This Guideline is created within the project "Sustainable bats conservation in the cross-border area" (Bats Conserve), funded under a cross-border cooperation program INTERREG V-A "Greece – Bulgaria 2014 – 2020".

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Guideline for the Conservation of bats in Urban Areas

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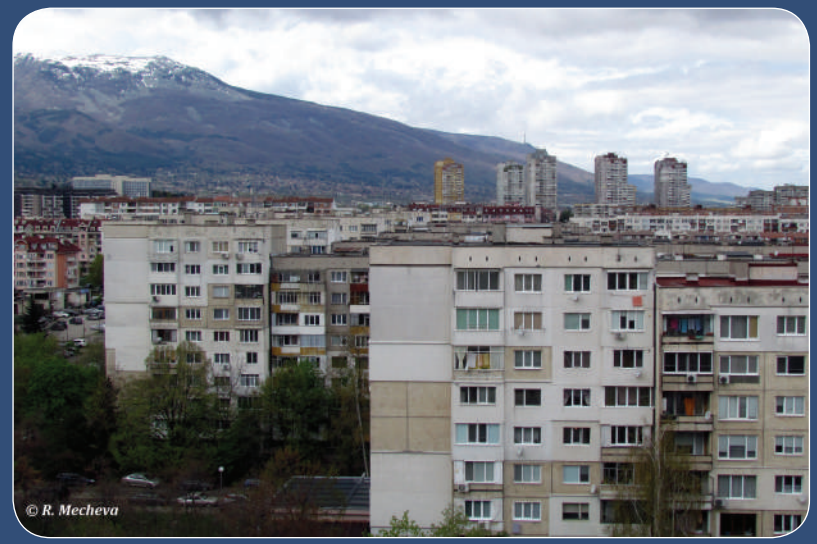

Sofia, 2019

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GUIDELINE

for the Conservation of bats in Urban Areas

Sofia, 2019

EDITOR: Elena Georgieva

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Content

Introduction

This guideline has been prepared as part of the implementation of a contract for "Performing specialized activities under a project “Sustainable bats conservation in the cross-border area” (BatsConserve), funded under a cross-border cooperation program INTERREG V-A “Greece - Bulgaria 2014 – 2020”.

The guideline has been developed from Consortium Bat-Map, with a lead partner OPIMOS and partners “Gap Consult” LTD and “Bul Pro Consulting” LTD.

Its development also takes into account the results of modern research and concepts for the conservation of bats in urban areas of Europe. The main methodological guidelines for monitoring are presented as well as the legal framework for the protection of bats with an emphasis on the Bulgarian legislation.

Project co-funded by the European Union and National Funds of the participating countries.
The contents of this publication are sole responsibility of project partners and can in no way be taken to reflect the views of the European Union, the participating countries, the Managing Authority and the Joint Secretariat.

1. Institutional framework

All bats found in Europe are subjects of protection as under international conventions and agreements and under national laws specific to each country of Europe. Analysis of this legislative and institutional framework can be found in management for assessing the environmental impact and assessment regarding bats (Petrov, 2008). A number of legislative documents determine the terms, conditions and requirements under which to perform various types of coordination regimes for investment plans in order to protect the bats as endangered group of animals. For almost all types are required to be performed some form of coordination with different state institutions. For example, for Bulgaria it is the Ministry of Environment and Water's regional divisions (RIEW).

INTERNATIONAL LEGISLATION ON THE CONSERVATION OF SPECIES AND HABITATS

1. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

Ratified on 25.01.1991 (Promulgated, State Gazette 13/1991). Special attention is given to endangered and vulnerable species, including endangered and vulnerable migratory species specified in appendices The Countries undertake to promote education and disseminate general information concerning the need to conserve species of wild flora and fauna and their habitats. Each Country shall take appropriate and necessary legislative and administrative measures to ensure the conservation of the habitats of the wild flora and fauna species, especially those

specified in Appendices I and II, and the conservation of endangered natural habitats The Countries undertake to give special attention to the protection of areas that are of importance for the migratory species specified in Appendices II and III and which are appropriately situated in relation to migration routes, as wintering, staging, feeding, breeding or moulting areas.

Appendix II – Strictly protected fauna species
All bat species except *Pipistrellus pipistrellus*
Appendix III – Migratory species *Pipistrellus pipistrellus*

2. The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

Ratified on 23.07.1999. The Countries acknowledge the importance of migratory species being conserved and of Range States agreeing to take action to this whenever possible and appropriate, paying special attention to migratory species the conservation status of which is unfavourable, and taking individually or in co-operation appropriate and necessary steps to conserve such species and their habitat.

In particular, the Countries:

a) should promote, co-operate in and support research relating to migratory species;

b) endeavour to provide immediate protection for migratory species included in Appendix I;

c) endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II.

All European bat species are included in Appendix II.

3. The Agreement on the Conservation of Populations of European Bats - EUROBATS

As migratory species, the Agreement was set up under the auspices of the Bonn Convention and stipulates that each coun-

try shall adopt and enforce such legislative and administrative measures as may be necessary for the purpose of maintaining a favourable conservation status of all species by prohibiting the deliberate capture, keeping or killing of bats, identifying the areas of importance in terms of bat reproduction and wintering, promoting research programmes on the protection and management of bats, taking into account the potential effect of pesticides on bats and making additional endeavours to save the bat populations designated as threatened.

Fundamental obligations:

1. Each country shall prohibit the deliberate capture, keeping or killing of bats except under permit from its competent authority.

2. Countries shall identify those sites within its own area of jurisdiction which are important for the conservation status, including for the roost and protection of bats. It shall, taking into account as necessary economic and social considerations, protect such sites from damage or disturbance. In addition, each country shall endeavour to identify and protect important feeding areas for bats from damage or disturbance.

3. When deciding which habitats to protect for general conservation purposes each country shall give due weight to habitats that are important for bats.

4. Each country shall take appropriate measures to promote the conservation of bats and shall promote public awareness of the importance of bat conservation.

5. Each country shall assign to an appropriate body responsibility for the provision of advice on bat conservation and management within its territory particularly with regard to bats in buildings. Countries shall exchange information on their experiences in this matter

6. Each country shall take such additional action as it considers necessary to safeguard populations of bats which it identifies as being subject to threat and shall report under Article VI on the action taken.

7. Each country shall, as appropriate, promote research programs relating to the conservation and management of bats. Countries shall consult each other on such research programs, and shall endeavor to co-ordinate such research and conservation programs.

8. Each country shall, wherever appropriate, consider the potential effects of pesticides on bats, when assessing pesticides for use, and shall endeavor to replace timber treatment chemicals which are highly toxic to bats with safer alternatives.

The provisions of this Agreement in no way affect the right of Countries to take stricter measures concerning the conservation of bats.

In this national implementation is planned:

1. Each country shall adopt and enforce such legislation and administrative measures as may be necessary for the purpose of giving effect to this Agreement.

4. Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (The Habitats Directive)

The main purpose of this Directive is to „enable the natural habitat types and the species" habitats concerned to be maintained or, where appropriate, restored at

a favourable conservation status in their natural range".

Article 2 includes 13 bats species: *Rhinolophus blasii, Rh. euryale, Rh. ferrumequinum, Rh. hipposideros, Rh. mehelyi, Barbastella barbastellus, Miniopterus schreibersii, Myotis bechsteinii, M. blythii, M. capaccinii, M. dasycneme, M. emarginatus* and *M. myotis*.

The member countries are obliged to guarantee adequate protection of these species and their habitats particularly within the ecological network of NATURA 2000 sites. Upon discovery of the presence of any of these species, the assessment of the status of their populations in the examined territory must be particularly thorough. For all species listed in Annex 2 standard

forms have been worked out with specific criteria to determine if the species enjoys a favourable conservation status. Achieving such a status is the major purpose of the Directive and all the ensuing obligations for our country to guarantee adequate protection for bat roosts and foraging habitats

NATIONAL LEGISLATION FOR CONSERVATION OF SPECIES AND THEIR HABITATS

National environmental legislation of Bulgaria is in line with EU-wide directives, setting priorities, guidelines and regimes for the conservation of bats and their habitats.

1. Biodiversity Act

This act regulates the relations between the countries, municipalities and legal and physical persons in terms of the conservation and sustainable use of the biological diversity of the Republic of Bulgaria. **Under this act all bat species in the country are proclaimed strictly protected.**

2. Forestry Act

This law regulates the public relations related to the protection, management and use of the forest territories in the Republic of Bulgaria, in order to ensure multifunctional and sustainable management of forest ecosystems. The preparation and adoption of forest management plans is a key stage of forest management in Bulgaria.

3. Protected Teritories Act

This act defines and categorises the protected territories within Bulgaria, the procedures for their establishment and provides for the implementation of their management plans. Around **40%** of the caves known to be host to large colonies of

roosting bats in **Bulgaria are included in the protected territories**. Some of these important bat caves have the status of natural landmarks. In the majority of the cases the protected are also includes adjacent territory (forests or land).

NATIONAL BIODIVERSITY MONITORING SYSTEM (NBMS) is a complex mechanism for monitoring and reporting on changes in the biological diversity of Bulgaria in the long run. This is achieved through a system for assessment and analysis of the impacts on biodiversity, its state and the measures that need to be undertaken to prevent its loss. The NBMS is the basic instrument for assisting decision-makers in protecting and conserving Bulgaria's biodiversity at a national level and to provide information to as many other users as possible. The monitoring focuses on species of different biological groups and selected types of habitats. The information is gathered regionally and summarized nationally. Regional databases are kept in the RIEW and the departments of national parks.

With high monitoring priorities are:

- Schreiber's long-fingered bat (*Miniopterus schreibersii)*
- Bechtein's bat (*Myotis bechsteinii)*
- Lesser mouse-eared bat (*Myotis blythii)*
- Long-fingered bat (*Myotis capaccinii)*
- Geoffroy's bat (*Myotis emarginatus)*
- Greater mouse-eared bat (*Myotis myotis)*
- Blasius's horseshoe bat (*Rhinolophus blasii)*
- Mediterranean horseshoe bat (*Rhinolophus euryale)*
- Greater horseshoe bat *(Rhinolophus ferrumequinum)*

All the listed bat species are monitored by expert teams, who visit underground habitats such as caves, disused mine galleries and bunkers, which are known to have been inhabited in recent years by hibernating or breeding bat colonies. The list of monitoring sites corresponds with the caves and galleries included in the document „Important Bat Underground Habitats in Bulgaria" (IVANOVA, 2005). The document was drafted in

compliance with Resolution 4.3 MoP4 („Guidelines for the protection and management of important underground bat habitats“) and represents the official Bulgarian position (through MOEW) for the EUROBATS Convention. This national report evaluates all the important underground habitats (92 in total) in terms of the number of species and the seasonal character of the habitat, their number, protection status and level of importance (regional, national or European/world). Fifty-two caves and galleries are considered to be highly important on a national and European level.

2. General information about the bat species and their habitats

Bats are the only ones active flying mammals. Their body is covered with thick and soft fur, which protects the body from the cold during times of rest in flights. Their front limbs are converted into wings. Their bones, expect the first finger, are strongly prolonged. The neck, wing bones, sides of the body, legs and the tail have flight membrane (Peshev etc. 2004). Their hindlimbs also have a specific structure. They are rotated, so that knees flex in the direction of the back. The ears are particularly oversized, as with some of the species compared to the body, they are enormous. The ears of almost all bats have a fleshly projection called tragus. Exception are Horseshoe bats. The function of the tragus is still not fully understood. The tail on the most of species is long, usually wholly or in part included in the middle the interfemoral membrane. The back end of this intercostal membrane is reinforced by a pair of cartilage or bone spurs extending from the heel of the back step. At the edge of the spur is a leather fold called a keel. In some species, the keel is further strengthened with a transverse cartilage seal. The wingspan of European species can reach to 46 cm, the body-weight is from 5 till 55 g. With the widest wingspan is the Greater noctule bat *(Nyctalus lasiopterus)* and with the smaller is Soprano pipistrelle *(Pipistrellus pygmaeus).* Schreiber's bent-winged bat (*Miniopterus schreibersii*) and Common noctule (*Nyctalus noctula)* have elongate wings. This makes them fast and maneuvering flyers, capable of cover long distances without efforts. Other species are with wide and short wings, which is factor for slow and flapping flight. The first finger ended with a nail, which helps for the bats that walk on the ground. All kind

of bats have different size of the eyes, which are well adapted to see in the dark, even that they are not the main body for orientation and hunting.

Bats have a specific biology, which makes them different from the other mammals with similar sizes, such as shrew and other small rodents. The most important difference is connected with the rate of reproduction and the life expectancy. While most of the rodent species and shrews, produced a large number of small ones, usually more than ten, bats give birth only to one and rarely two and it is only to some species. For one season most of the rodents and shrews have a few generations, in case of bats give birth only to one newborn. Another feature for bat species is that not all of the females take part in breeding.

