified over a short length of time (hours up to a few days), partial trimming of fur on a small skin surface will suffice. This operation, carried out on different body regions, makes individual identification possible (Barlow, 1999). The method proves especially useful when using mistnets or harp-traps: by marking captured bats on release, it is possible to recognise them in the event of re-capture. Similarly, tattoos or coloured liquids may be used (Barlow, 1999; Jurczyszyn and Bajaczyk, 2001). Reflective or coloured adhesive tape may be attached to either the dorsal surface or the abdomen, depending on the species' flight style. Dorsal application proves most useful for species flying low over water or ground, such as *M. daubentonii*, whereas ventral marking is preferred for those flying higher up (Stebbings, 1999). However, these ways of marking bats are ineffective when the bat is more than a few metres away from the observer. Moreover, tape is often readily groomed off by the bat. The least invasive technique should be adopted, especially if recognition is required only for a few hours or days.

4.5.2 *Light-tags, beta-lights*

Light-tags are small glass or gel capsules containing two chemicals which react and produce light when mixed together (Buchler, 1976; Barclay and Bell, 1988; Barlow, 1999). The chemical reaction is started by breaking the element keeping the two substances separated. This is simply achieved by bending the capsule, whose external structure remains intact. Quite cheap light-tags may be purchased in an angling shop (fishermen use them to make floats visible in the dark). As with radiotags, light-tags may be applied with a surgery cement such as SkinBond ® to the bat's dorsal surface after partly trimming the fur in the corresponding skin surface. Always use small amounts of glue and wait for it to dry completely before releasing the bat. In good conditions, light-tags may be seen at a distance of up to 200 m, and further still using binoculars (Buchler, 1976; Brown *et al.*, 1983; Racey and Swift, 1985; Barlow, 1999). Such tags generally allow for observations lasting a couple of hours. Tagged bats often groom them off within 1-2 days (Stebbings, 1999). In dense vegetation light-tags are useless because observation is often impossible. For the sake of completeness, we also mention *beta-lights* (Saunders–Roe Development Ltd.). In this case the capsule contains phosphor made luminescent by Tritium radioactive decay. They have a half-life of 15 years yet they are generally removed by the tagged bat within a few days (Stebbings, 1999). Light-tagging proves useful to determine flight trajectories from roost, flight patterns and foraging areas (Pavey and Burwell, 2000). Large numbers of observers are often needed to successfully track the bats.

4.5.3 *Bat ringing*

As with birds, bats may be permanently tagged by applying rings bearing an individual-specific code (Figure 4.12). When a database is available, ring serial numbers allow for retrieval of date and place of ringing. The method, almost 80 years old (Hitchcock, 1957; Pierson and Fellers, 1993; Baker *et al.*, 2001), was widely employed in Italy in the '50s and '60s (Dinale and Ghidini, 1966). Ringing is crucial when individual recognition is required over many years. In fact, rings normally stay in place all life long. To mention some of the main types of application, ringing is most useful to determine migratory routes, analyse long-

Figure 4.12 - A ringed Leisler's bat. The serial code is unique to each ring and makes individual recognition of ringed bats possible (Photo by P. Agnelli).

term roost fidelity and bat box use patterns, and in assessing population size and density (Thomas and La Val, 1988; Barlow, 1999). For details on mark-recapture analysis of survival in bat populations, see Keen (1988).

4.5.3.1 Ring types

Two metal ring types are available on the market: those with truncated margins, used for birds, and those whose edge is either rounded or bent outwards, often referred to as bat bands. Their impact on bats, as tested in Australia, depends on the species considered (Baker *et al.*, 2001). European experiences have shown that “bird rings” (i.e. those with truncated margins) *must not be used* on bats. For the sake of information, the most widespread bat ring type, formerly produced by Lambournes, are now manufactured by Porzana Ltd. (Elms Farm, Icklesham, East Sussex

TN36 4AH, U.K.), the trade branch of WetLand Trust (U.K.).

Further rings, coloured and made of either plastic or anodised aluminium, are used to tag and recognise bats at a distance, as in behavioural studies (Kerth *et al.*, 2001). The models available on the market should be modified by widening the ring gap, so that the ring can move freely along the bat's forearm. The edges should also be rounded before they are fitted (Stebbings, 1999).

4.5.3.2 Banding procedures

Bat ringers must be experienced and authorised according to national laws (see par. 3.1.3). The ring should be applied around the forearm and should not be fully closed. Always leave a small gap between its edges to avoid harming the wing membrane. Ringing is generally performed by tightening the ring with the hands. The circular ring shape is often lost in the process (Baker *et al.*, 2001), a fact which increases the risk of injury (Figure 4.13). Everything possible should be done to avoid this happening (Stebbings, 1999).

Figure 4.13 - Serious injury determined by incorrect ringing procedure in *Myotis daubentonii*. The bat was rescued by S. Vergari and G. Dondini (Photo by S. Vergari and G. Dondini).

Once applied, the ring should be wide enough to glide freely along the forearm; however, it should not be so large as to cover the elbow and block the joint during flight (Agnelli *et al.*, 2001). To avoid the bat biting itself in an attempt to remove the ring, some bat workers apply a small amount of repellent to the ring before fitting it, such as powdered pepper or Tabasco (A. Martinoli, *pers. com.*).

4.5.3.3 Impact of rings on bats

Unfortunately, bat banding is quite an invasive procedure. Its impact is much greater than on birds, the latter being tagged on the legs, well protected by the keratinised skin. In bats, the ring is applied to an area of the body covered with soft, sensitive skin. In spite of the improvement in ring design, work carried out in Australia in the last few years (Baker *et al.*, 2001) has suggested that the risks attached to bat ringing may be underestimated. The cited study has led the

Australian Bird and Bat Banding Scheme (ABBBS) to put a stop to banding vespertilionids, molossids and emballonurids, considering applications for banding case by case.

On the basis of what has been established so far, *bat banding is acceptable only when strictly necessary to obtain important scientific information which cannot be obtained by less invasive techniques, and only when the risk for bats is acceptable.* Clearly the outcome of a capture session is not made "more scientific" merely because rings are applied: using rings without a specific objective is absurd. Typical ring injuries are represented by major skin reactions in the area where the band is applied. The skin often looks swollen and shows wounds and blood loss. In some cases the ring rotates round the forearm and breaks the wing membrane with its edges (Baker *et al.*, 2001). As already mentioned, if the ring is too loose it may move over the elbow and cause injuries. A range of injuries have been recorded, from negligible impact to serious damage involving the bat's incapacity to fly or even death. Although incorrect ringing procedures are responsible for many cases of ringing impact (Happold and Happold, 1998), other factors such as band type, species-specific behavioural responses and unknown variables may also cause damage (Baker *et al.*, 2001). Some intolerant species bite the ring, tightening it around the forearm and causing serious problems (Baker *et al.*, 2001). Gnawing may also partly erase the ring's serial number. A more resistant metal would solve the problem, but this may be detrimental to teeth. As mentioned, the use of non-toxic repellents may help mitigate these reactions. Correct ring type and ringing procedures significantly reduce risk. In a first *Chalinolobus tuberculatus* ringing session, C. O'Donnell recorded such a serious reaction to ABBBS rings that he stopped the operation. In such cases, the old bat ring model manufactured by Lambournes (Birmingham) Ltd. had been used. Subsequently, the adoption of a more recent ring type practically solved the problem (just two out of 2,770 bats recaptured showed ring injuries). The apparently subtle difference between the two ring types resided in the edges being rounded and well manufactured in the more recent model – which in fact was also made of a different material.

Bats should not be banded (Agnelli *et al.*, 2001) during hybernation in order to avoid fat reserve depletion following arousal. Banding pregnant females might lead to abortion or death by stress. When banding bats in a roost, avoid catching them inside to minimise disturbance – catch them near the exit, on evening emergence, or better still along known flight paths. As mentioned, reaction to ringing may be species-specific. Baker *et al.* (2001) recommend regarding species showing injuries with frequencies >2% as unsuitable for ringing. The absence of data on many European species, for which knowledge of ringing impact is either null or anecdotal, complicates a satisfactory preventive risk assessment. An international co-ordination on ringing injury monitoring is most desirable to quantify the impact on different species and identify those whose conservation status is not threatened by ringing.

In Spain, the Ringing Committee of Sociedad Española para la Conservación y el Estudio de los Murciélagos (SECEMU) has warned that not all species are suitable for ringing. When a researcher wishes to carry out ringing, the project has to be submitted to the Committee (J. Quetglas, *pers. com.*). Having considered all the relevant factors (species, researcher skill, scientific merit), the Committee makes an assessment which helps the institution issuing the licence - Dirección General para la Conservación de la Naturaleza – to reach a decision.

Table 4.1 illustrates, for Italian species, the maximum inner diameter (taken from rings with a 1-mm residual space between margins) recommended for rings according to Annex 9c to Resolution 4.6 of Fourth Session of EUROBATS Meeting of Parties (Sofia, 22nd -24th September 2003). Data from published work (Stebbings, 1999; Baker *et al.*, 2001) as well as communications from Swiss, British, Spanish and Italian bat specialists are included. The recommendations provided by Resolution 4.6/Annex 9c are not regarded as definitive by EUROBATS. For several species, values are extrapolated from experiences gained on similar bats, and further studies are recommended before drawing conclusions. Hence, the table presented here is not meant to offer guidelines: it presents current knowledge and encourages exchange of experience among ringers.

Stebbings (1999) highlighted that *R. hipposideros* is especially sensitive to banding. In the U.K., a high occurrence of injuries noticed in this species has led to the interruption of a banding programme (G. Jones, *pers. com.*). Elsewhere, however, both recaptures and observations made from films have documented no impact of 2.8-mm rings in this species (F. Bontadina and A. Ruggeri, *pers. com)*. According to the SECEMU member J. Quetglas (*pers. com*.), of two colonies studied in Spain, one had no problem after years of ringing, whereas the other showed serious injuries in most banded bats. SECEMU currently recommends avoiding ringing *R hipposideros* unless the reaction of banded bats may be frequently and constantly monitored.

EUROBATS recommend the use of rings with an inner diameter of 2.9 mm (Table 4.1). In the case of *Rhinolophus mehelyi* (diameter recommended by EUROBATS: 2,9/4,2 mm; Table 4.1), ringed with 4.0 mm rings in Spain, problems have been recorded in 5.8% of cases ("problems" being represented by all effects attributable to ringing).

Table 4.1 - Ring size for Italian bats (sources: EUROBATS; Stebbings, 1999; Baker *et al.*, 2001; Hutson *et al.*, 2001; unpublished data). This table does not provide final guidelines, but presents EUROBATS recommendations as well as published material and information communicated by ringers from several European countries. Ringing is an invasive operation and should be employed only in cases when no alternative (less impacting techniques) is available, and when necessary to obtain major scientific data (especially if these may contribute to a step forward in bat conservation and management). Besides diameter, important elements to be considered when choosing the "right" ring to minimise ringing impact include ring structural features (see text).

Species	Ring internal diameter (mm) (Source: EUROBATS)	Remarks
Rhinolophus euryale	2.9/4.2	
Rhinolophus ferrumequinum	4.2	Same size recommended by Stebbings (1999) and used in Switzerland (F. Bontadina. *pers. com.*).
Rhinolophus hipposideros	2.9	Same size recommended by Stebbings (1999); in Switzerland F. Bontadina (*pers.com.*) used rings with an internal diameter of 2.8 mm. See text for details.
Rhinolophus mehelyi	2.9/4.2	J. Quetglas (*pers. com.*) recorded 4 injured bats out of 69 recaptures. Rings used had an internal diameter of 4.0 mm.
Barbastella barbastellus	2.9	Same size recommended by Stebbings (1999). The species seems to be sensitive to ringing (Hutson *et al.*, 2001).
Eptesicus nilssoni	2.9	The ring size suggested by EUROBATS is estimated (i.e. not based on observed responses to ringing).
Eptesicus serotinus	4.2/5.5	Stebbings (1999) suggests rings with an internal diameter of 4.2 mm.
Hypsugo savii	2.9	The ring size suggested by EUROBATS is estimated (i.e. not based on observed responses to ringing).
Myotis bechsteinii	2.9	Same size recommended by Stebbings (1999). No adverse reaction observed in the Varese province (A. Martinoli, *pers. com.*).
Myotis blythii	4.2/5.5	
Myotis brandtii	2.9	Same size recommended by Stebbings (1999) .
Myotis capaccinii	2.9	
Myotis daubentonii	2.9	Same size recommended by Stebbings (1999) .
Myotis emarginatus	2.9	The ring size suggested by EUROBATS is estimated (i.e. not based on observed responses to ringing).
Myotis myotis	4.2/5.5	Stebbings (1999) suggests rings with an internal diameter of 4.2 mm.
Myotis mystacinus	2.9	Same size recommended by Stebbings (1999) .
Myotis nattereri	2.9	Same size recommended by Stebbings (1999) .
Myotis punicus	-	The same ring size recommended for *M. myotis/blythii* (4.2/5.5.) would apply to this species

Nyctalus lasiopterus	5.5	The ring size suggested by EUROBATS is estimated (i.e. not based on observed responses to ringing). J. Quetglas (*pers. com.*) employed rings with an internal diameter of 5.2 mm (see text).
Nyctalus leisleri	4.2/3.5	Stebbings (1999) suggests rings with an internal diameter of 4.2 mm such as those used in Tuscany where no negative response was recorded (S. Vergari, *pers. com.*).
Nyctalus noctula	4.2/3.5	Stebbings (1999) suggests rings with an internal diameter of 4.2 mm such as those used in Switzerland (F. Bontadina, *pers.com*).
Pipistrellus kuhlii	2.9	Same value suggested by F. Bontadina (*pers.com.*).
Pipistrellus nathusii	2.9	Same size recommended by Stebbings (1999) .
Pipistrellus pipistrellus	2.9/2.4	Stebbings (1999) suggests rings with an internal diameter of 2.9 mm.
Pipistrellus pygmaeus	2.9/2.4	
Plecotus auritus	2.9	
Plecotus austriacus	2.9	Same size recommended by Stebbings (1999) .
Plecotus macrobullaris	2.9	
Plecotus sardus	2.9	The ring size suggested by EUROBATS is estimated (i.e. not based on observed responses to ringing).
Vespertilio murinus	4.2	C. Jaberg (*pers. com.*) employed rings with an internal diameter of 2.9 mm.
Miniopterus schreibersii	2.9/4.2	For Australian populations, Baker *et al.* (2001) used rings with an internal diameter of 3.0 mm, height 4.0 mm, and width 0.3 mm. Reactions observed (n = 308): no damage in 67.9% of bats, 30.2% minor problems, 1.9% serious injuries.
Tadarida teniotis	4.2	J. Quetglas (*pers. com.*) used rings with an internal diameter of 5.2 mm.