For the shrews and small rodents, the duration of life is not more than year and a half, but for bats the duration is average between seven and ten years and in some species can reach thirty years. The small rodents and shrews are spread freely over the area. They are spread relatively evenly according to their environmental abilities. This allows to them easily to adopted to the changes caused by the humans. Even though that the species that have developed to fly, it is possible to displace them over long distances, many of them are attached to their roosts, where they concentrate and form colonies. Those characteristics of bats make them particularly sensitive to long-term sustainability in the landscape structure. The relationship between the bats and landscape elements is multi-layered and is consistent with the diverse aspects and their biology (Popov etc. 2007).

Specific feature of the bats is their need for roosts. Depending on the season, bats inhabit different types of roosts:

- **During the winter** all bats inhabit roosts with a permanent temperature of between 2° to 10°C. Such conditions are most often found in water caves and flooded mine galleries and occasionally in the attics and basements of residential build-

ings. Most of the time during winter they are in hibernation in colonies or individually. Usually populations of many species are concentrated in several winter roosts.

- **During the spring and autumn** bats can be found in different roosts with a variable or constant temperature (e.g. abandoned or inhabited residential or industrial buildings, underground bunkers, galleries, discharge and ventilation shafts, pipes, chimneys, hollow posts, small and large caves, rock crevices, etc.) When it is time for awake from hibernation is slowly process and requires a lot of energy.

Nursery colony of horseshoe bats in abandoned house

©R. Mecheva

- **During the summer** bats prefer roosts with a higher temperature and this is where they breed. Species which form larger colonies congregate in caves with larger entrances so that

in the evening hundreds or even thousands of bats can fly in or out simultaneously. During summer season, female species form nursery colonies, in which the small ones are born and grown up. Those colonies use most diverse roosts – caves, tree hollows, different human-made structures, such as: domes, attics, cavities, basements, abandoned buildings. Nursery colonies are social groups, which can occupy one roost or periodically to change several roosts. Usually all of female species, capable of breeding and inhabiting a large and extensive region are gathered in one or several roosts. They are strongly attached to them during many years. Thereby they become highly vulnerable to different changes, connected with those roosts.

During summer the male bats lives individually or on small groups. There are some individuals who can join the nursery colonies. Through the autumn they occupy individual territories, including roosts for mating. Those territories and roost are protected from other male groups and are trying to attract the females with invocation sounds. Those territories and roosts are close to each other, usually on strategic locations on migrating paths or in winter roosts. The changes in those roosts and their surroundings can affect seriously on the population of many bat species in large geographical area.

Depends on environment preferences of bats they can be grouped into four main categories:

- **Cave-dwellers** – breed and hibernate exclusively in caves or other underground roosts. They are found mainly in karstic, volcanic or sea caves. The size of colonies can reach between 100–10 000 individuals in the summer and between 50 till 100 000 individuals in the winter.
- **Forest-dwellers** – breed mainly in hollows, crevices and under the bark of trees; some of these species spend the winter in caves. They can be found in broad-leaved, deciduous, mixed and more rarely coniferous forests which offer roosts and a supply of food. The number of individuals roosting in the hollows is around 10 to 50, with colonies well distributed throughout a large area.

- **Wetlands** – due to their high biological potential and rich biodiversity wetlands provide one of the most important foraging habitats for nearly all bat species. They are important during the summer months when thousands of bats hunt above the water surface and become an important part of the regional food chains. Most species that depend on water areas live in proximity around those areas. They occupy tree hollows, residential or industrial buildings, caves and other nearby roosts.
- **Synanthropic** – live almost in man-made roosts such as attics, basements, shafts, chimneys, ventilation facilities etc., throughout their entire life cycle. They can be found everywhere in villages, towns and other urbanized areas. The colonies of some species vary from 5 to 20 individuals and of others from 50 to 1000 individuals.

Practically bats are feeding everywhere where they fly or crawl with nocturnal insects. They usually capture them during flight using echolocation. Most often this is around lakes, swamps and other wetlands where is full of insects. The flight is associated with a large amount of energy that determines the need to catch large quantities. Those needs are increased during the breeding season. The bats of some colonies hunt on strictly defined permanent hunting areas. Soon after dusk, bats fly out and proceed to the hunting areas. They can be close to their daily roosts or considerably distant, depending on ecological characteristics of the species – forest, forest meadows, wetlands, parks, orchards, pastures. To reach the hunting areas, bats usually fly through other territories by following linear landscape elements – river paths, roads, valleys, forest paths. After hunting during the night, they are returning to their daily roosts.

This common model is changing, depending on the ecological and biological characteristics of the species. Large bats, as for example Common noctule (*Nyctalus noctula*) hunts only during several short periods during the night, flying on high attitude, sometimes above 100 m, during the rest of the time he is resting in temporary roosts. Smaller species, such as Dauben-

ton's bat (*Myotis daubentonii*) and Common pipistrelle (*Pipistrellus pipistrellus*) are following linear landscape elements, including higher trees and hunt without interruption during the whole night, as consistently visit different hunting areas. Linear trees and shrub plantations are of great importance for the life of most bat species. They provide them landmarks, protection from predators and bad weather, temporary roosts for the night and more.

The bats can eat up to 1/3 of their own weight per night. The larger bats in Bulgaria have an average weight of 20 – 30 g, which means that a colony of 300 individuals can eat per night around 20 000 mosquitoes, beetles, butterflies and other insects (most of them considered as pests), and for one summer it consumes around 550 kg insects. This illustrates the great importance of bats in the ecosystems that they inhabit. As predators they occupy the upper levels of the food chain and this makes them particularly sensitive to the use of different types of chemicals (Petrov, 2008).

The main thing for orientation in the surrounding that bats use is the echolocation. This unique bio sonar gives the ability to bats to fly unmistakably in complete darkness and to find without problems the pray, usually flying insects. Except for determination the distance to their prays and obstacles, bats use ultrasounds also for communication. The duration of this calls is from a few milliseconds to a few hundred. Usually their frequency range cannot be heard from the humans, because it is over 20 kHz. Only for some of the species those calls are with frequency from 9 to 20 kHz and they can be heard from humans. Even though inaudible for our hearing, the power of those sounds of bats in ultrasonic area is really big – they "scream" with power of 50 till over 100 dB. In depends of the specific features in the biology of the species, emitted sounds can be often strongly frequency modulated or to be referred to the so-called quasiconstant. The energy of the sound can be concentrated in different frequencies – from 11 – 14 KHz at Free-

tailed bat, until over 100 KHz at some Horseshoe bats. There is direct connection between surrounding environment, the remoteness of surrounding object and how often the make calls. In practice the sound serves as orientation, the more "open" the less is the needed information about the surrounding objects. In a "complex" environment, made up from diverse objects and at shorter distances, bats need more detailed information to be able to navigate themselves. Because of that reason, when the bats fly in "outdoor" they emit sounds more rarely, than flight in varied environment and closer objects, they emit sound more often. There is the connection between ecology of bats and how often they emit their sounds. Species that hunts high over the vegetation and other terrestrial objects, emits more rarely sounds than those who feeding around the tree crowns or under forest canopy, which make sound more often.

Except the frequency, with which they make the sounds, the habitats are reflected also to that if the calls are loud or quiet (amount of energy, focused in the sound). Through that way in complex area with more objects, the sounds can be quiet, because there is no need to travel far. The bats that inhabit such areas do not emit loud sounds – "not screaming", which can cost them a lot of energy. Bats who inhabit open spaces, have to invest much energy to into the sounds they make - literally "scream", to reach faraway distance and to allows them to find their distant prays also to orient themselves better in open spaces. The third volume of the sound, which is affected from the habitat is the frequency. Since the high frequencies sounds have more detailed information, the ideal option would be for all bat species to emit such sounds. Unfortunately, those sounds are absorbed from the air much more than those with low frequency. Through that way, species who inhabit open areas can not navigate themselves and locate their victims, which is located on a greater distance. That is why such species emit sounds with lower frequency, which can travel far into space, without being absorbed. It is exactly opposite for

species, which inhabit complex habitats with multiple objects around them. They emit high-frequency sounds, which allows to them to get detailed picture for the surrounding area.

This, as well as the following specifics of their biology: night activity, using echolocation for orientation, hibernation, seasonal migrations, forming large clusters (colonies) up to a few thousand species, the life expectancy in natural conditions, makes the bats exclusively interesting and unique for researches, compared to other groups of mammals. Part of those characteristic can make field studies more complicated, because it requires specialized technique, which makes bats one of the least explored groups mammal in the world, also in Bulgaria (Ivanova, 2005).

In Bulgaria are established 33 bat species, which are extremely insectivorous, from the group *Microchiroptera* (as for Europe they are 35) (Benda et al. 2003, Dietz & Von Helversen 2004).

The reason for that is, that Bulgaria is located in region, representing the intersection of 4 major faunal complexes (boreal, immoral, steppe and Mediterranean) and it is roost for around 100 mammal species, 30% from which are bats. From total 35 species, inhabitants of Europe and its islands, in Bulgaria are established 33 species, grouped in 4 families: Horseshoe bats (*Rhinolophidae*), Vesper bats (*Vespertilionidae),* Bent-winged bats (*Miniopteridae*) and Free-tailed bats (*Molossidae*). Some of them such as Blasius's horseshoe bat (*Rhinolophus blasii*) and Mehely's horseshoe bat (*Rhinolophus mehelyi*) are typically cave-dwellers, while the others as Western barbastelle (*Barbastella barbastellus*) are hiding in hollows or under loose barks of old growth trees. A number of species such as Common pipistrelle (*Pipistrellus pipistrellus),* Soprano pipistrelle (*Pipistrellus pygmaeus)* and Common noctule (*Nyctalus noctula)* etc. are adapted for life in the urban environment and they feel good in already abandoned buildings and mine galleries, as well in fugues of panel buildings or attics of habitable houses.

3. Ecological features and requirements of the species

Bats are extremely endangered animals and at the same time, an indicator of environmental quality. As insectivorous mammals, in many cases they are close to the lower floors of the food pyramid. A large number of insects are plant-eating and can sense changes in the environment very quickly. Any destruction of any habitat degrades the quality of the environment and causes bats to start disappearing and leaving the site.

Researcher for bats from urban environment in different parts in Bulgaria are represented from Kalchev and Beshkov, (1963), Popov et al. (2007), Popov, Sedefchev (2003), Peshev et al. (2004), Petrov (2008), Bartonička & Zukal (2003), Benda & Ivanova (2003), Schmidt (2002), Grimmberger (1991), Papadatou et al. (2008), Ivanova (1998), Ivanova, Guerguieva (2005), Pandourski (2004), etc.

Benda et al. (2003) describes 6 species for the territory of Plovdiv city: Lesser Mouse- eared Myotis (*Myotis blythii),* serotine bat (*Eptesicus serotinus),* common pipistrelle *(Pipistrellus pipistrellus),* common noctule *(Nyctalus noctula)*, giant noctule (*Nyctalus lasiopterus)*; Pandourski (2004) established 6 species for Burgas: *Nyctalus noctula*, Lesser Noctule (*Nyctalus leisleri)*, Serotine bat (*Ept*esicus serotinus), common pipistrelle (Pipistrellus pipistrellus), Nathusius's pipistrelle (*Pipistrellus nathusii*), Soprano Pipistrelle (*Pipistrellus pygmaeus*).

Synantropic species are considered to be: whiskered bat (*Myotis mystacinus)*, steppe whiskered bat (*Myotis aurascens),* common pipistrelle (*Pipistrellus pipistrellus*), Kuhl's pipistrelle (*Pipistrellus kuhlii)*, grey long-eared bat (*Plecotus austriacus)*. Also, those structures could be presented by greater horseshoe

bat (*Rhinolophus ferrumequinum), and lesser horseshoe bat (Rhinolophus hipposideros)*.

Most in those urban habitats, a lot of species can find roost inside of habitable buildings (*Plecotus austriacus, Nyctalus noctula, Pipistrellus kuhlii, Hypsugo savii*), less in cracks on facade of livable buildings (*Nyctalus noctula, Pipistrellus pipistrellus,* Savi's pipistrelle (*Hypsugo savii*) and only one species into hollow (*Nyctalus noctula*) as well in holes and bridges.

Most of the bats find roosts in uninhabited and partly destroyed constructions. Such species are, for example *Rh. ferrumequinum, Rh. hipposideros, Pl. austriacus, P. pipistrellus, P. nathusii, Hypsugo savii*. Or in fugues on outer side of buildings - *N. noctule* for example.

Most of the species in the urban habitats can be found in spaces between buildings with dominating by wooden plants and parks from forest type, houses with yards, around forest or grasslands riverside, in mountains and flat regions.

Old and wild houses provide roost to a lot species especially to family Horseshoe (Rhinolophidae)

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Holes into under-roofing of old houses – often inhabited by species from genus Pipistrellus and Nyctalus

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Cracks on facades of buildings that are easily available from the bats

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Dams structures are also a good roost for the bats

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Natural ecosystems are also a good opportunity for synanthropic bat species

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Urban areas can be a nice refuge for forests bats and also new places for invasion of unusual species from different groups.

The high biodiversity of chiropterfauna of the towns even through that they are anthropogenically transformed defines them as high important value for the bats.

Urban habitats of the bats can be typified according to Gaisler et al. (1998), Schmidt (2002) and Bartonička & Zukal (2003).