This figure was obtained from a small sample, i.e. 4 injuries in 69 recaptures (J. Quetglas *pers. com.*). For this rhinolophid, the most serious concerns would be due to the impact of roost captures carried out to band bats, rather than by banding itself.

There is talk in Poland of banning banding *Barbastella barbastellus*, which is apparently sensitive to this practice. Hutson *et al.* (2001) consider the assessment of ringing impact as one of the conservation priorities for this bat. Little data is available on the impact of banding on the largest European species, *N. lasiopterus*, probably due to the species' rarity. Rings with an internal diameter of 4.0 mm, formerly used in Spain, proved harmful (J. Quetglas, *pers. com.*), so banding this species was banned. From 2000, Lambournes rings (1BR3503) with a diameter of 5.2 mm (safely used on *T. teniotis* too) have been employed; the only bat so far recaptured showed no problem. For this species, EUROBATS recommends the use of rings with an internal diameter of 5.5 mm (Table 4.1).

In his work E. Vernier (*pers. com.)* adopted the former Lambournes rings (manufactured in 1989). Although he generally noticed no problems, some variation in reaction to ringing across species was recorded. Specifically, he found that occasionally some bats (especially rhinolophids) chewed the ring, which could then become incorporated in the wing tissues. A. Martinoli (*pers. com.*) captured some *P. auritus* females, banded by other colleagues, showing various degrees of damage: in the least concerning cases the skin appeared reddish and thick, but in other cases the forearm muscles were seriously injured. To study *M. capaccinii* and *M. daubentonii* in Lombardy, Lambournes bat bands made of a magnesium-aluminium alloy with a diameter of 2.9 mm were used (F. Farina, E. De Carli, L. Fornasari and P. Bonazzi, *pers. com*.). In the former species, 10.7% of recaptured bats (9 out of 84) showed ring-related injuries, whereas these were found in 2 out of 25 recaptured *M. daubentonii*. The same researchers reported that over 7 years from ringing, a *M. capaccinii* showed incipient wing membrane damage: worn out ring edges, originally rounded, had become rather sharp, causing the problem. It should be highlighted that statistics based on recapture are somewhat "optimistic", because it is generally assumed that non-recaptured bats had no problems. In fact, some of these subjects might even have died of detrimental ringing effects, such cases being consequently overlooked.

The application of coloured rings to the same forearm bearing the metal ring (the one showing the serial number) should be avoided. A study on *M. myotis* and *M. blythii* (Norman *et al.*, 1999) proved that during flight, the two rings collide and alert sound-sensitive prey. Consequently, the insects under investigation (the moth *Noctua comes*) exhibited neurological reactions or evasive manoeuvres (spiralling falls, escape from sound source).

In conclusion, although banding may contribute to a better understanding of bat ecology, it should be carried out only when necessary and only for species showing no adverse reaction to bands. It is highly recommended that, unlike in the past, all bands used on the Italian territory should bear the same serial code system. Only in this way will recaptures actually allow researchers to document the movements made by tagged bats. Finally, a national database, including all bats ringed in Italy, is needed (see par. 5.5.2).

4.5.4 *PITs: passive integrated transponders*

These devices feature integrated circuits in a biologically inert capsule. The device may be temporarily glued to the bat's dorsal surface, but is most commonly used to permanently tag the animal. In this case it is injected just below the skin by means of a special needle, generally between the scapulae, parallel to the backbone, or in the neck (Kerth and König, 1996; Baker *et al.*, 2001). PITs are 11-12 mm long, with a diameter of 2 mm or less and weigh 0.1 g (Kerth and König, 1996; Hutson and Racey, 1999; Baker *et al.*, 2001). A special reader, placed at a distance of 15 cm or less, may detect the PIT serial number. In a study of social behaviour in *M. bechsteinii*, Kerth and König (1996) identified most bats even without handling them – they just placed the reader outside the bat box used by tagged bats for roosting. Although the presence of several tagged bats in a box could lead to identification problems, the ambiguity was generally solved by detecting the PITs from different directions around the box. In this way, up to 17 tagged bats in a single box could be identified. The technique has been employed for several other species, including *P. pipistrellus/pygmaeus* in the U.K. (Hutson and Racey, 1999), and *Eptesicus fuscus* and *Myotis lucifugus* in the USA (Barnard, 1989; Baker *et al.*, 2001). The drawbacks of this technique include the high cost of the reading device (Baker *et al.*, 2001), as well as occasional PIT malfunctioning or loss, as observed in bats (Kerth and König, 1996) and other *taxa* (Baker *et al.*, 2001).

4.6 **Radiotracking**

4.6.1 *General considerations*

Radiotracking consists of locating an animal equipped with a radio-transmitter (tag) that produces a brief intermittent radio signal. The signal may be detected with a VHF radio-receiver connected to a directional aerial (Spagnesi and Randi, 1995; Rabinowitz, 1997) (Figure 4.14). In the last 20 years, radiotracking has become increasingly popular among bat researchers (Bontadina et al., 1999). The technique allows researchers to:

- determine activity patterns,
- measure longest distances travelled from roost by a bat, highest elevation reached, home range size and structure;
- assess time budget of tracked bats;
- locate main foraging areas and analyse habitat selection;
- locate roosts (except those underground).

As with all tagging techniques, radiotracking should be employed only by experienced researchers and when the data needed cannot be collected by alternative, less invasive methods (e.g. acoustic surveys). It must be borne in mind that radiotracking is a powerful yet expensive approach, because the equipment involves high costs.

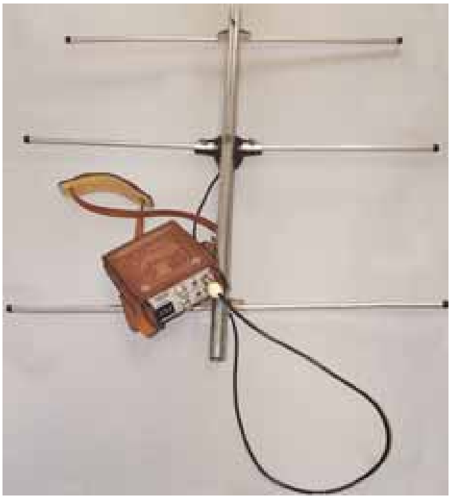

Figure 4.14 - A typical radiotracking receiver connected to a directional antenna (Photo by A. Martinoli).

4.6.2 *Radio-tagging bats*

The commonest tag used for bats is a small, relatively flat transmitter fitted with a thin metal antenna (Figure 4.15). Tags may be activated in different ways depending on the model. In some cases, two thin metal leads on one of the tag sides must be soldered. In others, a small magnet has to be removed. Transmitters needing soldering are more difficult to activate in the field. It is generally advisable to activate them a few hours before tagging the bat to make sure they work properly and track possible frequency shifts. Magnet-activated tags pose other problems: they are heavier; may activate accidentally, even prior to fitting; and even when inactive, they keep consuming a little energy. The model chosen will depend on the researcher's objectives. The transmitter may also include an activity sensor (which unfortunately implies some extra weight). By varying pulse rate, the latter signals whether the bat is active or not. Note that even with no activity sensor, experience is generally sufficient to derive bat behaviour from signal properties.

A crucial consideration in choosing the right tag is weight, which should not exceed 5% of the bat's body mass (Figure 4.16) to avoid affecting bat manoeuvrability (Aldridge and Brigham, 1988). Although some published studies document no significant effects on bats of tags exceeding this limit (Entwistle *et al.*, 1996), it is prudent to respect this rule of thumb. Today, tags as light as 0.3 g are available, making it possible to radiotrack even small bat species (Bontadina *et al.*, 2002). In some cases, especially for crevice-dwelling bats, a more robust antenna may be required to avoid it being damaged. The tag should be applied on the bat's back, between the shoulder blades. Of the two tag surfaces, make sure it is the flat one which is glued to the bat. The tag should be fixed with a

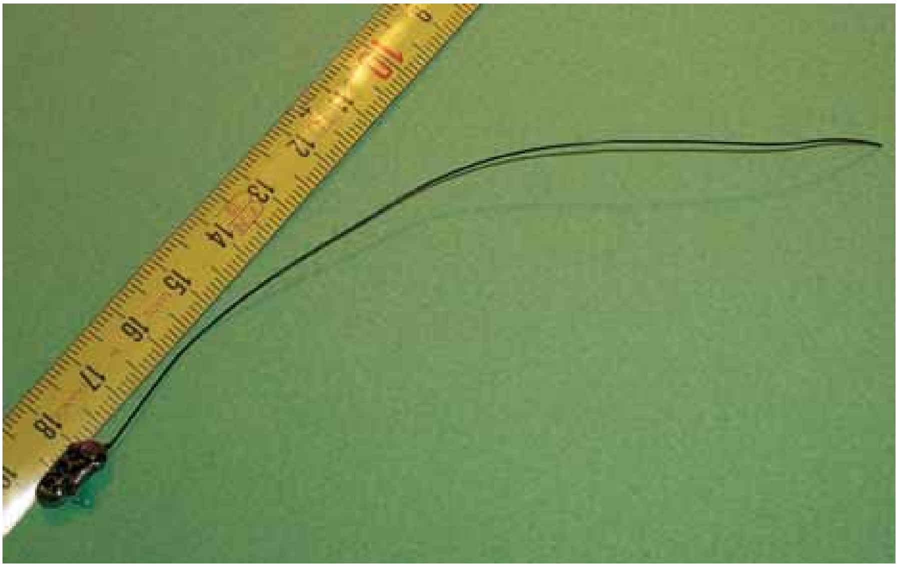

Figure 4.15 - Holohil LB-2 tag, weighing 0.5 g. Tag length ca 1 cm, antenna excluded (Photo by D. Preatoni).

non-toxic glue (generally surgery cement such as Skinbond®) after *partly* trimming the fur with small scissors in the application area. To trim the fur, lay the bat down with its ventral side on a flat horizontal surface (it is best to cover the surface with fabric or a cotton bag). Keep the bat in this position, holding its forearms and head with one hand. Hair trimming is an extremely delicate operation: the skin is very fragile and scissors may cause serious injuries. Should the skin be accidentally damaged, clean the wound with disinfectant and release the bat without tagging it. Once hair has been trimmed, apply a thin layer of glue to the tag flat surface first, then a little to the trimmed skin surface too.

When using Skinbond®, wait until the glue layers start bubbling to apply the tag. *Do not use too much glue*: a very small amount will suffice, and any excess glue should be immediately removed with a tissue. Once the tag is placed in the correct position, keep it in place with a *gentle* finger pressure and keep the animal still for a couple of minutes. It is then advisable to put the tagged bat in a cotton bag to enable it to recover before release. If the bat has been captured at a roost, release it at roost entrance – the bat will probably fly inside and rest for some time. Both before gluing on the tag and after the operation is complete, check that the tag is functioning correctly. Tags are sometimes applied with a silicon or plastic collar, which can break off after the period necessary for data collection (Bontadina *et al.*, 1999). However, collars are cumbersome and generally more invasive. Avoid applying collars to rhinolophids: their perch hunting will be affected (Bontadina *et al.*, 1999).

Figure 4.16 - Barbastelle bat, *Barbastella barbastellus* fitted with a tag. Tag weight should be less than 5% of the bat's body mass (Photo by G. Jones).

4.6.3 *Data collection*

A general limitation of radiotracking is represented by the signal's maximum detection distance. Generally speaking, bat tags are detected in the range of a few kilometres, but their performance varies according to terrain complexity (steepness, presence of mountains or depressions, etc.) and the elevation of the point from which the observation is made. Before starting a study, test the performance of the tags you are using in different locations of the study area – this will help in interpreting the actual bat location during data collection. Also, locate as many vantage points as possible from which clear detection is obtained. These preliminary activities will help both interpreting the data and assessing their quality.

We will now deal with two main radiotracking objectives: locating roosts and assessing bat activity.

a) Locating roosts

Radiotracking is a precious aid in locating roosts used by house- or tree-dwelling bats. Underground sites are excluded because the signal cannot be detected from outside such roosts (Agnelli *et al.*, 2001; Russo *et al.*, 2002). However, bats roosting in exposed rock crevices or small cavities may still be picked up (D. Russo, *pers. obs*.). Bats are generally captured at foraging or drinking sites, tagged and released immediately afterwards. In the daytime, the area may be surveyed to detect the signal transmitted while the bat is in the roost. Scan for the bats from a vantage point – this will help reveal otherwise overlooked bats roosting at sites sheltered by obstacles or in terrain depressions. Once the roost is located and reached, the researcher can measure a set of main variables (e.g. roost type, geographical coordinates, elevation, aspect, and tree height, diameter, etc.). A GPS receiver will help in storing roost position for future retrieval. Group size may then be assessed by counting bats on evening emergence. To see whether and how tree-dwelling bats select their roosts, features of roost trees may be compared with a set of available trees chosen at random in the study area (Sedgeley and O'Donnell, 1999; Russo *et al.* 2004).

b) Assessing bat activity

The objective is to locate bats while active – i.e. commuting or foraging. In this way, it is possible to delimit their home range and assess time budget, commuting routes and habitat selection. Of course, especially because small tags provide data only for a few days before the batteries run down, it is desirable to obtain as many locations (fixes) as possible. In the best situations, especially with species moving little or flying high up, a full night contact may be maintained. Track at least ten subjects to obtain a minimum set of observations both suitable for statistical analysis (Bontadina *et al.*, 1999) and representative of the population, or species, under analysis (i.e. not flawed by individual variation; Rabinowitz, 1997).

Bats may be located by either homing in on them or triangulation (White and Garrot, 1990). In the former case, the operator will track the signal and move, getting closer and closer to the bat, until the signal is so strong (e.g. detected even when the receiver gain is set to zero) and non-directional as to suggest the bat is in the immediate vicinity (Jones and Morton, 1992; Arlettaz, 1995; Duvergé, 1996; Russo *et al.*, 2002; 2005). In open habitats, it is possible to watch the bat and/or detect its echolocation calls with a bat detector (Duvergé, 1996). A small torch equipped with a red filter will help observe the subject (L. Duvergé, *pers. com.*), but be careful not to disturb the bat. In cases when the bat is not physically reached, as long as the observer gets to within a few hundred metres it may still be possible to take a very close bearing and estimate distance from signal properties. Make a note of signal features and quality.

When triangulating, two or more observers, each equipped with a receiver and located at different sites, take a bearing on the bat. By plotting bearing lines on a map, the bat position will be determined with a certain accuracy (Bontadina *et al.*, 2002). In some cases, especially if we just wish to have a general idea of where the bat is, a single observer may move rapidly (e.g. in 30-60 secs) and take consecutive bearings which will "simulate" triangulation (Bontadina *et al.*, 2002). The bat position, especially if it does not change much over time, may be estimated by plotting the bearings obtained in this way. Species covering large areas and aerial-hunting may be well studied by triangulation, whereas more sedentary ones are easier to observe by homing in on them (Bontadina *et al.*, 1999). The latter technique is also advantageous since it may be used by a single operator (Arlettaz, 1995; Duvergé, 1996). Triangulation will require more operators in the field in constant radio-contact.

Home range analysis follows the same general criteria used for other animal groups (Minimum Convex Polygons, harmonic means, etc.). For a review, see e.g. Harris *et al.* (1990) and Spagnesi and Randi (1995). The best approach will be selected depending on the specific case dealt with. Since keeping contact with bats is often difficult, and tags last only for a few days or weeks, fix numbers are low and home range analysis by MCPs provides a more robust estimate (Harris *et al.*, 1990). Such data are also easier to compare across studies (Harris *et al.*, 1990). MCPs have been largely adopted in bat studies (Jones and Morton, 1992; Duvergé, 1996; Waters *et al.*, 1999; Bontadina *et al.*, 2002; Russo *et al.*, 2002).

Foraging habitat selection requires a comparison between the amounts of used vs. available habitats. If proportion of use is significantly greater than that of available, then the corresponding habitat is *preferred* (positive selection); otherwise it is *avoided* (negative selection). Finally, when the two proportions do not differ significantly, use is made corresponding to availability (null selection; e.g. Entwistle *et al.*, 1996; Russo *et al.*, 2002).

Several statistical approaches have been used to assess habitat selection by bats. Until recently, a very popular technique was compositional analysis (Aebischer *et al.*, 1993), successfully applied to *R. ferrumequinum* (Duvergé, 1996), *R. hipposideros* (Bontadina *et al.*, 2002), *R. euryale* (Russo *et al.*, 2002) and *N. leisleri* (Waters *et al.*, 1999). Recently this has come in for criticism, which lies outside the scope of this work (see Bingham and Brennan, 2004). In general, use proportions may be expressed as percentage of each habitat included within home range, or per cent number of fixes (these should be recorded at a constant interval, say every 5 minutes) within each habitat, or per cent time spent in each habitat. The available proportion is calculated as percentage of area covered by each habitat within single home ranges (as long as this is not what was adopted as "used"), or the entire study area. In several cases, it may be worth carrying out the analysis in both such ways, to highlight different selection patterns (Aebischer *et al.*, 1993; Bontadina *et al.*, 2002; Russo *et al.*, 2002).

The study area boundaries may be defined in different ways depending on the situation. In some cases, they can be chosen arbitrarily, provided the area selected is large enough and representative of landscape features, and including all known roosts used by study subjects. When roost location is known and bats never switch to different roosts in the course of the study, the maximum distance travelled by bats on one night may be used as a radius to delimit a maximum circular range (MCR) centred on the roost (Waters *et al.*, 1999). If bats never use areas above a given altitude, use an elevation cut-off to exclude them from analysis. Especially when the bats move to other roosts during the study, a MCP encompassing all bat locations may be regarded as the "study area" (Bontadina *et al.*, 2002; Russo *et al.*, 2002).

4.7 **Behavioural studies by direct observation**

Being nocturnal and elusive mammals, bats are difficult to observe, and behavioural studies by direct observation are quite rare. There are, however, good examples of analyses made on bat behaviour as observed inside the roost, or during flight activity. Luminescent or coloured tags, useful in some circumstances, have been described above. Direct observation should be carried out, when possible, avoiding artificial lights (using night scopes, night-shot videocameras, etc.; Barclay and Bell, 1988), or employing, for a limited time, a small torch equipped with a red filter (see above).

When studying *R. ferrumequinum* in England, R. Ransome used an IR light source and an image intensifier: details on setting up the observation point are given in Ransome (1990). In an elegant study on *M. bechsteinii*, Kerth and König (1996) combined the use of coloured rings with IR videocameras connected to the bat boxes where the bats roosted. Precision scales placed inside the box and linked with a data logger allowed the researchers to weigh the bats whenever they alighted on the scales and to film them without any handling. Subjects – especially juveniles – hanging from the videocamera lens occasionally made recording difficult (Kerth and König, 1996).

To assess time budget in roosting *Pipistrellus subflavus*, Winchell and Kunz (1993) found that the best sampling protocol involved scan sampling with frequent observations (10-20 scans every 15 minutes), whereas focal sampling was most useful at times of intense activity, e.g. return to roost after foraging and pre-emergence behaviour.

Among the studies on free-flying bats, Arlettaz (1996) adopted a night scope and an IR light source to study foraging *Myotis nattereri*. In this case, the species was easily told apart from *M. myotis* and *M. blythii*, occurring at the same sites, by noticing size difference. Species similar in size and ecology, such as *M. emarginatus* and *M. bechsteinii*, were absent from the area.

Another widely used technique to study flight speed and patterns as well as foraging behaviour is offered by stereo multi-flash photography, employing pairs of cameras and providing a sequential 3-D localisation of moving bats. Sequences may be associated with echolocation calls emitted in flight (Jones and Rayner, 1988; Britton *et al.*, 1997; Britton and Jones, 1999; Siemers and Schnitzler, 2000).

A sophisticated acoustical alternative to determine flight path and speed is offered by the sequenced localisation of a flying bat as provided by an array of microphones. The time difference in the arrival of echolocation calls to the microphones may be used to accurately locate the bat in flight within a range of 50 m and 0.2-2% error (Holderied and von Helversen, 1999).

For the sake of completeness, we also mention that some authors examine the bat *silhouette* and flight style to complement other techniques and aid identification. In some cases this may be possible: *M. schreibersii* has a peculiarly fast flight, the large size of *N. noctula* and *N. lasiopterus* may be noticed, etc. However, in most other cases flight style and shape of free-flying bats are so similar across species as to discourage this approach – it is best limited to the (few) cases in which the response obtained is credible. Even when strong lights are used, determining fur colour in free-flying bats appears unlikely. Consider, for instance, a bat emitting FM/QCF (see below) calls with a frequency of maximum energy of ca 55 kHz. Size and flight style should help greatly in telling whether the bat is a *P. pygmaeus* or a *M. schreibersii*. On the other hand, it will be really hard (in fact generally impossible) to discriminate small or medium-sized *Myotis* (e.g. *M. capaccinii* from *M. daubentonii*) based on visual observation.

Many studies have been performed on captive bats. De Fanis and Jones (1995) described post-natal growth, vocalisation development and mother-young interaction in *P. auritus*. Recent outstanding advances on echolocation are due to study on bats kept in flight rooms and trained to forage under captive conditions (Siemers and Schnitzler, 2000; Arlettaz *et al.*, 2001). Siemers *et al.* (2001) have provided new evidence of piscivory in *M. daubentonii* hosted in a controlled experimental set. Management of captive bats requires great experience and care. Information on several aspects of this activity is provided by Wilson (1988) and Racey (1999). Gaudet (1988) reviewed bat training, a crucial point to carry out studies such as those described above.

4.8 **Acoustic identification of bats**

4.8.1 *General considerations*

Echolocating bats, such as all the species occurring in Italy, find their way in the dark and locate prey mainly thanks to a sophisticated system, conceptually analogous to sonar, known as echolocation. This represents one of the most exciting fields of bat research and, almost fifty years on from Griffin's (1958) fundamental book, is now well established scientifically. Echolocation has important implications for studies on bat distribution and ecology. We shall briefly mention some of the main aspects of the phenomenon, inviting the reader to consult the wealth of scientific publications existing on the subject for further details. To fully understand the basic concepts presented below, the reader should have a basic knowledge of acoustics.

4.8.2 *Echolocation*

The sound emitted by a flying bat comprises mainly echolocation calls (and, secondarily, social calls). Echolocation calls are emitted constantly to allow the bat, equipped with a sophisticated "biosonar", to produce an "acoustic image" of the surrounding world. Among Italian bats, rhinolophids stand apart because they commonly call also if hanging from a perch, such as when they perform their characteristic sit-and-wait hunting strategy known as perch feeding. The frequencies of echolocation calls mostly lie within a range higher than the upper frequency threshold detected by the human ear (ca 20 kHz): i.e., calls are *ultrasonic*. However, in some cases calls are audible: of the Italian bat fauna, *T. teniotis* calls at 9-13 kHz, and *N. noctula* may emit calls with frequencies low enough to be audible (17-19 kHz).

Such calls are not to be confused with social calls, also often audible, whose function is communication.

In general, Italian bats emit calls ranging in frequency from the above mentioned 9-13 kHz (as in *T. teniotis*) to above 100 kHz (some rhinolophids: *R. hipposideros*, *R. mehelyi*, *R. euryale*), whereas duration varies from ca 1 (e.g. some brief *Myotis* calls) up to over 80 milliseconds (some long rhinolophid calls).

Most European bats employ an echolocation system based on the delay existing between call production and echo return: this is the case with all vespertilionids, *T. teniotis* and *M. schreibersii*. Such calls exhibit a more or less rapid frequency change in time, frequency values covering a range of variable width.

When a search call is emitted, it travels through the air until it bounces back from a target (a static object or moving prey) as an echo. By assessing the time taken from call emission to echo return, the bat may determine the target distance. The echo will also convey further information on the target, since the call-target interaction will have modified certain intensity and frequency characteristics (Neuweiler, 1989).