Lesser horseshoe bat (*Rhinolophus hipposideros*). Identifying mark is the horseshoe-shaped part of the nose leaf. The base of its fur is light grey in color and on the ventral side is even brighter. Flight membranes are red-brown in color. It has body length from 3,8 to 4,5 cm. Wingspan 18-25 cm and a mass of around 6-10 g. Often flying is relatively slow, but it's also agile, flying within 2 - 5 meters above the ground. When hunting they are close to its roosts (usually around 5 km) around forests outskirts, bushes, river sides, overgrown with greenery, above the water and also around rocks and karst regions. Can be found at the lower and middle altitudes. In Bulgaria during summer can be found in attics and other man-made structures, and spends his winter in shafts and caves. The summer colonies (usually in buildings) are mostly consisting of female individuals. They appear throughout April and fall out apart throughout August. They give birth around begging of July. The small ones can already fly after around 3-4 weeks. Summer habitats can be various - buildings (basements, attic), caves, artificial galleries, rock piles etc. Lesser horseshoe bats hibernate from October until April into caves or artificial underground galleries. They prefer insides parts where the temperature is around 5 - 9 degrees. When hibernate they prefer to hang in close proximity to others until 50 cm. Summer and winter roosts are usually no more than 15 km apart. It is considered for globally threatened species.

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Lesser horseshoe bat (Rhinolophus hipposideros)

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Greater Horseshoe bat (*Rhinolophus ferrumequinum*). The largest Bulgarian horseshoe bat. Its fur is reddish-brown on the dorsal side and cream on the ventral. Wing membranes and ears are light grey-brown. The ears are large and very mobile and also they do not have a tragus in the ear, they have only broad skin on the underside (antitragus). It can be found in the whole country, except the highest parts of the mountains. Occupies a variety of habitats, from pastures to rare forests, close to karsts areas and other rock regions and also water bodies. Greater horseshoe bat emerges soon after sunset, and sometimes the hunting continues all night. They can be active even during the cold nights. The

flight is slow, similar to that of a butterfly. Normally between – 0,5-3 meters (sometimes and above the trees) above the ground. During night is getting around 10 till tens of kilometers away from the roosts. They feed predominantly on beetles and moths and other range of other big flying insects. He is a social species. During the summer they live in shallow caves, rocks regions, under roofs, desolated buildings, artificial galleries. Sometimes those desolated buildings are close to caves and they use them as roosts through foul weather conditions. Summer colonies are too loudly, especially young ones when they need to be fed. Usually, they are using temporary night roosts, where they can rest during hunting and to feed with the caught insects. Hibernation is in caves, mines or artificial galleries – from October-November till April, and they prefer temperatures in the range 7-11°C. Often they can awake and change the roosts. Sometimes during winter if the weather conditions are softer, they can feed around the entrance of the cave. Travel distance between winter and summer roosts often do not exceed 50 kilometers, but there is recorded distance of 100 kilometers. Most mattings take place in the fall and the spring. A bats pregnancy lasts between 10-11 weeks. Females form large nursery roosts during May – June, often to several hundred bats (from 200 individuals rarely till 600). Youngs are born in June – mid July and they are raised by their mother. Usually they bear a single blindly young or rarely twins. Young ones can open their eyes and at their third or fourth week they can fly and after six to eight weeks they can leave the roosts and live separately. Mating colonies are falling apart at the end of August – beginning of September. They gave birth for the first time to the 3rd year and some individuals - to the 9^{th} year. Not every year females participate in reproduction. Males becomes sexually mature at their two years. A bat can live approximately 30 years.

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Greater Horseshoe bat (Rhinolophus ferrumequinum)

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Mediterranean Horseshoe bat *(Rhinolophus euryale).* Medium-sized horseshoe bat. In Bulgaria is common type species. With light grey base and the dorsal side is grey-brown color. Sometimes a slight reddish tinge, while the ventral side is yellow-white and the boundary between ventral and dorsal color is indistinct. The horseshoe and snout of the bat are light brown, and the ears and wing membranes are light grey. The species is nasal emitting, with an upper saddle process pointed and slightly curved downward. The lower saddle process is rounded when viewed from below, and is noticably shorter than the upper saddle process. The wings of the bat are broad. When it hangs, the body is not completely enveloped by the membranes, even during hibernation. Usually this species is living in the forests or karst regions. The summer reproduction colonies are made after the mid of May. Females give birth after the mid of June till the mid of July. Maternity roosts often contain from 100 till 600 individuals. They are much more social than lesser and greater horseshoe bat. Some-

times they formed independent colonies in caves from 50 – 300 individuals. They also often roost together with other bat species. During winter is occur in mixed colonies mostly with Blasius's and Mehely's horseshoe bat, less often with Greater horseshoe bat. Usually they settled up to more warmer parts (10-13°C) in the caves. In Bulgaria they migrate between summer and winter roosts up to 10 till 60 km. The longest registered movements do not exceed 140 km. There are missing specific information about the composition of their food, but probably small insects (flies, mosquitoes, moths). In Bulgaria are registered breeding colonies that often contains from a few dozen up to 2000 individuals. In cave in North Bulgaria is registered a record breeding colony of this species that is counting 20 000 individuals. Most births in this genus occur in the end of June – beginning of July.

Small colony of Mediterranean Horseshoe bat (Rhinolophus euryale)

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Greater mouse-eared bat *(Myotis myotis).* It is comparatively large bat species. The length of the body is around 6,5 till

over 8 cm. The species is found mostly in Eastern Europe and Mediterranean. One of the most common species found in karst regions. This bat is forming mixed colonies with Lesser mouse-eared myotis (*Myotis blythii*). The hunting area is often in deciduous woodlands and mixed sets and parks and their outskirts at an altitude of about a hundred meters till 800 – 900 m. The hunting area of the bat can reach 70-80 km^2. He feeds with large even non-flying beetles, discovering them by the sounds that they are making. The food includes and other invertebrates, such as spiders, flies, butterflies etc. They have selectively eating as it prefers large insects over than 5 mm, but if there is abundance of small ones, it can also eat with them. It breeds in natural karst, volcanic caves and less often in buildings and other artificial roosts. Females give birth from the end of May till the first part of June. It hibernates individually or forms large colonies, who can reach till several thousand individuals. It is migrating between summer and winter roosts, travelling up to 100 km. Avoids urban territories and his natural enemies are night birds of prey.

Breeding couple Greater mouse-eared bat (Myotis myotis)

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Lesser Mouse-eared myotis *(Myotis blythii).* Species similar to the Greater mouse eared bat, but smaller. On the dorsal side the fur is soft lighter brown, ventral – light grey. The weight is around 15 and 30 g. It is a common species, spread mainly in lower parts in the country. They typically roost in areas with roughest terrain such as hills, rocks, steep river side etc., karts areas with rare forests, bushes, parks, cities. Avoids extensive steppe areas. Behavior: it is hunting its victims by hovering in the air or often landing on the ground to capture insects. It is mainly found in caves all over the year. It forms big summer and winter colonies. Winter colonies are formed by females and male species. It hibernates in winter roosts with a relatively constant temperature of 3 till 12-15°C. The species is an occasional migrant, with average movements 60-70 km, and up to recorded around 600 km. This species feeds with larger insects – moths, beetles, grasshoppers. During the spring and

Lesser Mouse-eared myotis (Myotis blythii)

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summer, female ones are forming large colonies – up to a few thousand species, in which they are having population (in the end of May – beginning of June) and they raise their small ones there. They can start to fly on age of 30-35 days. The permanent teeth erupt on the 45th day and after 50th day they can live separately. Maximum life expectancy of those bats is around 30 years.

According to some database from genetics analysis both twins' species can hybridize, which can affect with under 5 % of the population in Bulgaria.

Daubenton's bat (*Myotis daubentonii*). Daubenton's bat is medium-sized. The length of its body is from 4.5 to 5.5 cm. It has brown dorsal fur and pale brown or silver-gray. Its snout is with red-brown color. This species is with relatively small ears. It is rare species on the Balkan Peninsula. It is found in high mountains areas – on 2500 m in Pirin mountain, Bulgaria. Roosts are typically in woodland flats and hilly mountains landscapes. It can be also found around water bodies, rivers, lakes etc. The flight is with rush moves, usually above some meters from the ground, more often above water. When it is catching insects, they can use the interfemoral membrane, till they are flying. Feeding with smaller insects (flies, butterflies, mosquitos) can happen during flight, but the larger ones it has to be on the ground. Summer roosts can be in tree hollows or in buildings and other artificial structures. They will hibernate in rock crevices as well as in caves. Seasonal movements between winter and summer roosts are mostly within a distance till 100 km. Mating occurs in autumn till the following spring. Females gather in maternity colonies of 20 – 50 bats during May. They typically consist of a single newborn, and they are able to fly by 4 till 6 weeks after they are born. They can reach 20 years old, but it is recorded case of 40 years old.

Whiskered bat *(Myotis mystacinus).* The whiskered bat is the smallest of our *Myotis* species in Europe. With forearm length from 3.5 cm till 4,8 cm. It has dark brown or sometimes grey-brown dorsal fur color and dark snout and ears. Its distribu-

tion can be in lowest parts and as well in forested mountain massifs. Summer roosts are usually tree hollows, but also inhabits attics of abandoned structures. Winter roosts can be in rock crevices, caves and similar environments. It is an occasional migrant, with movements till a few hundred kilometers. Although component of its diet are small flying insects, it can also capture his pray from the surface of the leaves. Mating is from autumn till the spring. Females maternity colonies consists from 10 – 20 individuals. During this period, males are solitary. Typically, it is single newborn in the end of the spring. Displacement of the colonies is at the end of the summer. The average life expectancy is around 4 years, but they can reach also more than 20 years.

Serotine bat *(Eptesicus serotinus).* The serotine bat is large, found largely in lower parts of the Balkans. The dorsal fur is dark brown, grading to lighter brown on the ventral surface. The boundary between dorsal and ventral side is indistinct. It flies relatively slowly, typically about 6 - 10 m from the ground and sometimes highly maneuverable, flapping flight interspersed with brief glides that is distinctive. Most of the food is caught within 2 km of the roost in parks, gardens, around outskirts of cities, around old trees, street lamps. It feeds with large flying insects. Sometimes will flop on to foliage to catch large insects – spiders, caterpillar. Summer roosts are mainly in buildings with cavity walls or rocks, sometimes in tree hollows. Maternity colonies start to build up in May (up to 100 individuals), usually remains at living structures, rarely in other roosts, where are the small ones born. The males during summer remain solitary or in small groups. During spring and autumn there are colonies from both genders. It is likely to hibernate (November – till the end of March) in rock crevices or caves, also often found in buildings on a temperature of 4°C. Sometimes they can go for pray during warmer winter nights. Mating normally takes place in the autumn. The baby is carried by its mother for 6 till 8 weeks and they are born at the second half of June. They feed their newborns till 2 months.

Noctule bat ***(Nyctalus noctula).*** Those are large bats, with body mass of 18-35 g, a wingspan till 35 cm and a forearm length to 6-8 cm. It has golden or ginger fur and flight membranes are dark brown. Mating season is in late summer till October, sometimes even during spring. In this period one male Noctule bat lives with 4-5 females in different hollows. Females are being pregnant for 6 till 8 weeks, and after that the suckling of the small ones is about 4-6 weeks. It is registered life expectancy of 12 years. It can be victim of night carnivorous birds. This species is very characteristic with its voice, described as sharp similar to the song of a bird and it can be heard during day. It will often hunt during dusk or exactly after sunset (mainly through autumn). Sometimes can be also seen during the day, especially during autumn migrations. It has rapid, efficient flight above 10 meters. It feeds in the open spaces, often also over trees. They catch and eat theirs pray during flight. Males and females live separately during summer. They are found in buildings and other man-made structures and they use those roosts for hiding places through the autumn migration, for hibernation or even for all year. Most of the population in Bulgaria hibernates in artificial buildings and other structures (overpass, bridges). At the end of May, females are migrating to the north, where the small ones are born and during August together are coming back. There are formed multiple groups up to several hundred individuals. The right time for choosing habitat is autumn, the period between August till the begging of October. During that time in the cities there are female and male species at the same time with young ones. The Noctule bat is active in the morning and night, but during the day he often fly away from the hiding places and it can be heard. During that period males establish territorial mating roosts, from where they can make distinctive calls, to attract females and to defend them from other. Those groups are containing till 10 individuals, there are bigger ones (up to 50 – 200) contained mainly by young males, because they can also be included in the repro-

duction. Because of the morphology of its wings, Noctule bat can fly fast and high which sometimes can cause him some limits inside of buildings. Often, they are found in flats went inside through the windows but because of the sizes of the rooms they cannot return outside.

Greater noctule bat *(Nyctalus lasiopterus).* The largest European bat. Length of the body can go above 10 cm. The fur is brown through along its entire length. He can be distinguished from Noctule bat only with the larger size and some characteristics of the tooth system. Especially rare species in this area, but with large population in Spain and Greece. As other Noctule, he lives mostly in forests and formed colonies in hollows and also in rock crevices and as well in bat houses. He is the only bat who's pray on birds during its autumn migration. He also feed itself with large insects (beetles, butterflies) and also small ones. He collects his preys from different surfaces including the ground. The greater noctule is hunting in long distances in open spaces, above water bodies, around forests. His flight is maneuver and quickly. In the cities is less common, but it is potential inhabitant of buildings.