The spectrograms of calls from such species may be categorised as follows (Figure 4.17):

- FM (frequency modulated), such as *Myotis* calls. Signals sweeping through a large frequency bandwidth.
- FM-QCF, made of a frequency modulated (FM) component followed

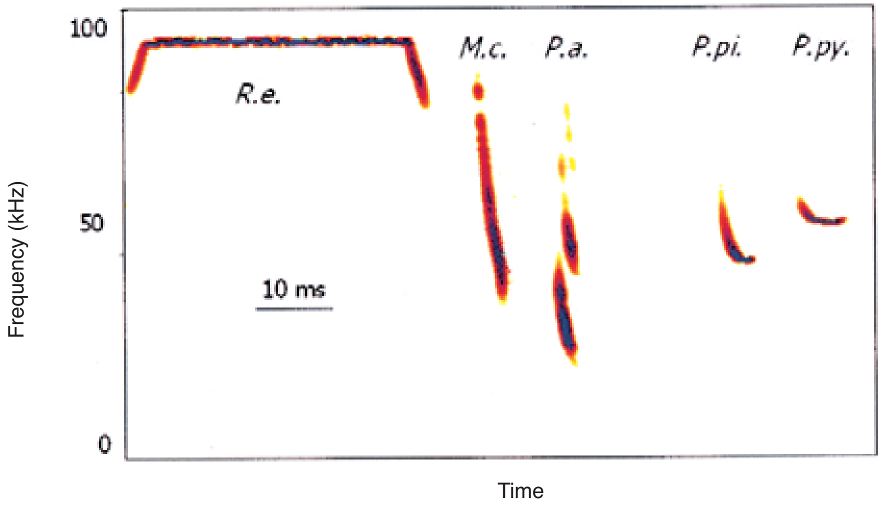

Figure 4.17 - Spectrograms of echolocation calls. FM/CF/FM (R.e. = *Rhinolophus euryale*), FM (M.c. = *Myotis capaccinii*, P.a. = *Plecotus austriacus*) and FM/QCF (P. pi., P. py. = *Pipistrellus pipistrellus, P. pygmaeus*).

by a tract whose frequency is almost constant (QCF, quasi-constant frequency) and generally contains the highest energy (for a description of calls by Italian bats see Russo and Jones, 2001).

A narrow frequency bandwidth signal is best suited for detecting objects over long distances, whereas it is less accurate in locating the target, and vice versa for broad-band calls. Hence, call structure varies across species according to the main habitat structure they are associated with (from open area to cluttered vegetation). FM and QCF components are both present in calls emitted by species well suited to exploiting a range of different habitats and needing to compromise between accurate resolution and long-range detection. For the same reason, the relative "importance" of FM and QCF components may change according to flight habitat. This is especially apparent in generalist species, such as *Pipistrellus* spp. (Kalko and Schnitzler, 1993).

Rhinolophids have evolved a different echolocation system. Such bats emit calls made up of a long, precisely constant frequency (CF) preceded and followed by short FM sweeps (the structure is known as FM/CF/FM). Although less accurate in distance resolution, these calls prove excellent for detection of prey moving against a cluttered background.

Call energy concentrates in the CF component, strictly constant for each individual as long as it does not move ("resting frequency"); for example, a rhinolophid calling while hanging from a perch. Each bat possesses a so-called "acoustic fovea", i.e. the cochlea has a maximum sensitivity to an individual-specific frequency value. A flying rhinolophid will perceive echoes from its own calls that are apparently lower in frequency. This is the result of the bat's own movement, produced by the well-known "Doppler effect". To compensate for this effect and make sure echo frequencies fall within the acoustic cochlea sensitivity, the bat lowers its call frequency (Schnitzler, 1968).

Long CF calls allow rhinolophids to detect moving prey in cluttered habitats with dense vegetation, such as forests. The wing beat of a prey insect will introduce in the returning echo the occurrence of a rhythmic frequency and intensity pattern along the constant frequency component, conveying to the bat information concerning prey features (prey wing size, wing beat rate, etc.). When insect wings are held perpendicular to the ultrasonic wave hitting them, they produce so-called "acoustic glints" (*sensu* Neuweiler, 1989), i.e. short and intense energy peaks. At least for *R. ferrumequinum*, data suggest that active prey selection occurs (Jones, 1990). This is probably linked with the capability of discriminating prey type offered by the typical rhinolophid echolocation system.

4.8.3 *Acoustic surveys*

In the last three decades, bat detector surveys (Figure 4.18) have become quite popular (Ahlén, 1981, 1990; Jones, 1993; Pettersson, 1999; Parsons *et al.*, 2000; Russo and Jones, 2002). Their main function is to convert the ultrasound emitted by free-flying bats into audible sound. When a bat flies at a distance falling within the detector's sensitivity range, its presence is revealed because the echolocation or social calls emitted are transformed into audible signals.

Bat detector effectiveness depends upon microphone sensitivity (Waters and Walsh, 1994; Parsons, 1996), signal strength (Waters and Jones, 1995), structure of habitat where the survey is carried out (Parsons, 1996), distance from the flying bats and their relative locations. In several cases, species identification may be accomplished either by listening to the transformed sound or by analysing it in the laboratory. Sound analysis is accomplished using acoustical spectrographs (such as Sonagraph, Kay Elemetrics) or more commonly by a software package run on a personal computer.

To study European bats, bat detectors have been employed to transform sound in three main ways (Ahlén, 1981, 1990; Zingg, 1990; Vaughan *et al.*, 1997a, 1997b; Parsons and Jones, 2000; Russo and Jones, 2002): heterodyne, frequency division and time expansion. Recently, direct ultrasound sampling has been becoming increasingly popular (Pettersson, 1999; Jones *et al.*, 2000; Parsons and Jones, 2000). Each of these approaches has its pros and cons, as detailed below. For the sake of completeness, we also mention the existence of another system, based on zero-crossing analysis (ANABAT), which is especially widespread in the US. O'Farrell *et al.* (1999a, 1999b) and Barclay (1999) offer a description of the identification method as well as a discussion of its advantages and disadvantages.

Figure 4.18 - Pettersson D980 bat detector. This device allows ultrasound to be converted into audible signals. Three different functions are allowed: heterodyne, frequency division and time expansion.

a) Heterodyne

Heterodyne bat detectors are the oldest produced. To study bat ultrasound, Pierce and Griffin (1938) first employed a heterodyne receiver devised to study ultrasonic emissions by insects. Their device used only one inner oscillator, whereas modern ones use two oscillators, so they should be more correctly called "super heterodyne bat detectors".

In heterodyne detectors, a first oscillator generates a signal (whose frequency is selected manually by the operator) mixing with that, emitted by the bat, which is transformed into an electric signal. The resulting output has two peak frequency values, one resulting from summation of the two signals, the other from their subtraction. A filter suppresses the former, whereas the latter mixes again with a high frequency signal generated by a further oscillator working at a constant frequency. Again, two signals are produced, one with a frequency well above the upper human hearing threshold, the other – which is that of interest – below it. In this way, the ultrasound is transformed into an audible signal (Parsons *et al.*, 2000).

By changing the first oscillator frequency, the operator may set the bat detector to a frequency value (± 5kHz) at which the signal emitted by the bat is null: the value, read on a display, is close to the frequency of maximum energy of the bat call. When we get close to the point at which this happens, the sound output by the bat detector shows peculiar tonal properties, which may help further in identification if the operator is well trained and, indeed, has a particular sensitivity (what Ahlén and Baagøe (1999) define as a "musical ear").

Heterodyne is a narrowband method, the frequency range examined being selected by the operator. Hence, all calls with a frequency outside the range selected are missed. Moreover, the transformed signal does not retain features such as duration, frequency and frequency trend over time (Parsons *et al.*, 2000), so no reliable quantitative analysis of sound is achievable.

b) Frequency division

In this case the frequency of the call picked up by the bat detector microphone is divided by a ratio selected by the operator so that the resulting frequency will have a much lower value and become audible (Parsons *et al.*, 2000). This is a broad-band method: all calls are detected, regardless of their frequency value, a property most useful to detect all bat passes (Vaughan *et al.*, 1997b). Although sound analysis of frequency-divided calls is possible, call structure is not fully retained – harmonics are missed because only the energy-richest component is preserved (Parsons *et al.*, 2000). Background noise is often quite high and it is difficult to obtain clear recordings.

c) Time expansion

This approach is convenient because call structure is fully preserved and detailed analysis of the resulting sound may be carried out (Pettersson, 1999). The incoming sound is digitised at a high sampling rate and then "slowed down", i.e. converted into sound whose frequency is lowered (duration is consequently longer) by a given factor (Pettersson, 1999; Jones *et al.*, 2000; Parsons *et al.*, 2000). Thus an ultrasonic pulse with a frequency of a maximum energy of, say, 40 kHz, and a duration of 5 ms, will be transformed by a 10 x time expansion into an audible sound with a frequency of 4 kHz and a duration of 50 ms.

Apart from the relatively high cost, a major problem with time expansion is that sound cannot be expanded continuously: after sound is expanded, i.e. during the downloading phase, the bat detector cannot process any further incoming sound. In other words, given a x10 time expansion factor, sampling times of 2, 3, or 12 secs will correspond to pauses of 20, 30 or 120 secs. This may considerably reduce sampling time (Jones *et al.*, 2000; Parsons *et al.*, 2000).

d) Direct ultrasound sampling

The outstanding progress in computer technology has recently made possible direct ultrasound sampling (i.e. without lowering call frequency). This involves an ultrasound sensitive microphone connected to a laptop computer equipped with a special sound card (i.e. operating at high sampling frequencies, > 330 kHz; Pettersson, 1999; Jones *et al.*, 2000). In this way continuous sampling is possible. This system, being less portable and more fragile than the others previously described, has limited usefulness for fieldwork (Jones *et al.*, 2000). However, the most recent alternative features bat detectors which include a direct sampling function (such as the Pettersson D1000X detector). Sound may be saved on a CF card, whose size is the only limit to sound file storage. This may then be plugged into a computer for sound analysis. So far, the main disadvantage consists in the high cost of such equipment.

4.8.4 *Bat acoustic surveys*

A first aim of an acoustic survey is generally to assess bat use of certain sites, or habitats, without identifying species or performing only limited identification work (e.g. by recognising genera instead of species). The overall number of bat passes (echolocation call sequences) has proved a useful index of bat activity. It must be borne in mind, however, that this variable *does not* represent the number of individuals detected, so it cannot be used to estimate population densities. In fact, several passes may be due to a single bat (Thomas and West, 1989).

As long as identification is not the main survey objective, many operators, even if not very experienced in acoustic identification, may be employed to cover wide geographical areas. In this way, comparisons of total activity across different habitats may be carried out. On this basis, models may be developed to forecast the importance of sites not directly investigated (Walsh *et al.*, 1995; Walsh and Harris, 996a, 1996b). When possible, species identification helps in obtaining detailed information on occurrence and habitat use in one or several species (McAney and Fairley, 1988; Rachwald, 1992; Rydell *et al.*, 1994; Vaughan *et al.*, 1996, 1997b; Shiel and Fairley, 1998; Waters *et al.*, 1999). Automatic monitoring systems have been employed to remotely monitor and record bat activity without the presence of an operator (Downs and Racey, 1999; O'Donnell, 2000). The choice of the "correct" sampling protocol depends upon the study objectives and operational conditions.

4.8.4.1 Classification systems

By "classification systems" we mean the objective and quantitative methods developed to classify echolocation calls from free-flying bats. The two approaches most commonly adopted are represented by Discriminant Function Analysis (DFA) and Neural Networks. The theoretical background of this subject goes well beyond the scope of this book. In brief, we may generalise that these methods rely upon a set of measurements taken from a call library made up of calls of known identity. These are used either to "train" a neural network or develop a discriminant function. Such tools will then be able to identify calls from unidentified bats. The variables needed to implement such methods are generally frequency and time parameters taken from bat calls (Figure 4.19). Further aspects such as call shape may be categorised and entered for analysis. For each of the species covered, classification performance is known and expressed as per cent probability of correct identification. In other words, the researcher is provided with a quantitative index of per-

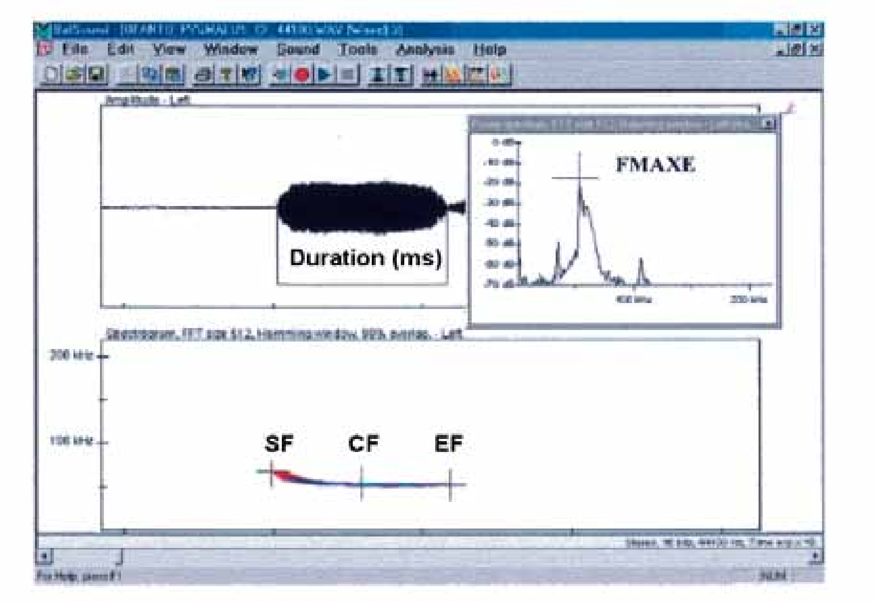

Figure 4.19 - Oscillogram (top left), spectrogram (below) and power spectrum (top right) with a time-expanded FM/QCF call obtained with *BatSound* ver. 1.0. Pettersson D980 bat detector, recorded Sony Walkman WM D6C. Sound analysis setting as follows: *sampling rate* 44100 Hz, 512 samples Hamming window, 98% window overlap (112 kHz frequency resolution); *threshold* = 20. Main analysis variables: SF (Start Frequency, i.e. frequency value at call start), CF (Central Frequency, frequency value corresponding to the highest energy at half call duration), FMAXE (Frequency of MAXimum Energy), EF (End Frequency) and call duration. In the example shown *(Pipistrellus pygmaeus)*, SF = 65.9 kHz, EF = 52.3 kHz, CF = 53.5 kHz, FMAXE = 53.6 kHz, duration = 5.8 ms.

formance "quality". To date, this is the most objective, fully repeatable approach, both qualities being greatly desirable in any scientific study.