Lesser noctule (*Nyctalus leisleri*). Middle-sized bat, but is the smallest in the genus. The length of the body is from 4,8 till more than 6 cm. The dorsal side is dark brown and the ventral is lighter grey-brown. The hair is darker at the base. The ears are short and wide. Mostly this bat can be found in forest regions under 800 m altitude. Its real abundance is underestimated because they fly in open space and rarely can be captured. In Greece is also found for lowland regions. Preferences of the species are for dry and warm extensive forest habitats. It can be adapted also in urban areas, more often is found in bigger cities. Inhabits hollows and buildings. It has been found also in bat houses. It flies away for hunting 10 minutes after dusk and it flies on groups. This system of hunting is involved with order to confuse them prays which are close to their roosts. During warmer summer days those species have two peaks of

activity – exactly after dusk and morning before dawn. While foraging it can cover territory of more than 10 km². It is moving away around 4 – 5 km from the daily roost, as it prefers forests outskirts, riverside trees, tree lines around roads etc. It feeds mainly with small flies and rarer with beetles, butterflies, aquatic insects etc. Echolocation sound are composed of both a frequency-modulated component and a quasiconstant frequency domain with maximum energy around 24 – 25 KHz. Mating is at the end of summer and autumn. Males choose individual roosts, where they may acquire 6-7 females. Maternity colonies are formed during April, as females give birth to one newborn during June. The nursery process continues 6 weeks. The life expectancy is around 8-9 years. Hibernates usually in hollows, buildings and rarer in rock crevices. This species is migratory, but his migration paths between summer and winter roosts are less studied. They have become enemies of owls. This species is migratory, but his summer and winter roosts are less studied.

Steppe Whiskered bat *(Myotis aurascens).* Often is considered as subspecies of Whiskered bat (*Myotis mystacinus*). It can be found in the whole country, especially in mountain areas. Occupies forestry and bushes habitats, also in crevices, cracks in the rocks and during winter in caves. During winter is forming small colonies till 15 individuals. Its weight is from 5.0 till 7.5 g, the forearm length is around 35-48 mm and wingspan between 190-225 mm. The dorsal side is light brown and shiny and on the ventral side is lighter, the ears and wing membranes are dark.

Brown big-eared bat (*Plecotus auritus).* Medium sized bat, with length from 3.7 till 5 cm. The dorsal fur is long and usually brown or grey-brown, grading to cream grey on the ventral side. Ears are very long, and merged at the core. In Europe can be seen even till the Polar circle, but on the Balkans is rare and it is specific for the higher mountain areas. It prefers medium mountain zone with forest lands. It has short wings for

slow flight, by making "silent" echolocation noises. They are catching smaller insects in free flight and bigger ones when landing on the ground. Those bats mate in autumn. Mating colonies are usually composed of 10 – 20 females and single ones male species. During summer mainly occupies tree hollows, but it can also be found in buildings. They hibernate in caves or undergrounds of buildings on temperature till 5°C. They do not fly long migration distances and even the range between summer and winter roosts is just a few kilometers.

Grey Big-eared bat (*Plecotus austriacus).* Medium size bat, it is morphology similar to Brown long-eared bat. Distinctive marks are long ears. The body length is from 4 till 5.8 cm, wingspan between 25-29 cm and body mass 5-13 g. Fur color on the dorsal side is dark brown, on the ventral side is likely to be light grey. It has slow flight and maneuver. Usually it is hunting in open areas, close to his roosts and on height around 2 - 5 m. Catching usually flying insects (dominating butterflies). Often it can be seen during evening in urban parks and around street lamps. Summer roosts are more often on attics on different building and tree hollows. Those bats hibernate in caves, mines, galleries, basements. The distance that they made for migration is not much – till 60 kilometers. It is attached to his roosts and it does not achieve long distance migrations. Often there are individuals that can be found in same roosts for years. Mating is during autumn in the summer roosts. During breeding period (June-July), females gathers on groups from 10 – 20 (rarely till 30). They give birth to one newborn. Life expectancy is till 14 years, but average is between 5 – 10 years. They are preys of night birds.

Common Pipistrelle *(Pipistrellus pipistrellus).* One of the smallest bat species in Bulgaria. With a body mass of 3.5 – 8 g, a wingspan around 20 cm and length of the body from 3.3 till 4.8 cm. The fur is brown to grey-brown color and at the tip is lighter. This species is widespread on the Balkans. It occupies different landscapes and urbanize territories. He is using roosts

during migration and hibernation. Also, the process of breeding can happen in buildings. In city areas it is one of the most common species. Flight is fast and agile. It hunts even when the weather sharply changes. They start to hunt in the evening, even if it's cold or rainy as sometimes it does not go back to the roost till dawn. He is catching and eat up the insects in the air. They hunt over water, swamps, along woodland edges also around street lamps. The diet is primarily small insects – flies, mosquitos, moths. It is a very social species. Echolocation calls are with the highest frequency in 45 kHz. The hunting territories and also flying ones of this bat are usually open linear landscapes, such as forests streaks, meadows, hedges. He often conveys to the "hunting" areas on groups from 2 till 6 individuals, as it moves from 2 till 5 kilometers. He is making specific social calls that can be heard from the humans as well. It stays active till late autumn. Breeding colonies often consist from 20 till 100 females. Summer and winter roosts are under the tree bark, tree hollows, bats houses, rock crevices, cavities, under tiles etc. Hibernation is from October till March. Sometimes they fly also during the winter. Winter roosts are occupied by solitary or small groups from 10 – 20 individuals. They copulate during autumn and more rarely during spring. Solitary males occupy individual small territories that are defended from the others by specific sounds. Pregnancy continues from 4 till 6 weeks, depending on climate features in the region. They give birth in the beginning of June till the middle of July. The newborn bats are with body mass around 1 g, but after three weeks they peak time that gives them the opportunity to live separately. Often, they live around 4 years.

Soprano Pipistrelle *(Pipistrellus pygmaeus)*. Often seen on the whole territory of the country. It has similar size and biology with Common pipistrelle. As opposed to Common pipistrelle, this bat hunts more often above water bodies. In urban areas is more rarely to be found, but during summer period is potential inhabitant of buildings, as its abundance of species

can be up to 15000. It is easy to recognize by the sounds that those bats make with most energy at 55 KHz.

Savi's Pipistrelle (*Hypsugo savii*). Small bat, similar to Common pipistrelle, but a little bit bigger. The fur is long, on the dorsal side is dark brown till yellow-brown, often with lighter at the tips, the ventral side is pale yellow or light grey. The boundary between dorsal and ventral sides is stripe. The snout, ears and membranes are dark brown. The tail emerges out of the membrane. They occupy rocks and karst regions, pastures and valleys, woodlands and cultivated areas. Out of breeding period they can be found in towns. It flies slowly in correct paths. Hunts over water bodies, around top of the trees, high in karst regions and edges of open areas. Summer roosts are in rock crevices or on buildings, tree hollows. During summer females' colonies (including the young ones) contain from 15-20 till 50-70 individuals. Often hibernates individually in more protected places such as narrow tree hollows, buildings, rocks crevices. Migration is suspected, there are registered flights more than 250 kilometers. Feeds on small flying insects. Breeding is during August – September. There are born usually 1 or 2 small ones in July.

Nathusius' Pipistrelle (*Pipistrellus nathusii*). Small bat, but bigger than Common pipistrelle. The fur on the dorsal side is brown, ventral side is grey-brown. The snout, ears and the flight membrane are dark brown to black. The body length is from 4.6 till 5.5 cm. During winter period he is not so common in Bulgaria and Greece, but during spring migration they are extremely numerous in regions with water bodies. He can find roosts in hollows of deciduous and mixed forests. Sometimes those bats can gather mixed colonies with other species, that use similar roosts. The flight is fast on height of 5 – 15 meters, its diet consists small flying insects – flies, mosquitos, moths. As in Northeast Europe does not have enough places for hibernation, he undertakes long-distance migration of more than 1000 km, as the major migration routes become the big river streams or

system of coastal freshwaters and brackish wetlands of Black and Aegean sea. Before the breeding period which is during autumn, males appear to use a distinctive call to attract females to those mating roosts. The pregnancy is about 6 till 8 weeks, and females give birth during June. In urban areas they can be seen more rarely, but they are potential inhabitant of buildings.

Kuhl's Pipistrelle *(Pipistrellus kuhlii).* One of the most common and multiple species in the Mediterranean region of Palearctic. Inhabits mostly plains, regions around coasts, river valleys, but also in urban areas or outskirts. It feeds with flying insects. His hunting area is above forests, in parks between the trees, between buildings, around street lamps. During the day this bat inhabits narrow crevices in trees or buildings. He is strongly attached to urban areas, because he shows one of the highest levels of synanthropic among the other bat species in Europe.

European Free-tailed bat (*Tadarida teniotis*). Large bat. The fur is short, soft and silky. The dorsal side is black-grey till brownish tinge. The snout, ears and membranes are black-grey as well. It has big ears, that are projecting forward over the face and they are touch in front at their base. The tragus is small. The wings are long and narrow - at least one third of the tail extends beyond the tail membrane. It has been found in some locations around Plovdiv, around Sandanski and in Eastern Rhodope. With ultrasonic detector has been established his appearance in the higher ridge part of „Vasiliovska planina" mountain, Samokov city region and the valley of Osum river close to „Devetashka peshtera" cave. Taking into account its hidden lifestyle and inaccessible roosts, the discovery of this bat is hard. It can be suggested that is widespread in the south parts of the country as also north of „Stara planina" mountain. Inhabits rocky and mountainous regions, high buildings, bridges. Its flight is at a great height – with a swift, direct flight, but with not exhibiting the sudden twists and turns. Sometimes it looks like it is flying in inertia. In addition to the ultrasound signals,

during flight also makes noises, which can be heard by the people. It forms small colonies from 5 till 50 individuals. Summer and breeding colonies are in rocks and walls of buildings. Bats in the summer roosts are communicating through the daytime, by making loud rhythmic noises in the audible frequency spectrum. By those signals it is easy to localize their roosts. They have short and interrupting hibernation, especially in caves. It may be a partial migrant. Its diet comprises of big flying insects. Breeding process is during autumn and spring. Pregnancy continues 75-85 days. They give birth to single small one, and he can start to fly after 3-4 weeks. After 7-8 weeks they are already independent. Bat species become sexually mature when about one year old. The average life expectancy is 10 years.

Particoloured bat (*Vespertilio murinus*). This bat is medium sized, around 4.7 till 7 cm, wingspan of 27-33 cm and body mass of 12-23 grams. Its fur color is dark brown on the dorsal side with silver tips and the fur on the underside is white. During summer stays usually out of populated areas, while through autumn is going to the big cities with a lot of high buildings, where the male species gathers and start to make specific social sounds. Often emits a characteristic "tsick-tsick-tscik", enabling it to be recognized by sound and it is the range around 17 – 18 KHz. The male produces this sound while flying in circles above the buildings. It usually happens around buildings which comes after that their roost. It feeds with flying insect - moths. There are registered more than 1000 km long-distance migrations from Northern to the South Europe. Breeding is during autumn and spring time. Usually female gives birth to two small ones in the end of June. The female bat raises her newborns alone, not in groups.

4. Common approach

Urban areas are preferred places for a lot of bat species and they can find their new roosts and food. The approach for their conservation is primarily based on requirements for their habitats.

Bat's roosts are varied accordingly to the types of building. This defines that not always the bats can be seen. The easiest ones to be seen are horseshoe bats, because they are usually in available sites for surveillance and they are easy to recognize for their size. Long-eared bats sometimes can be found in obvious sites on wooden roof structures.

Even though, a lot of Vesper bats prefer to settle in crevices and narrow spaces under roofs or between tiles and that specification makes them harder for surveillance. Also, in joints and crevices on residential buildings, small crevices on facades on buildings, different attic sites and basements, between tiles, between bricks on houses, shaft, bridge's fugues.

Bats can find roosts in almost every part of any building. In those crevices which they occupy, they have enough place to take from one to several species and they are protected from water, wind and sun. In different cases, bats can make colonies on attics and individually they can occupy shutters on windows. They can get into buildings through hole with at least 1,3 cm diameter. Usually entry points are open windows, not well installed or even missing tiles, sites where the planks are fallen or where pipes and cables are coming into the building. Often there are holes where the walls have contact with the eaves.

Lesser horseshoe bats (Rhinolophus hipposideros) on the attic of abandoned house

© R. Mecheva

Often bats can be found in bricks

© R. Mecheva

Fugues in old bridges can be also roosts for a lot of bats

© R. Mecheva

Checking for bats in concrete bridge

© R. Mecheva

Suitable opening for bats to go inside in attic of old house

© R. Mecheva

Sometimes bats can rest on some parts of residential buildings (e.g. railing of window, terrace) during night, when they are feeding with insects. They also often seasonally visit buildings including breeding time. Some of the bat species can hibernate in buildings. For example, Common noctule can hibernate in fugues of panel buildings, bridges etc. In general, habitats of urban areas can be distributed in following types:

a). Spaces between buildings with domination with herbaceous vegetation;

b). Between buildings with dominating tree vegetation;

c). Large standing ponds (lake) and overgrowth surroundings with dense forest vegetation;

d). River, river spills, canals with wooden riverside and bush vegetation close to structures;

e). Parks from forest type: occupied with indigenous vegetation and partly from cultural plant species;

f). City-type parks: park forest inside the city, entirely planted;

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Riverside vegetation

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Alley around natural forest vegetation

© R. Mecheva

Trees with loose barks in urban areas

© R. Mecheva

Old growth trees with hollows in urban area-provides roosts for bats

© R. Mecheva

g) Hills and rock terrains, located in urban areas with grass or forest vegetation or buildings.

Existence of favorable hunting territories. Different types of vegetation in urban areas together with park territories and water areas, offer relatively good conditions such as hunting areas for individual bats, which are attached to urban areas. The food activity for the bats in urban areas is specific for different species, depending on the habitat. For some synanthropic species such as *Nyctalus noctula*, it is highest around artificial lightning. For *Pipistrellus pipistrellus,* it is relatively equally around street lighting, in city parks and above small artificial or natural waterbodies. *Pipistrellus pygmaeus* feeds most active above river areas with wooden riversides and less around street lighting.

Available of drinking water sources. This is a significant limiting factor even in urban areas. Different in nature – natural or artificial water bodies are of great importance for the existence of bats.

Water body in urban area relevant for synanthropic bat species

© R. Mecheva

For example, it can be given the unusual bat diversity in Sofia city. It is due to a series of factors that together attract bats in the city: presence of several mountains that surround the city from north and south – Vitosha, Lozenska, Lyulin and Stara planina mountains. Many species live in the mountains during summer, but during winter prefer the warmer urban weather. Eight species are yearly inhabitants of the central parts of the capital.

There are many parks in Sofia. Although they have declined over the years, they continue to provide the right environment and roost for many wildlife species living in the area.

Several rivers pass through the town: Vladayska, Boyanska, Perlovska and Dragalevska rivers and several smaller rivers inflows, which are as natural corridors for night movements, seasonal migration and feeding.

Water areas, urban parks and abandoned terrains gives perfect conditions for abundant food for them – night insects.

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5. Threats

Currently the bats are among the most vulnerable groups of mammals. That is also one of the reasons to make a lot of efforts for their research and conservation in Europe. Bats are very important from ecologically point of view. It can be said that they are "freely" helping to the people in agricultural holding and forestry as they destroy many millions of insects without using chemical detergents.

The main threats for the bats in urban areas are:

- ***Loss of roosts***

Buildings or engineering structures such as constructers, barns, abandoned transformer stations, bridges and other preferences of individuals species that are connected with urban areas. For example, Grey long-eared bat (*Plecotus austriacus) and Lesser horseshoe bat* (*Rhinolophus hipposideros*) prefer old structures, while Common pipistrelle *(Pipistrellus pipistrellus)* is regularly found in modern buildings and even in panel blocks. Daubenton's bat *(Myotis daubentonii)* often find places to rest under bridges, while Nuctules *(Nyctalus noctula)* is more often in places with old growth trees.

In mountain areas most attractive and common in crevices and fugues of beams in farm buildings are Natterer's bat (*Myotis nattereri*) and Brown big-eared bat (*Plecotus auritus)*. The Brown big-eared bat prefers to rest along the central timber, as often leaves a trace of guano under the timber and this can be used as proof for its presence. All Natterer's bats have been observed in buildings, close to forests, with hollow niches, with open or without doors and unconstrained inside flight area. Sign that the places are used is the presence of coloring and absence of spider webs around the fugues. Presence of guano may not be noticed, because even if it is there it is too small.

The corridors of National library in Sofia, are often inhabited by bats. Its proximity to the park "Borisova gradina", turns to be convenient roost for Noctule bats.

- **Mortality of individuals**

The facades on most of the buildings and the ways of their maintenance are precondition for settlement from bats. Seasonally or permanently they settle in crevices and joints, under unstuck coat, in architecture ornaments, in attics, basements and many other places. They are extremely attached to the places where they live and come back again.

During repair of a terrace, when changing of old windows with new ones has been liquidated almost whole bat colony. Animals were kept alive, although some of them were under special protection.

On another repair the owner thrown away more than 50 individuals from the seventh floor and most of them died, but the repair continued. Upon receiving a signal from a neighbor only nine of the animals were saved.

After another signal, in December 2016 year, on open terrace were established over 61 bats crowded on groups. It is not a typical event to find bats during winter, especially on day light on fully open. Bats avoid staying outside and unsaved during the day, while during winter, they are in hibernation and they have chosen appropriate roosts in buildings, caves or trees. In this case, the colony was from Common noctule.

The most likely reason for their presence in this atypical place is abandonment (expelling from the roost). It is possible that this has happened during repairs, from different private persons (on terraces, facades etc. in which bats has roosts there and hibernate) or during rehabilitation on some of the panel buildings, implemented under the Energy Efficiency program. Winter is vulnerable season for the bats, during that they cannot leave their roosts, because they are in state of reduced activity (hibernating), during which time their body is in deep anabiosis. Hibernation is biologically adaptation during winter, when there are not enough active

insects and during those period vital functions are decreasing, pulse and breathing are slowed down, body temperature is low excretory processes and movements are minimal. The aim is to "save" energy, needed for the animal to survive till the spring, when there is again food. During that period, the metabolism is ensured by energy stored in autumn in form of subcutaneous fat. Hibernation is not a continuous through the whole winter period. Periodically, bats wake up briefly, move around and may even go out in warmer winter days (to drink water, for example). They can also wake up or to leave the roosts if there is reason of destruction or in case of extreme disturbance. In these cases, although that is slow, they come out of hibernation and can leave the roosts, to find more appropriate place for hibernation. Declining weather conditions through the autumn (heavy rains), not enough accumulated food supplies, duration of the winter, disturbance during hibernation etc. can become reason for depletion of energy, which in turn will now allow to bats to survive until the end of winter.

Hibernating Greater mouse-eared bat (Myotis myotis), studded with droplets condensed moisture

© I. Pandourski

When the repairs are during that period, the bats are literally filled in alive or crushed through those repairing, because there is no time for them to leave the roosts.

For the problem with renovation of buildings during vulnerable for bats periods (breeding and winter) repeatedly are informed all responsible institutions, because the destruction of individuals from those protected species constitutes as a violation of the Biodiversity Act, which provides for financial and administrative sanctions. However, the problem has not found a lasting solution.

In Sofia during winter months there is massive coming of Particoloured bat (*Vespertilio murinus*). During summer he lives in Vitosha mountain and during the cold months he is going down the slopes in the city. Then there are cases when during repairs, people find colonies of bats, occupy places above the air conditioners, streets, crevices. If their roost has been destroyed, they have no chance to fly away during the winter months when they are most vulnerable because of low temperatures. If they are not saved, they die from cold.

In order to prevent bat's mortality it is necessary to make a survey in advance of the buildings at the earliest possible stage for the presence of protected species, to implement measures for safety remove of the protected species from their roosts before the renovation. If possible to prevent repairs during the hibernation and breeding period of bats.

Prescription should be given to the construction companies before performing the installation works, for putting pipes for removal of bats.

The high degree of vulnerability and nature conservation status are sufficient reason for village administrations not to be able to take "appropriate measures" and to regulate in any way the distribution and abundance of bats in urban areas.

Building renovations is the biggest threat for bats in urban areas. Hundreds die because the workers are covering them in crevices. The reason for such actions is the lack of educational ecological culture and prejudices.

- **Disturbance**

Some species from the synanthropic bats are very conservative and use only one roost. Others can use up to 40 till 70 different sites during summer. The most critical period for carrying out construction works is when bats give birth and nurse their young (from 25th May to the end of July). About 5 species inhabit man-made structures irregularly, at some times of the year (for example during winter), instead of nearby mountains or forests they prefer to hibernate in urban conditions with microclimate. In most of the time, those species hibernate locally in very large numbers, near neighbor individuals from larger regions. Disturbance during winter will cause great stress and often to death of some or many individuals.

Different types of construction work in urban areas are the reason for disturbing bats, due to frequent impact of powerful lights (especially on all night and day construction). This way lightning of the site it is not consider with requirement for minimize the one-sided scattering, which is reason for disorientation of the animals and loss of habitats, especially for Brown big-eared bats. It violates routes, which can be important for the migration and genetic exchange for this type bat over a wide perimeter.

The breeding season (June-July) is the most critical period for carrying out repair or restoration activities. The anxiety of bat colonies certainly leads to high mortality and even collapse of the colonies.

In period June – August the young bats start to fly, but they are still carried and nursing from their mothers. The small ones require constant temperature and hourly meals. It is extremely hard to determine the period for switching from "milk formulas" to semi-solid or solid food. The newborns are helpless, especially when the mating roost is destroyed or the bats have been disturbed. Mothers often try to save their young ones, carrying them during searching new roost. The disturbance in maternal roosts, when the young ones are especially vulnerable, can cause to their mortality.

Lesser horseshoe bat (Rhinolophus hipposideros) – mother with small one

© Y. Yankov

Other threat for the bats in urban areas are pets, which loves to play with winged mammals, without killing them. They most often hurt them because they are amazingly fragile.

Most often bats fly into homes. Sometimes the animal may still be in the house even if it cannot be seen. Extremely small (the body of the smallest bat is with size of 4 by 2 cm, it can fit in half match box), he can be attached anywhere – in the curtain, behind the picture or closet, under the edge of ledge, in hanging garment. He only wants to hide and if he cannot go outside, he mummies in a corner without smelling, because he is with a very small body.

6. Types of impacts

Independent of the specific character of impacts over the bat species who are connected with urban areas, as resulting from natural factors or those resulting from human activities, during making an assessment of those impacts often it is applied common scale for their degree. In the next table there are criteria for assessment, as well scale of impacts and evaluation scale for those criteria.

Table 1

Matrix for assessment degree of impacts

Assessment	CRITERIA	LEVEL OF THE IMPACT
0	The activity has no impact	No impact – **0**
1	The activity has low negative impact	Low impact, which can be avoided without special activities, except compliance with best practices in forest exploitation – **from 1 to 3**
2	The activity can affect temporary with negative impacts	
3	The activity can affect in short-term period with negative impacts	
4	The activity can have secondary negative impacts	Moderate value of impact, which is not necessary to be reported with other factors and to be recommended measures about mitigation or eliminating – **from 4 till 6**
5	The activity can cause cumulative negative impacts	
6	The activity can cause synergistic impacts	

Assessment	CRITERIA	LEVEL OF THE IMPACT
7	The activity can cause secondary, cumulative, synergistic negative impacts. The impact can be eliminated by mitigating or compensatory measures.	Significantly impact, which is necessary to be eliminated by choosing alternatives or implementation of mitigating or compensatory measures – **from 7 till 9**
8	The activity can cause secondary, cumulative, synergistic negative impacts. The impact can be eliminated by mitigating or compensatory measures.	
9	The activity can cause significant, mid-term or long-term constant negative impacts. The impact can be eliminated by mitigating or compensatory measures.	
10	The activity can cause significant and constantly/irreversible negative impact. The impact cannot be eliminated by mitigating or compensatory measures.	Significantly impact, which cannot be eliminated by implementation of mitigating or compensatory measures - **10**

7. Character of the impacts

Impacts that can affect synanthropic bat species can be short-term in period and reversible or long-term, irreversible.

The short-term and reversible impacts can be disturbance in the roosts or temporarily expelling the bat species. The bigger part of the impacts in urban area are the long-term and irreversible impacts and those are:

- destroying roost or self-destruction of old buildings;
- removal of old growth forests or trees with loose bark, hunting areas or corridors,
- changes in structure of population;
- fragmentation and interruption of migration paths;
- mortality of species in the roosts;
- interruption of genetic structure between populations in species areas.

8. Risk assessment and assessment of sensitive areas

Humans constantly is destroying or disturbing the natural habitats of those wild animals. They are adapting to the changes: forest species disappear at the expense of other species, they settle down in unusual areas about them, including in big cities.

In some cases, there is even "conflict" with people – e.g. noisy colonies of common noctule (*Nyctalus noctula)* in the crevices in living buildings. Also often happens that some species as the Common pipistrelle (*Pipistrellus pipistrellus*), Common nuctule, Grey big-eared bat (*Plecotus austriacus*) etc. are getting inside of rooms, inhabited from humans and this leads to unwelcome feelings in the humans and this is usually because of ignorance.

The important thing to know is that the presence of bats is not a danger for the people. They are trying to avoid the contact with humans as each other wild animal. Those situations are even more stressful for the bats.