4.8.4.2 Guidelines for bat acoustic identification

Acoustic identification offers great advantages. It allows the researcher to carry out many more observations than captures, with no impact on bats. Species flying at greater heights, often difficult to capture (e.g. *Nyctalus* spp.), are revealed with a bat detector. Field discrimination of cryptic pipistrelles *P. pipistrellus* and *P. pygmaeus* is easily carried out by measuring peak frequency of echolocation calls, whereas morphological criteria set for identification are still debated. However, to make the most of acoustic methods, it is necessary to have a good knowledge of acoustics, to apply repeatable, objective identification criteria and carry out species identification with great caution.

Here are some basic notes on how to make prudent but rewarding use of a bat detector.

- Be careful when using a heterodyne bat detector for species identification. The researcher should rely upon this method only for those species easily recognised, and not carry out species recognition for *taxa* exhibiting great overlap between spectral or time call parameters across species, such as those of the *Myotis* genus.
- Heterodyne identification is based upon personal experience and skills, at the expense of performance repeatability and objectivity.
- Whatever the method adopted, recordings should be made available to the scientific community. In all papers and reports, recording conditions, sampling methods, approaches adopted for recording and analysis of sound must be described thoroughly. Also, *fully* explain methods adopted to carry out species identification. In other words, the reader should be provided with all the information making it possible to *repeat* identification from the field recording phase. When possible, show spectrograms of the most important species found, i.e. rare or especially interesting ones.
- Sound processing approaches allowing for acoustical analysis, especially time expansion or direct sampling, should be preferred because they are more reliable. Frequency division also offers this opportunity, although it implies loss of harmonics and often a low signal-to-noise ratio.
- Recording quality should be taken into account because it may seriously degrade identification performance. For example, *M. nattereri* often emits peculiar calls with a very high (> 100 kHz) start frequency and quite a low end frequency, sometimes within the audible range. However, when calls are weakly recorded, start frequency may end up

appearing lower than in the actual call, making identification problematic.

- Calls from many bat species are more structurally similar when emitted in cluttered habitat. Specifically, frequency bandwidth increases, duration drops, and frequency variables (start, end, central, peak) increase. In such circumstances, diagnostic features may be suppressed. Bear in mind that calls recorded in the open are easier to recognise. Similar effects are found in calls emitted on roost emergence, so it is advisable to take recordings at some distance (20-30 m) from roost exit.
- Finally, (in some cases considerable) alteration of call structure is commonly observed in echolocation calls from hand-released bats. When setting up call libraries, when possible prefer echolocation calls of known identity from bats either leaving the roost (recorded at some distance from it) or recognised in flight thanks to species-specific social calls. When hand-release recording is inevitable, analyse the last calls in the sequences recorded, and wait until the released bat gains height before taking the recording. The application of a light tag may help track the released bat for a while in order to point the microphone at it; moon-lit nights also help in seeing the bat after it has been released.
- It is advisable to stick to the same recording and analysis conditions. These include bat detector and recorder gain levels selected, sampling frequency adopted, type and size of analysis windows chosen, threshold value applied to spectrograms, etc. This is all the more important when the aim is to compare call characteristics across species or individuals, or when setting up a call library for implementation of quantitative classification methods (DFA, neural network, etc.).
- We are against extending qualitative identification, as commonly performed with heterodyne, to time-expanded recordings. This profoundly degrades the otherwise high potential for identification quality and objectiveness offered by time expansion.
- When possible, quantitative classification methods implemented for a specific area may offer good results. As explained above, they represent an objective approach for assessing identification performance. Moreover, in this way the researcher will be able to select “quality thresholds” above which a given identification may be accepted as good enough (Russo and Jones, 2002, 2003). If a discriminant function provides, for the various species, per cent values of correct classification ranging between, say, 35 and 100%, the researcher may choose to accept identification only for species scoring over at least 80%. The other species may still be classified to genus level, renouncing species identification (it is far more prudent to attribute a call to, say, *Myotis*

sp. rather than to *M. mystacinus* if this is recognised with a 40% likelihood of correct classification).

- The old slogan, popular among computer geeks, "garbage in, garbage out", is all the more true when implementing quantitative identification methods. Their effectiveness is critically influenced by sample sizes of calls considered for each species, as well as by the degree of call variation represented for each species. Hence, when developing call libraries, try to record bats in a variety of situations, including different sites, roosts, habitat structures (open areas, vegetation of different density, etc.) In some species, call variation is related to sex and age class. Finally, do not pseudoreplicate sample units: each call should correspond to a single bat.
- The implementation of discriminant functions, neural networks, etc. is time and energy consuming: it relies upon the recording of large numbers of reference calls. A less demanding alternative is offered by the use of simpler (quantitative) identification criteria whenever possible. For example, in a study of habitat use by *N. leisleri*, Waters *et al.* (1999) attributed calls to this species only if these had an FM/QCF structure and the following features: a) frequency of maximum energy > 23 kHz, and b) were part of call sequences showing an alternation of call spectrograms respectively showing a more pronounced FM portion and an almost fully CF structure (typical of *Nyctalus* genus). In this way there could be no confusion with *N. noctula* (calling at lower frequencies) or *Eptesicus serotinus* (which does not alternate between different calls). Likewise, in a study on *P. kuhlii* social calls, Russo and Jones (1999) attributed to this species only free-flying bats records by street lamps whose echolocation calls were FM/QCF and had a frequency of maximum energy of 36-41.5 kHz. In this way, confusion with *P. pipistrellus* – mostly emitting at higher frequencies – was avoided. Echolocation calls could still be confused with those of *P. nathusii*, but this is infrequent in Italy and never recorded in the study area considered. In the above examples, both species might emit echolocation calls covering a larger variation than the one considered. In other words, one cannot rule out that, however unlikely it may be, in both studies some bats belonging to the species targeted were excluded from the analysis because their calls did not meet the conservative criteria applied. However, this approach still grants a high level of credibility to the identification performed, excluding cases of misclassification with species emitting similar calls.
- Social calls emitted by bats are often species-specific, i.e. their struc-

ture shows less variation than that of echolocation calls because they are used for communication, not orientation or prey localisation. Those whose structure has been described may be successfully employed for species identification. For European pipistrelles, see e.g. Barlow and Jones (1996, 1997a, 1997b) and Russo and Jones (1999, 2000). The main disadvantage is that bats do not constantly emit social calls; their production is in fact relatively rare.

- The use of call libraries, reference recordings and diagnostic keys produced for geographical areas other than that where identification is carried out (especially if these are far apart) should be avoided if possible because echolocation calls are subject to geographical variation.
- Species such as *Plecotus* spp. and *Rhinolophus* spp. emit calls which are difficult to reveal with a bat detector. *Plecotus* bats adopt faint calls to circumvent their main prey's (tympanate moths) sound sensitivity. Such calls are hardly audible with a detector. Likewise, rhinolophids produce high-frequency, directional calls, undergoing strong atmospheric attenuation, so they may easily be overlooked, especially at a distance. If these are the target species, it is perhaps best to opt for alternative methods.

4.8.4.3 Assessing relative abundance using bat detectors

When the number of bat passes is recorded from a vehicle moving at a (relatively!) high speed, in principle it would be possible to derive relative abundance indices for making comparisons across different areas. Unfortunately, this method is not free from problems, and caution is needed in using it. First, apart from the identification problems discussed above, an important variable is represented by species-specific detection. As we have seen, species emitting either weak or strongly directional echolocation calls are likely to be overlooked, and this is all the more true when recordings are made from a moving vehicle. Data obtained in this way will probably not be suitable for quantitative assessment of these species' presence. Clearly, when comparing the abundance of different species, the data would be flawed by the different probability of detecting a species, those most frequently overlooked being underestimated.

Another problem, as mentioned above, is the risk of counting several passes from the same bat: even if recordings are made along a transect rather than at fixed sampling points, this risk cannot be ruled out. Such data should always only be used to obtain *activity indices*. Of course, the risk of double counts will be much higher for transects carried out on foot than for those covered with a bicycle or a car, at higher speeds. In the latter case, however, another problem should be taken into account. Many bat species are specifically associated with foraging habitats found away from roads or paths, so when surveying an area with a vehicle, or even a bicycle, the risk of underestimating bats dwelling in habitats out of reach is not negligible.

For example, consider a project designed to assess the relative abundance of *P. pipistrellus* and *P. pygmaeus*. In Italy the former is much more widespread than the latter, being generalist and often hunting around street lamps (i.e. easy to encounter along roads). *P. pygmaeus* is much more associated with riparian habitats and forests (Vaughan *et al.*, 1997a; Russo, 2001, Russo and Jones, 2003), so the likelihood of detecting it from main roads is quite low. A comparison between the two species which did not take this aspect into account would probably underestimate *P. pygmaeus*.

In conclusion, when surveying large areas with a bat detector, it is advisable a) to limit identification to species that are easy to detect and recognise, evenly spread over the area; b) to plan a sampling protocol as representative as possible of the heterogeneity of the study area's habitat; c) to bear in mind the risk of pseudoreplicating bat counts, inevitable when walking transects.

4.9 **Other data sources**

Information on the bat fauna of a given territory may also come from activities and situations not directly connected with planned research. The occasional finding of dead specimens, however rare, offers a way to improve the scarce information available on species distribution. In order to avoid these data being missed, the local authorities at Province level and other institutions working on the territory might help by collecting the material and adequately advertising the activity. They should also provide all the information needed to preserve the specimens and collect basic data on their retrieval. In all cases, identification should be performed by specialists; the data should be filed in databases recording at least species, date and place of retrieval. Specimens should then be consigned to different institutions according to existing laws and further information needs. For example, the so-called "Istituti Zooprofilattici" (public health institutions dealing with animal-human relationships) might examine well-preserved specimens to look at pathogens or contamination by pollutants.

Another source of information is related to the fact that many bat species roost in buildings, or sometimes bats accidentally enter houses. These cases are very frequent and often lead to unmotivated panic, leading to calls for the intervention of the fire brigade, public health institutions (A.S.L.), environmentalists or even pest-control operators! According to Italian law, these cases should be dealt with by Province institutions or, where appropriate, park authorities. In both cases, it is hoped that bat specialists will be involved in staff training or management of difficult cases. Not only would the correct management of such situations (according to existing laws) have important conservation implications, it would also achieve a significant increase in the available data. This would greatly help in surveying species distribution and estimating population sizes.

As for dead specimens, also cases of bats roosting (or dwelling) in buildings should be appropriately recorded in a database. For details on roosts see paragraph 5.5.1. In all other situations, the information collected should include: species, number of bats, date and place of observation. Collecting such data would meet the provision of article 8, D.P.R. n. 357/97: "Regions and autonomous Provinces of Trento and Bolzano must constantly record capture or accidental killing of wildlife species listed in Annex D, point a), and submit an annual report to the Environment Ministry."

Another potential source of data is bats accidentally caught during bird mist-netting. Unfortunately, bat species identification is often a complex matter and requires the intervention of a specialist. However, even bird workers lacking sufficient experience with bats might try to carry out an identification in the simplest cases, perhaps limited to the genus level. Even the mere recording of numbers of bats captured may help in locating main migration routes or foraging sites. In all cases, to get the most out of this potential source of data, collaboration between the Italian Chiroptera Research Group and bird netters has been set up.

Finally, it would be most useful to encourage collaboration between bat specialists and cavers. Not only would this increase cavers' awareness of the potential (yet involuntary) impact on bats of the disturbance associated with caving activity (and consequently reduce it), it would also be a way to get important data on colony locations and sizes in otherwise overlooked caves. A specialist might then survey the main sites and get more details. Quite often, cavers come across dead specimens or skulls. Collecting and preserving them would greatly help getting a better picture of species distribution.

4.10 **Bats and human health problems**

4.10.1 *Rabies*

Bats are generally not harmful to public health. However, there are some risks the researcher should take into account, however rare. First, in some bat populations the presence of the rabies virus (*Lyssavirus*, family Rhabdoviridae; Constantine, 1988) has been reported. The virus determines an acute syndrome of the central nervous system, leading to death within 3-7 days from the first symptoms. In Europe, the following EBL *(European bat lyssavirus*) types have been documented: EBL-1a, Denmark, Germany, Poland, Russia; EBL-1b, Holland, France and Spain; EBL- 2a, Holland, United Kingdom; EBL-2b, Finland and Switzerland (Rønsholt *et al.*, 1998). In the ‘80s, Denmark and other countries had a large number of EBL-1a cases, observed in *E. serotinus*, followed by a lower incidence for 10 years, and – in Denmark – by a new crisis in summer 1997. Until the end of the ’90s, Great Britain was regarded as bat rabies-free. Ever since, cases have been recorded, and there was widespread alarm at the death of a Scottish zoologist bitten by a rabid bat (probably a *M. daubentonii*) in 2002. In July 2002, in north-west England, a young *M. daubentonii* with an injured wing was reported to be EBL-2 rabid. No cases have ever been reported for Italy (Frati *et al.*, 1999). As far as we know, Italian populations should be rabies-free. However, it must be borne in mind that bats can migrate over long distances, and that rabid bats have been recorded in neighbouring countries, so the arrival of sick bats cannot be ruled out.

Rabies is most commonly transmitted by the bite of a rabid animal, the virus occurring in the saliva. Always wear at least a light glove when handling bats, and as a precaution take the anti-rabies vaccination (which should be repeated every 1-3 years). If bitten by a suspect animal, wash the bite carefully with water and detergent. Then apply a disinfectant, and immediately take the vaccination. In all cases seek urgent medical assistance.

4.10.2 *Histoplasmosis*

In wet, hot climates, especially in the Tropics, a fungus – *Histoplasma capsulatum*, a soil saprophyte – may occur where large amounts of bat (or bird) guano accumulate. When spores are inhaled, humans and other mammals may contract a non-contagious infection which initially affects the respiratory system. In histoplasmosis-risk areas, when entering roosts, always use masks equipped with filters excluding particles as small as 2 microns in diameter, or use self-contained air supplies (Constantine,1988).

5. Data storage and analysis

Adriano Martinoli & Elena Patriarca

5.1 General issues

5.1.1 *Background*

Modern conservation science is steadily becoming more dependent on tools designed to organise, manage and summarise information to support effective strategies and adequate planning. Especially for conservation actions targeting large areas (i.e. on a national or international scale), databases of species status or distribution are crucial tools from which the data necessary to implement valuable programmes may be extracted. Regrettably, the current situation is quite problematic. Several factors make it difficult to obtain and order the necessary information. Besides the absence, scarcity or poor quality of data, a major obstacle to setting up effective conservation strategies lies in the lack of information exchange among the various parties (conservation, management, socio-economical and political actors, etc.) (Toxopeus,1996). Most information employed for bat conservation is represented by data on species distribution or important roost sites. This knowledge is needed to designate protected areas, modify the boundaries of those already existing, and conserve single species or their habitats, as well as to check the performance of, and if necessary, improve corridors between protected areas.

A "simple" knowledge of distribution may help answer some crucial conservation questions, i.e.:

- Which species should be targeted for conservation?
- Which information is really necessary?
- Which methods are most suitable?
- Which strategies are possible and what are the expected results?

The analysis of data on bats may help identify priority species to target for conservation actions, or locate and protect habitats important for bats. On the other hand, field data collection is expensive and time-consuming. A correct identification of the variables to be monitored in the field before actually starting data collection is essential to maximise data quality while minimising the efforts invested. To help detect trends in the medium to long term, data collection design should also include periodical updates and an increase in data collection detail over time. In such cases, standardised monitoring techniques are needed to ensure repeatability and allow for comparisons of datasets collected in different periods. This approach requires the production of sampling forms and protocols suited for each of the data types to be collected, i.e. for the specific recording techniques adopted. Data structure must make it possible to store the information in an adequate filing system.

Another application stemming from the analysis of the data collected is the prediction of the effects of different management strategies. Tools simulating scenarios, as well as testing the management outcome in progress (*auditing*) play a crucial role, particularly when sensitive species such as bats are concerned. The final goal of collecting and ordering the information is to build up a thorough *knowledge* base, rather than simply a database, useful for developing conservation programmes and strategies.

The basic features of this information collection may be summarised as follows:

- *Standardisation*: the information available should be ordered according to rigorous yet flexible criteria (i.e. subject to further adjustments and updates over time) to present it in a consistent, homogeneous form.
- *Concentration*: possibility of physically entering and storing the data at one place, avoiding dispersion and consequent loss of information consistency.
- *Accessibility*: a database must be "friendly" to all users who access it to take decisions or make plans.
- *Scale independency*: possibility of managing data on species status and distribution regardless of their spatial resolution. In many cases, the information available is taken from previous studies or surveys, carried out with a range of different aims. Given the high costs, it is often not feasible to start new, dedicated surveys: an effective system should be able to store the existing data, however heterogeneous they are, without degrading the quality of the best information available, and including data of lower detail and quality (which may nonetheless be valuable).

5.2 **From field data to conservation**

The methodological solutions presented here mainly involve the design phases of data storage and elaboration, with special reference to PC-based tools such as geo-referenced databases *(geodatabases:* Zeiler, 1999). The methods examined rely on some basic features. One is the possibility of adding data over time. Geographic databases need to be structured by a module-based design, in order to manage data collected at different spatial and temporal resolutions, while ensuring data consistency, easy use, high possibility of access and data dissemination safety. Potential data sources (signs of presence, sightings, estimates, counts, etc.) may be categorised in terms of quality. Each source may be labelled with a certain data quality indication, based on the nature of the variable measured.

Table 5.1 - Categorisation of data types and corresponding quality level.

Category	Definition	Quality level
Binary data	Only species presence recorded	Low
Discontinuous data	Data structured according to ordinal scales, or relative abundance class	Medium
Continuous data	Population density or number of subjects	High

A first quality classification may be made on the categorical vs. continuous data structure (Jongman *et al.*, 1987). A drawback of such a classification system is that it ignores the value of the data point information (Ripley, 1981): continuous data referred to a large-scale, coarse-grained geographical unit will be certainly less important than ordinal data referred to a site with a high spatial resolution (i.e. as a data point). Hence two factors contribute to defining "quality" of distribution data to be applied to conservation: data "metrics" and spatial resolution. The implicit possibility of georeferencing the data, depending on the way these are collected, is therefore part of what we can regard as "data quality". In the specific case of storing and managing data by Geographic Information Systems (GIS), this aspect is crucial because data *must* be referred to space.

A second quality ranking based on the data spatial scale may be illustrated (Table 5.2), the best being represented by the highest resolution obtainable – i.e. a point-referred record, such as most records concerning bats.

Table 5.2 - Categorisation of data type based on spatial resolution.

Basic spatial unit	Type	Scale
Pair of geographic coordinates	Data point (GPS or map record)	Local
PRU	Polygonal record unit (PRU) used in counts, variable according to species or survey method	↓
FSP	Faunal Survey Patch (FSP), corresponding to one or more PRUs	↓
FSP (level 2)	Pooling of several FSPs for management aims (e.g. as sectors of a wide management area)	↓
FSP (level 3)	Wildlife management unit (e.g. parks)	↓
Province		↓
Regioni		Global

The classification illustrated in Table 5.2 is based on an *a posteriori* categorisation of different geo-referencing options available for a faunal record. It also offers the advantage of matching territorial classification criteria adopted in other contexts of management and environmental planning, so that other users will find it easy to use the information.

5.3 **Data management and rational use**

Structuring data as described above inevitably complicates the information storage and management system. However, the increased complexity should not determine reduced accessibility or simplicity of use, both factors being of prime importance. The problem may be overcome by designing interfaces to enter and manage data on the basis of comments and criticism by the *geodatabase* final users. This is a vital point because in this way the storage system will adapt to users rather than vice versa. An analysis of rough data will make it possible to make the most of features peculiar to the different data types to simplify data management and limit the risk of entering erroneous records.

5.4 **Data integration**

The main advantage of storing distributional data in a geodatabase is that archives may be accessed both in the classical alphanumeric tabular format and as a thematic map. In the latter case, the information on data distribution stored in the geodatabase may be overlaid and compared in a simple, straightforward way with all other available georeferenced information, such as terrain morphology (e.g. Digital Elevation Models) or vegetation cover.

Figure 5.1. illustrates an example of a geodatabase including information on bat distribution recorded as datapoints concerning captures or roost surveys. In this case, not only could species occurrence be represented as a thematic map, but colony sizes and mean values of biometry variables could also be displayed. Recent advances in relational databases (Gogolla, 1993; Momijan, 2000) have also improved data access to users (including remote access).

As far as GIS-linked databases are concerned, a set of ancillary functions may be associated to a specific database to facilitate data use and dissemination (Figure 5.2). These make it possible to consult the data in both alphanumeric and map formats, thanks to the peculiar system design which separates data storage (*geodatabase server*) from use (*client*) by specialised programmes. In this way it is possible to provide specific interfaces offering a range of options, from remote data storage through generic Worlwide Web-based clients to their applications to more sophisticated GIS-based decision supports (ArcGIS or ArcView GIS clients). This

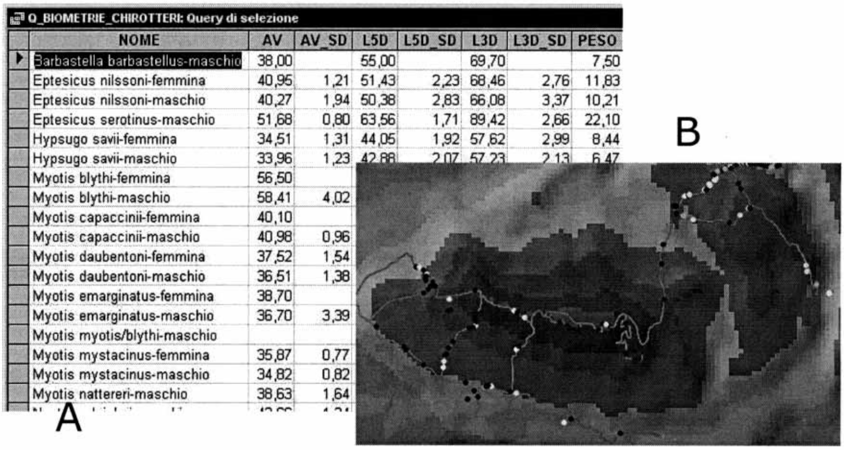

Figure 5.1 - Tabular (A) and thematic map (B) outputs of bat distributional data, including biometry measurements (AV = Forearm length, L5D = length of digit 5, L3D = length of digit 3. Code_SD corresponds to standard deviations for each variable).

kind of system design also offers different levels of access to different users, contributing to a high level of safety in information management.

The methods proposed represent a comprehensive, self-consistent approach to developing systems to plan and put into practice effective strategies for conservation and management of nature resources. These may range from the production of thematic maps showing species distribution in ways which may be customised for different users, to sophisticated simulation and prediction systems analysing environmental quality and the importance of a given area for the fauna.

5.5 **Data banks and projects in progress**

Recently the *Direzione Protezione Natura* (the steering office for nature conservation) of the Italian Environment Ministry, in cooperation with the Verona Natural History Museum and the Scientific Committee for Italian fauna, produced a data bank featuring a “Checklist and distribution of Italian animal species”. Although this certainly represents a first useful tool summarising basic information, it focuses on generic presence records, including historical data – which often do not represent the current situation. In fact, this is an extensive database, concerning the whole Italian fauna and pursuing a general aim.

To meet the urgent needs of bat conservation, much basic information is still to be acquired, ordered and evaluated. To optimise conserva-

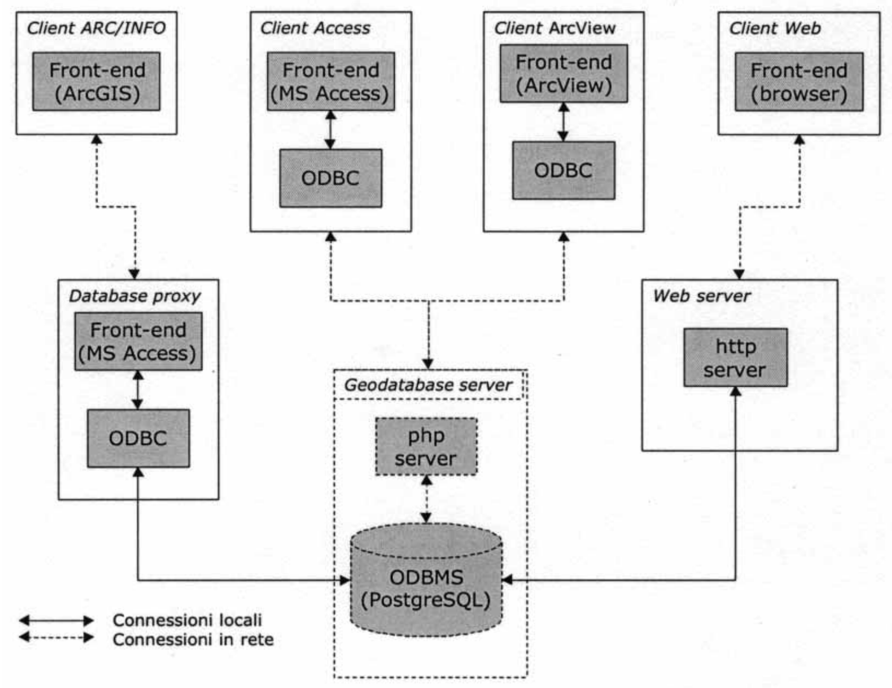

Figure 5.2 - Example of a client-server structure of services for data use and dissemination by a distributed geodatabase. Specialised clients (Access, ArcView GIS and ArcGIS) are connected through an ODBC protocol *(Open Data Base Connectivity)*. A web-based client is linked with a web server *(http server)*, in turn connected with the central database *(Object Data Base Management System)* by specific procedures developed in php language *(Personal Home Page)*.

tion, the various actions should be ranked by priority. This need is also highlighted (and in some cases subject to specific prescriptions) in several steering documents enforcing international agreements and laws in Italy (see chapter 3).