In urban environments it is not possible to identify clearly sensitive areas which to be described. In this connection, it is advisable to make a preliminary assessment of the presence of bats in a habitat presented in the table below:

Table 2

Advanced assessment of the presence of bats

1 – LOW VALUE	Isolated site not connected by prominent linear features, (forests, channels etc.). A small number of possible roosts present on site Site may contain isolated habitat that could be used by foraging bats e.g. a lone tree or area of scrub but not parkland
2 – MODERATE VALUE	The site is connected to the wider landscape by linear features that could be used by commuting bats e.g. lines of trees and scrub or linked back gardens (rivers, channels, forests etc.) Has several potential roost features within the site, such as buildings, trees or other structures Habitat on site that could be used by foraging bats e.g. trees, shrub, grassland or water
3 – HIGH VALUE	The estimated area is part of a complex habitat associated with well-defined linear landscape elements that can be used by bats for orientation The site contains buildings, trees or other structures that have features of particular significance for roosting bats Habitat of the site is favored by foraging bats e.g. deciduous woodland, tree-lined watercourses and grazed parkland
4 – CONFIRMED ROOST	Evidence found that indicates a habitat being used by bats: There is a cave with bats Droppings scattered on buildings, galleries etc. Bats heard “chattering” inside a feature on a warm day or at dusk. Bats observed flying around lamps.

Examples of rescued bats, living in cities/urban environment:

- ***Facade fugues***

Part of the maintenance and insulation of old blocks involves filling facade fugues, most often in alpine style. In majority of the cases the plaster of such buildings fell off a long time ago and over time individual bats and even colonies have come to settle here. The Noctules (*Nyctalus noctula*), serotine bats (*Eptesicus serotinus*) and during winter the particoloured bats (*Vespertilio murinus*) are the most frequent inhabitants of crevices and fugues. The best approach, after establishing the presence of bats in the fugues that have to be filled in, is to remove the bats and release them at an appropriate location. Removing the bats from the crevice requires willingness, gloves, a thin stick (or a long pincette), a cotton bag or a plastic bottle.

If the bats are active it may take several minutes to take them out. If they are in an inactive state (for example in hibernation), they need to be warmed a little using human breath and a small pipe, when they start crawling then they can be caught. Their release can be immediate, if the day is warm. If they are inactive, they must be taken out in the bag or plastic bottle and released into an appropriate attic space whit open shutter.

After received message about presence of a bat colony in a company office (on the top floor of a building in industrial area) in Plovdiv city has been made a verification and it was confirmed the presence of bats, inhabiting the vertical fugues of a concrete slab above the office suspended ceiling. On the place has been found dead body of Kuhl's pipistrelle (*Pipistrellus kuhlii*). During the next inspection recordings were made with a Pettersson D240x, bat detector, which after the analysis, confirmed presence of colony of this species. Observations showed that the colony consisted of over 50 individuals and the capturing of a juvenile individuals proved that it was also a maternity colony. The presence of bats did not pose any threat to the people working in the office. It was recommended that the com-

pany seal fugues in the suspended ceiling to avoid bat droppings in the office and to put anti-mosquito nets on the windows to prevent bats from entering the office.

- ***Fugues and cavities in bridges and engineering constructions***

Hibernating colony of Common noctule (*Nyctalus noctula*) has been found during reconstruction works of bridge "Gerdzhika" in the town of Plovdiv. In the end of November 2005 started plans to reconstruction works under the bridge, where was planned to reconstruct the pavement, shift the slabs, break the pillars and close the hollows underneath the bridge. At the very start of the repairs the workers found that many of the fugues below the bridge were full of inactive bats, which were being squashed when the slabs were shifted, buried under construction or falling into the water of Maritsa river. After the alarm was raised urgent action to save the hibernation noctules (*N. noctula*). Over 6 days a total of 977 live bats were taken out (average around 80 individuals per joint). Considering the number of individuals that fell in the river, the found dead bodies and the ones who managed to escape, the total number of wintering bats was calculated as approximately 1500.

9. Cumulative effect

In Bulgaria is almost missing any information about bats and impact on them in different environment assessment plans, project and investment proposals. Through that way there are no reports about some negative impacts on bats. This gives "green light" about their realization and it leads to serious damages over bat populations, significant habitats of bats. That is why it is extremely important during achievement those environmental assessment to pay special attention to the bats as well to proceed more researches, which can guarantee that those projects are not going to affect them negatively.

Massive buildings lead to a number of other potential threats for bats population, as well and their consequences for their habitats, especially if they occur in a protected or conservation zone. In addition, it should be noted that a new construction will have an impact on the breeding sites of the bats. Such projects, combined with the construction of road and industrial infrastructure, can create a negative cumulative effect. In order to be mitigated or avoided is needed to have a functioning and sustainable strategy related to spatial planning and development. It should be also under assessment in terms of the habitat's disposal, where are recommended guidelines for entrepreneur and designers, and also procedures which can guarantee that any potentially significant impact it will be assessed.

Where mitigation is required is good to be observed the following recommendations:

- Bat sites for breeding, foraging, migration lines in the protected sites and areas or around them must be identified, retained and protected in the long-term. This includes considering how much light is available.

- The riparian corridors along the rivers should be enhanced to create a mosaic of wetland and species-rich grassland habitats.
- If the site is in a woodland nature area, landscaping includes a high proportion of woodland planting, particularly where this provides enhanced ecological connectivity with wood massive. Contributions towards opportunities for woodland creation in the landscape setting of the site where possible.

By complying with such requirements, the cumulative effect of the urban environment will be greatly reduced and problems will be avoided.

10. Limiting factors

Globally, habitat loss, degradation and fragmentation of ecosystems are identified as one of the most important factors for biodiversity loss. From the point of view of Bulgarian legislation about conservation of habitats, competent authorities are committed to ensure full respect of EU legislation, also as regards the protection of bats species.

The worry is the extent of the building up the urban areas and it is connected with the impact which this construction can have on the bat populations in the territory and the connection of those populations with the urban area, where the landscape is highly influenced by the industrial activity over the centuries. Bats as an essential element of ecosystems are also subject to specific factors leading to reduction in their abundance. Bats as taking high sections of food chain are especially sensitive to the environment changes and as a slow-breeding species are difficult to recover after population crises.

In urban areas, there is often a strong negative impact on the existence of bat populations, which are disturbed, suffer from amateur pressure and habitat degradation. This often leads to a negative chain effect.

In order to avoid the limiting effect of the urban environment, it is necessary to apply and observe here some basic rules related to the protection of species and their habitats, even though these are urban territories already exposed to anthropogenic impact.

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11. Conservation measures and recommendations

Urban environment appears to be like a refugium for native, synanthropic as well as forest bat species and as new places for invasion of non-typical for this area species such as groups of rock facultative cave dweller. The increased biodiversity of the city's chiropterfauna compared to their highly degraded by anthropogenic influence surrounding identifies them as important habitats for bats and shows their high conservation significance.

Several species in Bulgaria such as Greater horseshoe bat (*Rhinolophus ferrumequinum*), Lesser horseshoe bat (*Rh. hipposideros*), Geoffroy's bat (Myotis *emargnatus*), Savi's pipistrelle (*Hypsugo savii*) etc. are inhabitants of basements, attics, crevices between bricks of old buildings.

Many local populations of bats have a long tradition of using the same sites, often attracted by the special climate, which buildings often keep for long time. As a first measure, it is necessary to keep as much as possible bat's roosts.

For the measures to be as effective as possible, there are standard recommendations. They should be as precise, specific and clear as possible so that they can also be easily understood by non-professionals.

In order to prevent the destruction of individuals or colonies is necessary competent expert assessment, which is required to reflect or present evidence that there are or not bat's roosts. If a bat colony has been founded, the bat expert should periodically monitor the activities performed during the repair. It is advisable to make a photo documentation of the structure(s) and evidence of the presence of the bats, if found, to draw a sketch indication the location of the access points and the roosts of the bats.

In this guideline are presented some standard measures for decreasing the harmful impacts on the bats. They are not comprehensive and in certain specific circumstances, there are other recommendations that may be used.

An example for potential conservation measures and recommendations:

1. Preparation of schedule of activities for destroying of buildings and constructions and repair activities. It is a good idea that any repairs that take place in a bats-inhabited building should be carried out during the winter months - November to March, since during this period the number of bats in the buildings is significantly smaller. This will reduce the impact on these animals. If individuals are found or if a breeding colony is established, then all types of repair activities must be carried out outside the breeding period - from March 30 to May 15 and from August 1 to October 30.

2. When a structure is destroyed or restored, activities must be carried out with care and it is expected that individuals may be found. It is advisable to check the presence of bats before starting the activities. The exposed animals to be well placed in a box and released at dusk. It is a good idea to repair large roofs in sections to reduce the effects of work on bats.

3. In order for the bats to continue to occupy a building that is being repaired or restored, it is good to keep access, while adapting or creating new constructions. Fugues with sizes of 12 till 20 mm will provide continuous and future use of bats. In such cases, it is advisable to seek advice from a bat specialist.

4. For water reservoirs placed in roof areas or if they are installed, it is advisable to be covered all the time in order to prevent future accidents like drawing or contamination of bats.

5. Where possible, lighting should be avoided. The reason for this is that it does not allow certain species of bats to eat. A bats specialist should advise on the location of the lighting taking into account the resting places that may be affected. This is especially important if there is a roost for Lesser horseshoe bats,

because they are very sensitive to the light. Where lighting need to be set up it must be on limited height and pointing down to prevent distraction.

6. Development of scheme for installing bat houses. This is one of the options for an additional alternative roost to compensate for the potential loss of casual nights that can happen when buildings are destroyed. The recommended number, the material of which they are made and their design can be recommended by an expert. Species such as Brown long-eared bat (*Plecotus auritus*), Common pipistrelle (*Pipistrellus pipistrellus*), Soprano pipistrelle (*Pipistrellus pygmaeus*) and Lesser noctule (*Nyctalus leisleri*) are hypersensitive and will often use houses for temporary roosts. It is advisable in the place where the demolition of buildings will be made to be develop a scheme for placing a bat house to compensate for any potential loss of casual nights. It is good to place enough houses (the number of them may be determined by specialist). The houses are placed on sturdy and old trees. For the purpose, there have been developed wooden, concrete material for Brown big-eared bat, Natterer's bat and Common pipistrelle.

7. Preserving old growth trees. All trees planned for removal must first be inspected by a specialist for potential roosts. All existing old growth trees should be saved, should be protected from damage to their root system.

8. Conservation and planting of vegetation. The linear characteristics of the landscape, such as hedges and roadside tree plantings, should be preserved or planted wherever possible. In this way continuous bio-corridors are formed, which can be used from bats as resting places. They are related to existing linear characteristics both at and outside the site and where is possible to ensure continuity. For this purpose, local plant species should be used because they provide more living conditions for many insect species than other plant species.

9. Monitoring. In order to assess the conservation and mitigation measures applied and assess their efficacy in terms of

protection the bat's fauna is good to carry out random visits during the first three years of the measures (during the appropriate season). Bat's houses will need to be cleaned and if necessary, moved if were not used.

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12. Good practices

The bats usually inhabit the buildings seasonally, including during breeding period – that is why their removal should not happen before the juvenile ones learn to fly. After the young ones growth enough, all bats can be forced to leave their roosts. The breeding period lasts from May till August. Young bats can already fly during the late August and they can be removed then. In the late autumn most species living in buildings migrate to warmer areas or winter in caves or abandoned mines. Some of them can hibernate in buildings (for example the common noctule in joint of panel blocks, bridges etc.) and in the warmest climate they can remain active throughout the year. Since the winter is cold in Bulgaria, bats are not active, the removal from their roosts must be postponed until the spring when they are already going out for feeding.

Supposing that in some residential building, garage or other structure there is a bat roost, which can be easily to access, so for them to be safe and easy to leave it, it should wait for them to leave it alone (usually they leave the roosts at dusk, but it can happen to be later or in certain night when they go for feeding). After a thorough check there are no bats left, the hole is clogged with the appropriate material.

A relatively successful practice for improving the conservation status of bats in Europe and North America is installation of bat houses. The main function of bats houses is to provide artificial resting places, especially in habitats where there is a shortage of natural roosts, such as in conifer plantations. Besides, the houses provide and facilitate the finding of bats resting places, which also ensure a greater presence of these species in the region, which proved to be a particularly valuable tech-

nique. Guidance for types of constructions, position and verification is provided by Stebbings & Walsh (1991).

Placing the bat houses is the most successful when it is already known that an old building or residential block has already been inhabited by them. The same is true when such a habitat is gradually replaced by structures that are not suitable for bats, forcing them to find new roosts or to perish. All European bats are useful for keeping the huge number of flying insects in balance, although their main nutritional preferences vary considerably.

Practices in different countries and geographical areas show varying degrees of success – from not inhabiting to 3 – 100 % success rate of settlement. Essential to success is the orientation of the houses and their exposure to sunlight.

The selection of the place and height at the house is also of great importance. The greatest success was noted when placing houses that were placed about 500 m from a lake, pond or stream and at least 10 – 15 m above the ground. In areas where the average temperature fluctuations during the day are lower than 20°C the houses can be mounted on poles in pairs with north-south or east-west exposure. When daily temperatures exceed 20°C, they must be installed on buildings (which serve as radiators). All houses should be exposed to at least six hours on direct sunlight (even in how climate). In general, the more, the better. Bat houses are like hot homes, so in all or even to those in the coldest weather they have to be equipped with ventilation openings either front or side. These holes should be approximately 15-20 mm near the entrance to prevent overheating. The least successful are houses that are mounted on walls that are close to trees, because they are often too overshadowed and too vulnerable to predators.