In this context, the Italian Chiroptera Research Group (GIRC) has started projects aiming to record data and set up databases, pursuing the reliable assessment of species conservation status and the implementation of adequate conservation planning and actions. Finding roosts (especially hibernacula and nurseries) and characterising them (location, site type, bats present, conservation status) is important to analyse population trends and assess conservation status. Hence, a national roost database is being developed through GIRC's efforts. Another database on which GIRC members are currently working includes records concerning ringed bats, crucial for a reliable data management.

5.5.1 *The roost data bank*

The "Italian roost data bank" project, started by GIRC in 1999, focuses on bat roosts categorised as hibernacula, nurseries or "other" day roosts (i.e. those used for day resting or other biological functions either not ascertained or not considered as a specific category). The database covers information on present bats, site features and location referred to the UTM mapping system at a 10-km spatial resolution (see Appendix I).

The project's aims are as follows.

- Short term: site inventory; identification of most important sites for conservation. To identify sites deserving more conservation efforts, data relative to the entire national territory must be recorded and roosts classified according to species and colony size. In general, as in other countries (see e.g. Mitchell-Jones *et al.* (1993) for the U.K.), the major conservation bat sites will be those used by especially numerous colonies of species deserving special protection (but maybe only one species), or sites frequented by a large number of species, each represented by numerous subjects.

  Table 5.3 illustrates the criteria set by GIRC to assess the importance of sites on a national scale. Of course, less strict criteria may be applied to ensure conservation of sites which are less important on a global scale but nonetheless locally important (e.g. on a regional scale). For instance, this may be the case with roosts used by small maternity colonies whose loss would imply a decrease in genetic variation and isolation. Once more basic information is available, the criteria will have to be validated and improved. Their definition is based on the information collected in preliminary surveys, experience gathered in other countries, and practical needs. To avoid constant updates, fixed threshold values were defined for the numbers of bats, rather than proportions relative to the total counted (i.e. sites where a given per cent value of the total species count is found), or ordinal selections (i.e. the *n* best sites). Hibernacula or maternity roosts meeting the criteria illustrated in at least one row are classified as of special conservation importance on the national scale. For example, these include roosts numbering at least 100 wintering or breeding bats from at least 3 species, or at least 50 bats from 4 or more species, except where aggregations of *Pipistrellus kuhlii, Hypsugo savii, P. pipistrellus* and *P. pygmaeus* are found. The above exclusion is based on the fact that according to available knowledge, these species are common (i.e. abundant and widespread) on the national territory and quite synanthropic. However, the scarcity of data on distribution (especially for *P. pipistrellus* and *P. pygmaeus*, for which most information refers to a "mix" of the two species) and the unknown role played by Italian popu-

N species	Species	N bats
≥ 4	All	≥ 50
3	All	≥ 100
2	All, except (*) when both species are from the following: *P. kuhlii, H. savii, P. pipistrellus* e *P. pygmaeus*	≥ 150
≥ 1	*M. punicus* and species in Annex II of 92/43/EEC Habitats Directive except *M. schreibersii*	≥ 50
1	*M. schreibersii* and all species mentioned in the cell above except (*) *P. kuhlii, H. savii, P. pipistrellus* and *P. pygmaeus*	≥ 200

Table 5.3 - Preliminary criteria set by GIRC to assess roost importance. The increase of the available information may result in a revision of such criteria. The appropriateness of the exclusion of *P. kuhlii, H. savii, P. pipistrellus* and *P. pygmaeus* (cases marked with an asterisk) awaits confirmation.

lations in the species global conservation require caution in applying the exclusion criteria described above. Of the sites used by only one wintering or reproductive species, those numbering at least 200 bats are regarded as of special conservation importance, except, for the above reasons, those used by *Pipistrellus kuhlii, Hypsugo savii, Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*. On the other hand, for species of high conservation priority, a lower threshold (at least 50 bats) has been fixed. Because of insufficient knowledge of the species status in Italy relative to a global conservation perspective, the latter threshold has been applied only to the Habitat Directive Appendix II species (Table 3.1) plus *Myotis punicus* (in the past confused with other species in the same Appendix due to insufficient taxonomical knowledge), and excluding *Minopterus schreibersii* (for whose monospecific colonies a threshold of at least 200 bats is applied).

Roosts whose ecological role (whether reproduction or hibernation) has not been ascertained (indicated as “X” roosts) and that meet the criteria in at least one of the rows of Table 5.3 are regarded as sites of potentially high interest, on which further data should be obtained. In fact, once these sites are found to meet the above criteria, they might be considered of special conservation importance, or as valuable for functions other than those covered in the current data bank (e.g. as swarming sites). In this context, it is worth highlighting the need for specific surveys looking at biological roles not included in the current roost project.

- Medium-long term: identification of population trends by standardised periodical monitoring of bats at a sufficient number of representative sites. Such sites should be those considered of major (national) conservation importance, on the basis of the above criteria, plus possibly further sites to cover a sufficiently representative sample. In general terms, species which may be monitored by roost counts are those roosting exclusively or mainly in underground habitats or buildings, whereas tree-roosting bats are easily overlooked; besides, their common habit of switching roosts (e.g. Russo *et al.*, 2005) further complicates surveys. By focusing on the former group – representing most of our bat fauna – through standardised monitoring procedure, it will be possible to obtain a reliable conservation status assessment for several species.

Everyone may join the project; the participation of regional and provincial administrative institutions would be most welcome, according to article 7 of D.P.R. 357/97. Since bat surveys are a highly specialised matter, such institutions should stipulate agreements with scientists to locally coordinate monitoring actions.

A potentially important source of data for this project is the outcome of surveys made following requests from the public in buildings where bat presence is reported. This activity should be carried out by those institutions officially charged with ensuring wildlife protection. Each project participant reserves all property rights on the data provided, which may be disseminated only after his/her explicit authorisation. Periodically, the data are published in an aggregated form, i.e. as statistics on general roost features, species frequencies of occurrence and relative abundance. For further information see *http://www.pipistrelli.org/*

5.5.2 *Bat ringing database*

A recently approved agreement ratified by all Italian research groups establishes that bat ringing data (included data collected in the last decades) will be entered in a single database (currently being designed by GIRC) accessible through a controlled system via the Internet. In the past, the various research groups employed rings with different codes. However, it is now mandatory to use rings distributed by the National Institute for Wildlife (INFS) along with a positive assessment of a temporary capture/ringing application. Scientists carrying out captures and ringing will also have to communicate the data collected to INFS – the official reference institution for wild animal tagging (see also paragraph 3.1.3).

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DATA RECORDING INSTRUCTIONS FOR ROOST INVENTORY

General considerations

Some fields are factors generically characterising roosts and should be filled in with specific information for each roost. Others, concerning bat counts (bat numbers, both overall and by single species) in the different biological phases, need more data to be entered for each roost. Only records of direct bat observation are considered, signs of presence being excluded (e.g. guano, etc.). Each roost may be assigned up to three "biological roles": hibernation ("S" roost, after the Italian word *svernamento*), reproduction (nurseries, or "R" roosts), and other roles either not considered as a separate category or not assessed ("X" roosts, also including cases of suspect hibernacula or nurseries to be verified). For each roost, the largest colony sizes assessed in each of the biological phases above mentioned are entered.

Field description

Fields to be filled in with single pieces of information: general information

Site (1)
City council (2)
Province (3)
10x10 UTM (4)
50x50 UTM (5)
Altitude (6)
Type (7)
Interferences (8)
Accessibility to people (9)
Protected area (10)
Conservation (11)
N species ascertained as S (12)
N species ascertained as R (13)
N species ascertained as X (14)
Notes (15)

Site. Identifies the site where the roost is located and, at the same time, the single roost (consequently, the name entered must correspond to one roost only and different roosts must be recorded in this field with a different name).

Example: *Grotta dei Dossi; talcum quarry in Col Bione; Castle of Fenis; house in Coazze.*

Each underground site is regarded as a single roost (regardless of whether the bats roost near the entrance or deeper inside). Separate rooms in the same building, which cannot be regarded as a continuous structure, should be considered separate roosts. In such cases, use letters to label different roosts. Example: *Fort Exilles*, a (the roost is an under roof space), *Fort Exilles*, b (another space, separate and distant from the former). The same system is used to record bat boxes and tree roosts.

Example: *beech woodland in Pescasseroli*, a (corresponding to a given tree); *beech woodland in Pescasseroli*, b (different tree).

City council. The one whose territory includes the roost.

Province. Car number plate abbreviation in capital letters.

10x10 UTM. UTM code corresponding to the 10-km grid cell, as follows:
- locate UTM sector (numbers at top and bottom, 32, 33, or 34)
- locate the 100-km grid cell by the pair of letters shown on the outer edge of grid, giving first EAST coordinate (L, M, N, P, Q, T, U, V, W, X.. those on top), then the NORTH one (T, S, R, Q, P, N… those to the left);
- give the pair of metric coordinates of the single unit, following the small table top right in the grid, below the distance. Respect the convention of providing the east coordinate first, then the north (both fall between 0 and 9).

Example: Mount Argentario has coordinates 32PM70.

50x50 UTM. Leave blank (will be filled in by database managers)

Altitude. Enter altitude above sea level. For caves, entrance altitude is considered.

Roost type. Use one of the following abbreviations:
PO bridge (*It.* Ponte**)**;
DA dock (*It.* Darsena);

AL tree (*It.* Albero);
BB bat box;
PR crevice of limited capacity on exposed rock (i.e. not inside underground habitats);
GR cave/grotto (underground habitats of natural origin, including those partly excavated by humans): large spaces and crevices in cave walls, ceiling or other internal substrate;
MI mine/quarry (underground habitats of artificial origin, or natural ones which have been largely modified by excavation): large spaces and crevices in cave walls, ceiling or other internal substrate
TU tunnel (along roads, railways, canals or other water bodies, modern aqueduct);
NE necropolis, catacombs, ancient aqueduct, other structures (except the buildings listed below) of a special historical or artistic value reproducing conditions of natural underground habitats;
TM other human-made structures (except buildings listed below) reproducing conditions of natural underground habitats, e.g.: underground part of a recent grave, cellar (if not part of a building), pit (if not part of a building), outdoor oven, charcoal burning site;
BK (+ localisation, see below) bunker, small-scale fortification (buildings of limited height, often divided up into several parts, generally dating from the two World Wars);
MO (+localisation, see below) monumental building of recognised historical or artistic importance, castle, palace, etc.;
CH (+localisation, see below) church, chapel, bell tower or other religious monumental building;
EA (+localisation, see below) all other building types (*It.* Edificio di Altro tipo), i.e. those either not included in the above categories or whose type has not been assessed. Includes houses, schools, hospitals, aboveground parts of graves, stables, bat boards, signs or tables hung on buildings;
AT other type (*It.* Altra Tipologia) (to be specified in the “Notes” field).

Localisation. When the exact localisation within the site of roosting bats is available, add the corresponding number to codes **BK, MO, CH, EA:**

1 Room or spaces under roof (inside the building);
2 Space in roof (beneath elements of cladding such as tiles, but outside the attic);
3 Undetermined situation referred to either case 1 or 2 (defined as above);

4 Space (or interstice) of a room above ground other than the attic;
5 Space (or interstice) of a room below ground;
6 Outer wall interstice (interstices between walls/balconies/shutters; rolling shutter boxes; space beneath gutter pipes, cladding elements, bat boards, …)

Example.: CH6 roost in an interstice of a chapel outer wall.

N species S. Number of species found hibernating (for a definition of S, see the "biological role" field below). For this field, only species confirmed to be hibernating at the site are considered

Example (see also the information on the field "taxon" below):

MYO_MYO; MYO_BIS corresponds to one confidently identified species only

N species R. Number of species confirmed to be reproducing at the site (for a definition of R,} see the "biological role" field below).

N species X. Number of species with a status referred to the "X" category (see the "biological role" field below).

Interference. Use only one of the following codes, selecting the one characterising the strongest impact:

LC Demolition/Renovation/Use change activity in underground habitats (caves, mines, quarries)

LE Demolition/Renovation (including remedial timber treatment)/Use change activity at roost sites other than underground habitats (e.g. buildings);

AN People access for reasons other than those linked with factors LC and LE (e.g. tourism, caving, hiking, mineral collection);

FR Forestry;

OS Hostility by owners/residents;

AF Other interference factors (specify in the field "Notes").

Accessibility (= possibility that people access the site). Use only one of the following codes:

A1 Unauthorised access to the site avoided, granting protection to bats, by means of grilles and specific rules.

A2 Unauthorised access to the site avoided, granting protection to bats, by means of specific rules.

A3 Unauthorised access to the site avoided (various methods and reasons), but bat protection needs neglected.

A4 Unauthorised access possible;
A5 Roost inaccessible due to its structure (crevices, tree cavities, etc.) or location (e.g.: cave entrance on cliff).

Presence in a protected area. Use only one of the following codes:
YES Roost located in a protected area territory (including SACs);
NO Roost not located in a protected area territory (including SACs).

Conservation. Use only one of the following codes:
C1 Conservation actions not required;
C2 Roost conservation not ensured: requires, or might require, actions not yet taken (or so far not sufficient);
C3 Roost conservation ensured by citizens or private bodies (associations, NGOS, single persons, etc.);
C4 Roost conservation ensured by efforts from both citizens or private bodies and public institutions;
C5 Roost conservation ensured by efforts from public institutions.

Notes. Available for further remarks.

Fields which may require several pieces of information: information on the overall bat fauna

Informant (16)
Surveyor (17)
Biological role (18)
Date (19)
Maximum number of bats (20)
Count method (21)
Notes (22)

Informant. The person who has communicated the data.

Surveyor. The person who has made the observation.

Biological role. The same roost may have one, two or three "biological roles". In the latter case, the roost may be used for hibernation, reproduction and as a temporary roost. In each row, enter only one code:
S Hibernation: all observations falling in December and January; those made in November and February too, as long as the surveyor (also in con-

sideration of the weather conditions recorded when the survey was made) is sure that bats used the site in the central part of hibernation time;

R Reproduction: parturition and lactation;

X Resting place used during the day and/or the night, or site having a function either not classified with a distinct code (e.g. mating or swarming) in the database or not assessed (possible, albeit not verified, S or R roles).

Date. Survey date. For each biological role refer to the inspection when the highest bat number (of any species) was recorded. For maternity colonies, if possible refer to the dates immediately prior to parturition.

Maximum number of bats. Enter the highest number of bats (of any species) observed in a single visit. Maternity roosts: for the *taxa* confirmed to reproduce at the site, consider all adults and sub-adults (both sexes) but exclude juveniles. If the number of the latter is known, report it in the "notes" field. Numbers of bats from species not reproducing at the site (or of unconfirmed reproduction status), if any, should be recorded separately as from an "X" roost type. Use the highest *ascertained* number of bats recorded (corresponding to the real group size or less: *I have counted at least …bats)*. Alternatively, provide an estimate. If the number recorded is considered unrepresentative of the real number of bats occurring at the site (such as when maternity sites are surveyed at the end of summer, or partial emergence counts) enter " – 9999".

Count method. Explain how bats were counted (not how they were identified). Use only recommended codes. Hence, if some bats were caught, but the overall count was carried out visually inside the roost, use the code "VI" rather than "CA".

VI visual count inside the roost;

VE visual count of bat crossing roost entrance (emergence count);

FO Photographs or film taken inside the roost;

IR Film (either standard or I.R. technology) of emerging bats;

AV Automatic recording (infrared beam counter, etc.) of bats crossing roost entrance;

CA Captures made either inside the roost or near the entrance (bats entering or leaving the roost);

AC Other (specify in the "Notes" field)

Notes. Available for further remarks.

Fields which may require several pieces of information: information on species

Informant (23)
Surveyor (24)
Biological role (25)
Date (26)
Taxon (27)
Maximum number by taxon (28)
Count method (29)
Notes (30)

Fields 23, 24, 25, 29 & **30** as defined.

Date. Survey date. For each biological role refer to the inspection when the highest bat number (of any species) was recorded. For maternity colonies, if possible refer to the dates immediately prior to parturition.

Taxon. May be one species or a species association. These are considered when counts cannot be referred to single species in the colony, but only the overall number is known. Data referred to each species are preferred if available. Each species or association may be recorded once for each biological role. Therefore, for a given roost, up to three rows by species or association may be present. Use only fully reliable species identification. Each species is coded by using the first three letters of genus and species names joined with a "_" (e.g. MYO_BLY). If identification to species is not available, give only the genus (e.g. PLE_SPP). For species pairs which may be confused, when it is not known whether they share the site, use the following codes: e.g. *M. myotis* and/or *M. blythii* MYO_BIS; *M. brandtii* and/or *M. mystacinus* MYO_TER; *P. pipistrellus* and/or *P. pygmaeus* PIP_BIS.

Species aggregations whose species are confidently identified but have not been counted (only the overall colony size is know) should be indicated by placing in the same row the corresponding codes, alphabetically ordered and separated by a semicolon and a space (e.g.: MYO_BLY; MYO_MYO). For associations of sibling species in which only one has been confidently identified: use the code of the species identified and the one corresponding to the association of both species (e.g. MYO_MYO;

MYO_BIS means that *M. myotis* is certainly present, *M. blythii* presence is possible but awaits confirmation).

Maximum number by *taxon*. Use the highest *ascertained* number of bats recorded (corresponding to the real group size or less: *I have counted at least …bats)*. Alternatively, provide an estimate. Maternity roosts: for the *taxa* confirmed to reproduce at the site, consider all adults and sub-adults (both sexes) but exclude juveniles. If the number of the latter is known, report it in the "notes" field. Numbers of bats from species not reproducing at the site (or of unconfirmed reproduction status) should be recorded separately as belonging to an "X" roost type. If the number recorded is considered unrepresentative of the real number of bats occurring at the site (such as when maternity sites are surveyed at the end of summer, or partial emergence counts), enter " – 9999".

APPENDIX 2

DATA RECORDING SHEET

GRUPPO ITALIANO RICERCA CHIROTTERI	**GIRC – ITALIAN CHIROPTERA RESEARCH GROUP** ***Bat capture record sheet*** **Record no:**

DATE	**SITE:**	**UTM COORDINATES:**				
		ALTITUDE:				
WEATHER CONDITIONS	**Air temperature**	**Wind speed (Beaufort sc.)**	**% Cloud cover**	**Humidity**	**Other**	**FIELD OPERATOR**
HABITAT OR ROOST						

CAPTURE TECHNIQUE Mistnet □ Harptrap □ Hand-net □ Other : Capture time:	**SPECIES** **SEX** **Male** □ **Female** □	**AGE CLASS** **Juvenile** □ **Adult** □ **N/A** □	**REPRODUCTIVE STATE** ♂ testicles develop. : Other signs of reproduction: ♀ pregn. □ lact. □ post-lact. □ N/A □ non-breed. □ Further remarks:
REMARKS:			

MEASUREMENTS	
Forearm length	
Body mass	
digit V length	
digit III length	
thumb length	
claw length	
ear length	
ear width	
tragus height	
tragus width	
Foot length	
Other:	
1)	
2)	
3)	
TAGGING	**ID number or code**
Ring	
Radio-tag	
PIT	
Light-tag	
Other:	

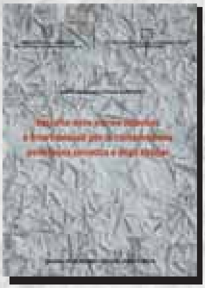
CALL RECORDING ON HAND RELEASE	
Recording technique: Direct ultrasound sampling □ Time expansion □ Frequency division □ Other:	**Tape** ID: Side A □ B □ Track: Counter:
REMARKS :	

OTHER SAMPLES	**SAMPLE NO**	**REMARKS :**
Skin □		
Parasites □		
Droppings □		
Hair □		
Wing profile □		
Other □		

FURTHER REMARKS AND COMMENTS:

“THE SERIES”

“Quaderni di Conservazione della Natura” - THE SERIES



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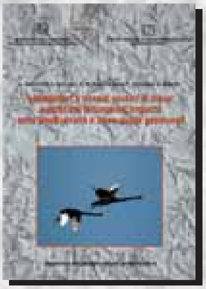
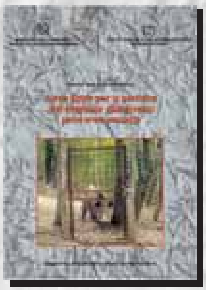
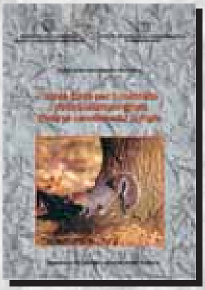
Raccolta delle norme nazionali ed internazionali per la conservazione della fauna selvatica e degli habitat



2
Mammiferi e Uccelli esotici in Italia: analisi del fenomeno, impatto sulla biodiversità e linee guida gestionali



3
Linee guida per la gestione del cinghiale *(Sus scrofa)* nelle aree protette



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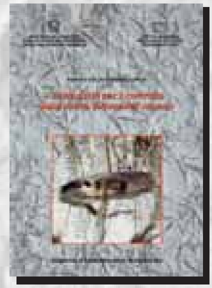

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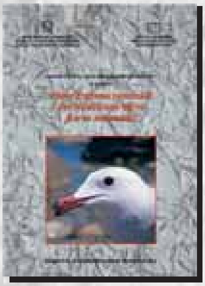
Linee guida per il controllo della Nutria *(Myocastor coypus)*



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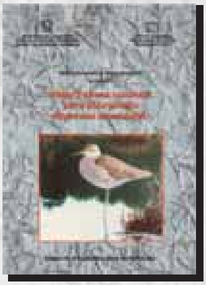
Piano d’azione nazionale per il Gabbiano corso *(Larus audouinii)*



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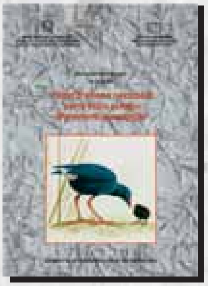
Piano d’azione nazionale per il Chiurlottello *(Numenius tenuirostris)*



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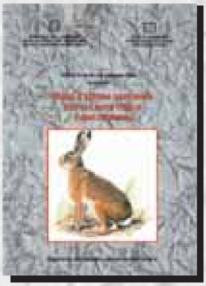
Piano d’azione nazionale per il Pollo sultano *(Porphyrio porphyrio)*



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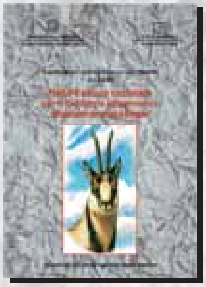

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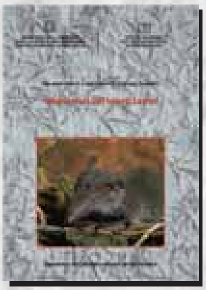

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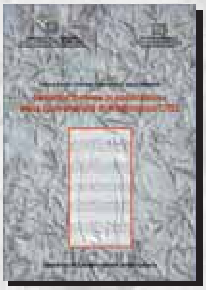
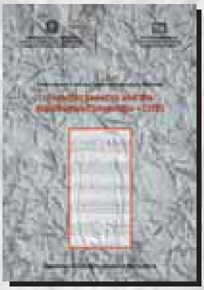
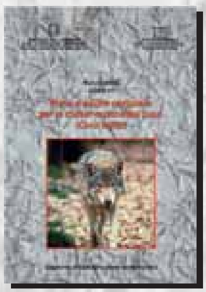
Mammiferi dei Monti Lepini



12
Genetica forense in applicazione della Convenzione di Washington CITES



12 BIS
Forensic genetics and the Washington Convention - CITES



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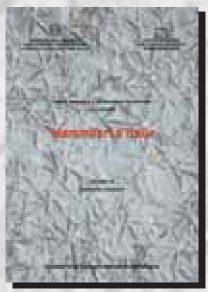
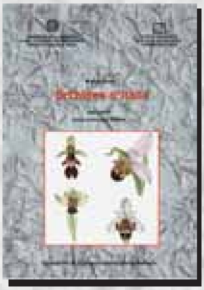
Piano d’azione nazionale per la conservazione del Lupo *(Canis lupus)*



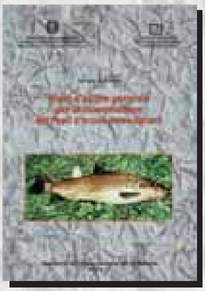
14
Mammiferi d’Italia

Tutti i “Quaderni di Conservazione della Natura” sono scaricabili, in formato pdf, dal sito
http://www.minambiente.it/Sito/settori_azione/scn/pubblicazioni/qcn.asp



15
Orchidee d’Italia

16
Uccelli d’Italia



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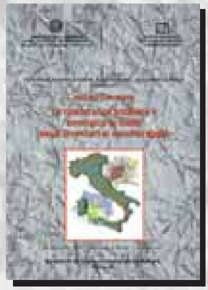
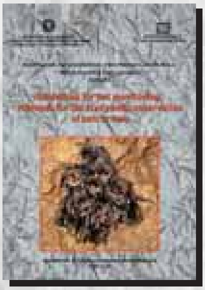
Piano d’azione generale per la conservazione dei Pesci d’acqua dolce italiani

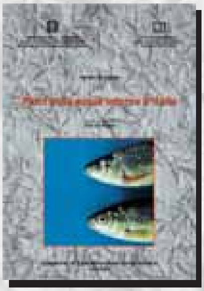


18
Atti del Convegno “La conoscenza botanica e zoologica in Italia: dagli inventari al monitoraggio”

19
Linee guida per il monitoraggio dei Chirotteri: indicazioni metodologiche per lo studio e la conservazione dei pipistrelli in Italia



19 BIS
Guidelines for bat monitoring: methods for the study and conservation of bats in Italy



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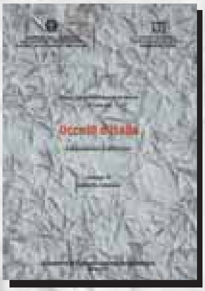
Pesci delle acque interne d’Italia



21
Uccelli d’Italia (Volume II)

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