From 2001 until 2005 in Bulgaria have been placed around 200 bat houses – in "Ropotamo" reserve – 60 houses, around „Izdremets" peak and the monastery "Sedem prestola" in the Western Stara planina – 50 houses. They proved to be a convenient way to monitor bats.

The hotel, provisional as an extension of Perla residence is located in the "Begliktash" area and it is in "Ropotamo" protected site and "Complex Ropotamo". The building has a huge spread area, three above ground floors and many underground floors. The roof has become with a specific form lake and the underground floors –flooded. Destroying since the end 1989 it is a refuge for over **6000** bats, 7 amphibian species and 14 reptile species. The property wat privatized in 2002. The initial investment plans were to build a hotel complex and resort buildings for more than 2000 visitors. An independent environmental impact assessment expert, conclude that there are no species whose habitats can be affected during construction. The presence of many individuals, some of which are protected, is stated in the opinion of the National Museum of Natural History at BAS.

To reduce the impact of the investment project several proposals have been submitted. One of them is the construction of a compensatory roost, a replica of Perla 2. The aim of the project is to create a facility that resembles the conditions in Perla 2 so that the bats can recognize it. It is proposed that the spot for construction is 20x25 m and is at a distance of 680 m from the destroying hotel.

13. Management and monitoring

Monitoring researches are in order to provide quantitative changes, which can occur in some bat community during some period of time. Most of surveillance methods are done as usual bats in some breeding colony are being counted during summer, number of bats which are hibernating during winter as well number of counts and bat species composition in range of transects on set periods. (Walsh et al., 2001). Also, there can be monitoring over the distribution and species composition of bats in specified habitats. That way there are provided valuable data/information about the changes in populations, their distribution, which sometimes can give more valuable information in comparison with counting, done only in the roost of one species.

Depends on aims of monitoring there can be different kind of surveillance, which can include yearly inspections of condition of some object, long-term researches in the dynamic of bat populations, researches of management practices, science research for mechanism of hibernation and tracking the reproduction biology of bats. Each of those aims requires monitoring and different intensity. In every type of conduction, it should be maximum avoided any disturbance of the bats.

Visiting of different habitats and long-term surveillance should not be conducted more often than one or two visiting per year. Important thing that it should be observed during monitoring is periodicity and seasonality of those visiting. It is important to ensure that the application of the method is standardized as much as possible, to allow comparison to be made. Although that the bats abundance is going to fluctuate in dependence of weather conditions during surveillance, then long-term trends are going to occur after the data is being processed from several years.

It is very important still from the begging of the planned research, to have some objective and measure in which is going to be conducted and to select suitable methods for this research.

Methods of monitoring:

There are nine bat species that are considered for synanthropic and they are not included in The National Biodiversity Monitoring System.

Those are:

Family *Vespertilionidae*

1. *Eptesicus nilssonii* (Keyserling& Blasius, 1839)
2. *Eptesicus serotinus* (Schreber, 1774)
3. *Hypsugo savii* (Bonaparte, 1837)
4. *Pipistrellus kuhlii* (Kuhl, 1817)
5. *Pipistrellus nathusii* (Keyserling & Blasius, 1839)
6. *Pipistrellus pipistrellus* (Schreber, 1774)
7. *Pipistrellus pygmaeus* (Leach, 1825)
8. *Vespertilio murinus* (Linnaeus, 1758)

Family *Molossidae*

9. *Tadarida teniotis* (Rafinesque, 1814)

There are missing methods for monitoring of species from those groups in Member states of European Union on national level. For the reporting under Art. 17 of the Habitats Directive in most countries regional studies have been used. Based on expert judgment has been extrapolated the size of the national population, habitats and species threats.

As a reference for the number and distribution of the species in this ecological group in Bulgaria are used data from the studies under the project "Reporting of the Republic of Bulgaria to the European Commission according to Art. 17 of the Directive 92/43/EEC on the conservation of natural habitats and wildlife flora and fauna (Habitats Directive) for the period 2007 – 2012".

- **Direct observations,** roosts inspection and counting

The object under inspection is visited by expert, who knows in advance and gives assessment of the habitats and/or by using satellite pictures from Google Earth to compare with a

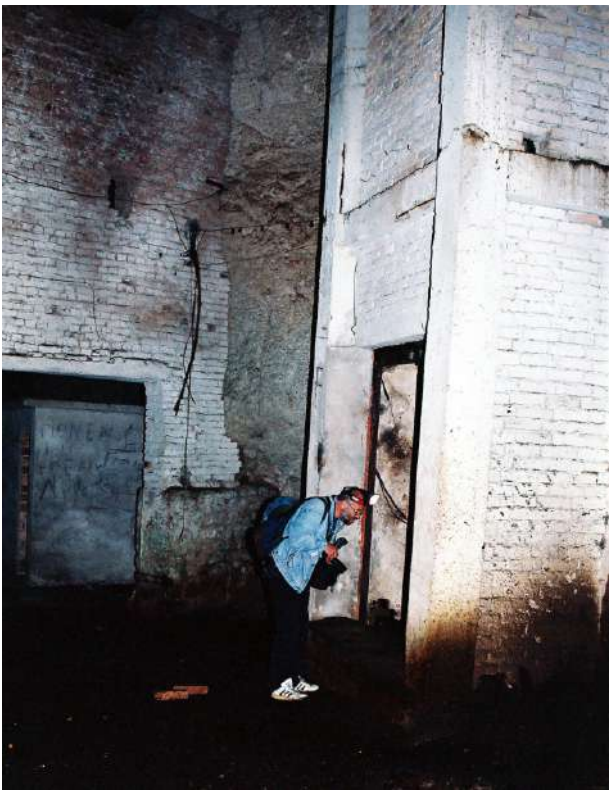
map of surrounding terrains such as physical characteristics of the study area, forests, rivers and other water bodies, who can be give opportunities to the bats for hunting areas or just movement of the bats. Directly after dusk on the same study place it should be done ultrasound audio detection as well. It is necessary because:

- To evaluate species composition or number of attendance bats;
- To be determined access points of bats;
- Full access to the building during day inspection it can be not possible.
- The building can be too dirty or ruining and thereby guano, food or any traces from bats cannot be noticed during day inspection.

The research should start around 15 minutes before dusk and to continue two hours, because each bat specie can be seen in different time. Ultrasound detection is good to be done also at dawn and this can lead to easily to be defined access and sites of bat's fly in. In a several points around the building can be seen or registered more bats than single bats flying out from the building during dusk.

Depending on the conditions, it is useful the place expected to be inhabited by bats to be visited with the owner and to put on plastic paper or other material with bright color on the floor of those buildings who have to be inspected and this can lead to easier registration of the places where the bats should find roosts. It is recommended the research to be done during favorable weather conditions, e.g. moderate temperatures, light breezes and less or none rainfalls. It is necessary on day light to have enough time for full researches of structure inside and outside. It is also good to look from distance surrounding habitats, because it is possible not to be everything established in preview or something can be changed. Before the research it should be done initial assessment of the risk of this property and identifying the dangers such as wastes (chemical,

biological etc.), cables, strength of constructions such as carrion planks, ruining walls, ceilings or roofs. Those risks should be discussed with the owner and if he/she knows that there are bats using the structures. Visiting have to be done before the end of September. Researches done after this date are possible not to give enough information and to guarantee that the building was able to be used from bats and the research is not going to affect over the bats and its roosts.



In view in elevator shaft for breeding colony of Greater mouse-eared bat (Myotis myotis)

© I. Pandourski

In view of attic of abandoned house, inhabited from Greater horseshoe bats (Rhinolophus ferrumequinum)

© I.Pandourski

Often during view of structures there been found traces from bats – guano

© Y. Yankov

All possible roosts that can be used from the bats seasonal or yearly should be explored.

Bats *Nyctalus noctula*, *Hypsugo savii*, *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Eptesicus serotinus* etc. are usually occupying almost all populated places in Bulgaria. They can be found in the attics or some crevices of walls, sometimes basement also. Only one visit is enough to detect bats presence.

Species are identified by morphological parameters from distance and after capturing also distinguished by body measures and then exemption. For circumstantiality of the assessment is important to be visited more places in the study area which can be potential roosts. The roosts are well inspected for bat's guano and food waste. Indirect tracks are owl's pellets, which often consist wastes from bats, living in the region. It can be also done view of road areas where bats can be victim of night traffic. It is prepared species list, which consists established species whereof is found guano. Towards the research is applied map with places where the bats have been found and assessment about their number for each roost.

Advantages. This is the easiest and relatively low-cost method for in situ assessment of species composition, abundance and the function of the various bat habitats.

Limitations. A single visit to some roosts before or after the breeding or hibernation season may show no signs of bats living there at all. For this reason, it is necessary that the visits are carried out during periods when the bats are likely to inhabit the studied area. Such periods are from 15th May to August 1st and from December 1st to March 30th. Information on the number of individuals in the winter and summer colonies can vary due to experts. Digital photographs can be very good way for archiving and substantiating the surveillance.

- **Mist-nets and traps for bats** for determining of species composition:

Mist-nets are made of a very thin polyester fiber. Some nets designed for catching small birds can also be used for catching bats. In urban area nets should be set around entrance of abandoned houses, park valleys, under bridge constructions. They are necessary only when its needed species identification.

Mist-nets for catching bats, placed inside of abandoned building

© R. Mecheva

Mist-nets for catching bats, placed on the exit of abandoned building

© R. Mecheva

The bat's trap for narrow entries (harp trap) consists of one or two rectangular aluminum frames each coiled with a fishing line and with canvas bag beneath the frames. The bats are stopped by the fishing lines and fall into the bag. This trap is used to catch bats emerging from small entrances where mist-nets cannot be properly set.

Tuttle's trap placed under a bridge

© R. Mecheva

The funnel bat's trap consists of a cone shaped plastic tube, rings connected with thin fiber and polyethylene tunnel with cloth bag at the end. The trap is usually set at tree holes/hollows and when the bats fly out, they fall into the tube, through the tunnel and into the bag. After capturing and species identification with nets or traps, the animals are being released.

Advantages. These are the most reliable methods for catching bats when there is no direct access to them and cannot observe their colonies in order to count their abundance and species composition.

Limitations. The setting and positioning of nets and bat traps at the right places requires previous experience to obtain the optimum results. Whenever a large colony is involved it is necessary to have assistants who can quickly release the caught individuals. During setting of nets in park valleys or under bridges there are caught principally species that have low flight and it is around vegetation.

Recommendations

Depending on the place and the number of field assistants one or several nets should be set before dusk. In forests more than one net must be set in order to increase the capture success.

During catching the experts must stay close to the net/trap and the captured bats must be promptly identified, examined and released. Bats can be kept in soft, cloth bags for a short period until they have been carefully examined.

- **Radiotelemetry**:

Bats can emit fast ultrasound calls and through processing the information at picked up again as signals (echo) they are capable to orientate in the environment and to catch its prey. The bats are forced to use ultrasound calls, because they have high-frequencies and short-wavelength sounds than most of the insects. Different ultrasounds call of bats are individually specific and also, they can identify the environment in which they are flying.

Through radiotracking method requires collecting detailed information on where the bats eat, flight paths for their hunting area, resting sites and living hollows. Radiotelemetry is an indirect method for research of animal's behavior including bats. There are three requirements for realization of this research:

– **Transmitter** – this emits constant signals within the 149.XXX or 151.XXX MHz. In ideal conditions, a bat can be detected from a distance of 5–7 km and from less than 2 km in hilly regions.

– **Receiver** – digital or analogue. The new models are highly sensitive lighter and easier to use

– **Directional antenna** – longer antennae ensure a better

signal. This method enables a researcher to know at any time where the bat is when it is with the transmitter. Its weight is up to mac 10% of bat's weight, usually some 0,50–0,70 g. Normally the bat is radio-tracked for 4–7 days and over this period it becomes clear where exactly its foraging ranges, resting sites and migration corridors, etc. The information accumulated during the radio tracking surveys is the best source of behavioral data, which can provide a basic foundation for the management and protection of bats in a given habitat. The method is widely used when the habitat is too complex to establish how bats use the different territories and can help clarify the most appropriate measures for their management. Telemetry is of undoubted value in helping to depict/analyze the exact home ranges of bats, which is particularly useful when new protected territories are declared.

Advantages. It is the only method for collecting rich information on the exact roosts of bats, their activities, foraging biology, hunting territories and individual behavior in a short period.

Limitations. The high value of micro transmitters and the need to be ordered a few months in advance. The tracking team needs at least two researchers. A GPS receiver can also be used to allow accurate mapping of the home range.

Recommendations

– Ideally the researcher will have a digital interactive map (e.g. Google Earth) on which the data from the GPS point tracking can be plotted.

– Telemetry is one of the few methods which can show exactly where a bat or a colony live in regions with no caves, what flight paths use for their local movements, the size and the type of foraging territories (e.g. becomes whether the bats hunt in an old forest, above shrubs, in wetlands or above farming areas), how much time they spend hunting and resting.

– Radiotelemetry should only be used for well-organized and authorized projects where essential data cannot be acquired with less intrusive methods.

• **Ultrasounds detection (detectors for bats)**: This is one of accessible and non-invasive method. It is based on the computer analysis of the bat species specific echolocation and social sounds. Based on ultrasound bats records they can successfully determine their flight, foraging and social activity.

Point (or transect) recording with a detector is a basic technique for monitoring bats in diverse habitats and urban sites. This is statistically the most supported method for monitoring of bats, which can be repeated in the same scheme, areas and duration. During the field study we use two main approaches:

Ultrasound detection for bats that is recording

© R. Mecheva

Stationary observations – the place of recording should be selected to allow for maximum information on the bat species composition. For point recordings, bats are usually used to "cluster" – under street lighting, near water body. In order for the results of a variety of habitats to be subjected to statistical analysis, it is desirable that the point records to be conducted with the same duration. For a given habitat (one habitat recorded point) it

is recorded audition with a duration of 30 to 120 minutes during the spring – summer season after dusk with weather – friendly climate conditions. For the autumn-winter period it is recommended that the recordings last from 10 to 70 minutes and it is particularly important to measure the temperature of the environment. The purpose of this measurement is that in most cases bats do not exhibit flying and nutritional activity below 5°C. Typically, recordings of 15-20 minutes in a particular point are considered representative. If the surveyed area is homogeneous but with a large area the point records should be carried out on evenly spaced points throughout the area.

Transect method– records are used to run on predetermined or designated routes. Applied in the study of linear objects or in habitats with a large area, but with approximately uniform characteristics of the environment. It is important to consider the coordinates and time at the beginning of the recording to allow georeferencing of registered sounds as different point on the route. The disadvantage of the method is that the recording quality can be decay, as a result of additional noise emitted by the movement (on foot or by car).

Combined method – the movement is done on a transect, as there are taken "sound samples" at certain distance or time intervals.

Record time

It is recommended that recordings start 20 minutes to half an hour before dusk. When conducting bioacoustics monitoring, it is important to record not only at dusk but also throughout the night, as different bat species are active in different parts of the night. For example, in most species of bats, there is a second peak in activity early in the morning before dawn.

Collecting other data

In addition to conduction the record, it is also important to collect data on the habitat and behavior of the bats. For example, if the recording is done near an open water mirror, surveillance with spotlight for bat behavior, coloring and flight can help us

with species determination, which will make the sound analysis even more precise. The exact geographic location of the recorded notes is relevant in the subsequent environmental analysis. For assessment of the impacts of environmental factors on flight activity, it is also important to collect data on air temperature, humidity, strength and direction of wind, cloudiness, etc. It is desirable that these data to be recorded some field notebook.

Acoustic monitoring as a method for research of bats – possibilities and limitations of the method.

As noted, acoustic identification is an important method for establishing bats when direct observation or capturing cannot be accomplished. On practice in many cases, it is the only method that can be used to determine the species composition of bats in a given habitat. It has other advantages such as:

– non-invasive study method;

– a comparatively affordable method;

– capabilities to automatically identify certain types;

– allows for the establishment of species composition and for observations on behavior – food, social, other;

– in some cases the differentiation of species is easier on their sounds than on morphological features (e.g. *Pipistrellus pipistrellus*/*Pipistrellus pygmaeus*).

However, the method has its limitations, arising from the following circumstances:

– identical or very similar echolocation sounds emitted by bats;

– great variability of the sounds generated by the different conditions (habitats, including bat flying, the distance from surrounding objects, age, hunting strategy, social between other bats etc.);

– less sensitivity of the method to some groups – *Rhinolophus* („narrow" targeted sounds that can only be captured if they are projected against the microphone), *Plecotus* (quiet sounds);

– technical limitations associated with the range of microphones;

– greater labor intensity associated with the individual analysis of individual sounds of a large amount of data;

– need for knowledge and expertise on sound physics, echolocation in bats and their behavioral ecology;

– significant subjectivism in the definition of sounds, based on the different personal experiences and qualities of the experts.

The fact that technical constraints are overwhelming and the volume of invested work can be refined; the main limitation remains the fact that not all bats have type specifics or other characteristics of the sound.

The table below presents a list of bat species or groups of them in Bulgaria, which can be distinguished by their sounds. The presented confidence in the analysis is result of many years of practical experience of the researchers. Combined with direct observations of flying bats, detailed knowledge of existing roosts and environmental characteristics, in some cases this reliability can be almost 100 percent. The presence of social sounds can also increase the accuracy of determining the bat species in the studied habitat.

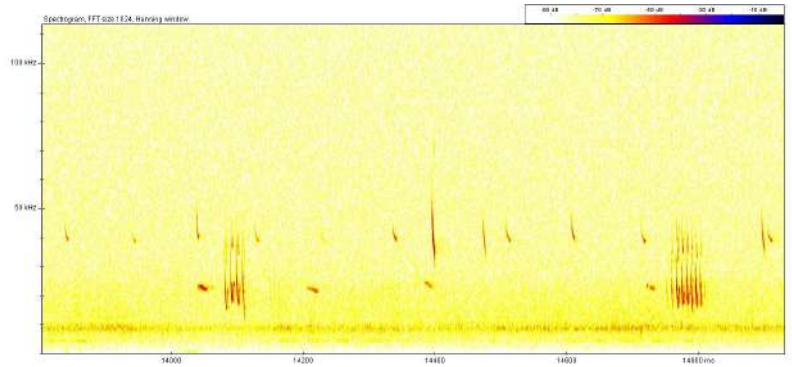
Table 3

Groups and bat species in Bulgaria, which can be distinguished by the sounds they make

Groups and bat species	**Degree of reliability of determination of groups and bat species only by echolocation sounds**
Family *Rhinolophidae* – Horseshoe bats	100 %
Family *Vespertilionidae* – Vesper bats	95 %
Family *Molossidae – Free-tailed bats*	95 %
Genus *Plecotus*	90 %
Genus *Myotis*	90 %
Rhinolophus hipposideros – Lesser horseshoe bat	70 %

Groups and bat species	Degree of reliability of determination of groups and bat species only by echolocation sounds
Rhinolophus ferrumequinum – Greater horse-shoe bat	95 %
Rhinolophus euryale – Mediterranean horse-shoe bat	70 %
Nyctalus noctula – Noctule	80 %
Nyctalus lasiopterus – Giant noctule	90 %
Nyctalus leisleri – Lesser noctule	60 %
Pipistrellus pipistrellus – Common pipistrelle	95 %
Pipistrellus pygmaeus – Soprano pipistrelle	95 %
Pipistrellus nathusii – Nathusius's pipistrelle	90 %
Pipistrellus kuhlii – Kuhl's pipistrelle	70 %
Hypsugo savii – Savi's pipistrelle	80 %
Eptesicus serotinus – Serotine bat	90 %
Eptesicus nilssonii – Northern bat	90 %
Vespertilio murinus – Particoloured bat	50 %
Tadarida teniotis – European free-tailed bat	95 %

The definition of some species among which the following are facilitated by the presence of social sounds*: Pipistrellus pipistrellus* – Common pipistrelle, *Pipistrellus pygmaeus* – Soprano pipistrelle, *Pipistrellus nathusii* – Nathusius's pipistrelle, *Pipistrellus kuhlii* – Kuhl's pipistrelle, *Vespertilio murinus* – Particoloured bat, *Nyctalus noctula – Common noctule*. Some of the species occurring in Bulgaria can be distinguished relatively easily because the echosounds they emit are with specific frequencies. For example, the European free-tailed bat (*Tadarida teniotis*) most often emit sounds in a range of 11 – 14 kHz, which are usually clearly distinguishable from those of other species. It is possible to be wrong with Giant noctule (*Nyctalus lasiopterus*), which is very rare in Bulgaria and can emit low frequency souns 16 kHz.



Sonogram of echolocations and social sounds of bats

© I. Pandourski

In cases where species cannot be expressly defined by their sound, they can also be reduced to "acoustic groups". This information is also valuable and after subsequent field studies it is possible to specify exactly which species has been encountered in the given habitat. For example some sounds can be defined as sounds types as: *M. schreibersii/P. pipistrellus, Myotis myotis/blythii, Rh. mehelyi/euryale, Rh. mehelyi/euryale/ hipposideros, P. kuhlii/P. nathusii, P. kuhlii/P. nathusii/H. savii, N. leisleri/N. noctula/V. murinus, N. leisleri/N. noctula/V. murinus/E. serotinus, N. leisleri/N. noctula, M. schreibersii/P. pygmaeus.*

Bats however do not emit sounds with the same constant frequency. They vary considerably depending on various factors such as – the surrounding environment, the distance of the subjects, hunting strategy and many others. This makes the sounds too "variable" in which sounds of two different types may look alike or similar, making it impossible to determine sounds.

Basic guidelines for the analysis of bats' sounds

– the sonogram analysis can be done with different software, according to the needs and capabilities of the analysis and the analyzer;

– conduction sonogram analyzes requires an extraordinary investment of time and knowledge to inspect the specifics of sounds of each type;

– the sounds of the bats are greatly influenced by the environment – its character and its distance from the objects, which further complicates the analysis and is the cause of significant variability even in the sounds of the same species;

– there is a significant degree of subjectivity in the sonogram analysis. For this reason, the results of each analyzer should be verified by specialists, until enough experience that can guarantee the reliability of the data.

All techniques for the exploration and observation of bats are somewhat selective and no technique gives a complete picture of the bat community at a given habitat. In surveys in buildings in urban environments, there are often higher results for the abundance of species that typically stay in the buildings. When using ultrasonic detectors, random species with low echocardiographic sounds, which are research not specifics and are just accidentally pass through, are also registered.

These entire factors must be compatible when organizing bat observations.

Management

Modern and efficient solutions for urban development include planning of public spaces, green areas, urban areas and connectivity, buildings, engineering infrastructure, regional connectivity, accessibility and equal treatment of natural resources in the city. In different, spatial plans of the urbanized territories, it is necessary to consider and evaluate the possibilities for realization of the green wedges that connect the different green areas in the city and eventually with the existing mountainous surroundings. It is an approach to exploring and understanding the city as a series of interactions, which are creating a complete urban ecosystem.

Buffer strips, riversides forests, park areas, tree valleys among meadows and arable lands are often close to ponds and

trees with undergrowth can provide favorable habitats for synanthropic and other species that temporarily inhabit urbanized areas, so it is particularly important to maintain of a continuous connection between bat roosts and feeding areas.

Buffer tree strips are particularly beneficial for bats, especially those with high old growth trees, varied bushes floor and open spaces or habitats such as forest riversides, rivers and lakes, providing habitat continuity. The tall old growth trees can be used as a resting place (any time of the year), as a route and landmark for bats. They also attract a large number of insects that bats use as a prey. Urban park territories and tree valleys imitate forests, especially outskirts of forests, which are preferred habitats for most species. The same way good structural diversity with different bush vegetation also attracts many different insects. If the bushes layers are tall enough it will be windproof and it will attract more insects and provide more feeding for the bats.

Old growth trees with hollows in park environment

© R. Mecheva

Maintenance of landscape diversity in urban area for wealthy bat species composition

© R. Mecheva

Each type of bat has specific habitats requirements, but the key factors affecting its distribution are the presence of hunting areas.

An example of how tree valleys are used is the Brown long-eared bat (*Plecotus auritus*). He feeds on trees and bushes and uses them as landmarks. They rarely cross open spaces when they are moving between the places for rest and food areas. Sometimes they spend their nights on trees, but mostly use buildings.

The Common noctule bats (*Nyctalus noctula*) overnight and their mating roosts are in hollows (old holes of woodpeckers). They also use tree valleys and bushes for feeding areas as well as Natterer's (*Myotis nattereri*). They feed around trees, forest surroundings and other vegetation, often gathering in-

sects from the leaf surface. The loss of convenient places for overnight can be the key to the survival of the species.

Often seen are Common pipistrelle and Soprano pipistrelle (*Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*), who feed with a wide range of habitats, including forests, pastures, agricultural, suburban and urban areas. They can sleep in tree hollows, under loose bark and to hibernate in cracks in trees. These two types also prefer linear vegetation for feeding such as hedges that can help navigate, feed or provide protection from predators. Feeding places of the Common pipistrelle are often located near water and outskirts as these habitats provide preys, mainly insects.

Hunting territories of almost all species from genus Pipistrellus are connected with water bodies

© I. Pandourski

Various engineering facilities can also be designed to create appropriate bat roosts. Such an example is the Dutch town of

Wertingen, where a new and unique bridge is built. Unique because it will not just connect the two banks of the river but because it is designed to become a convenient roost for whole colonies of bats. The Vlotwatering Bridge is at the discretion of local authorities. It passes through a wetland, designed for recreation and here tourists can rest and catch fish. The Poelzone area, designed to preserve existing ecosystems where people can safely have fun till watching the nature. The bridge of the bats has a length of 25 meters and it has three components that provide excellent conditions for settling them.

Exploration of bats in urban environments is extremely relevant. However, now on the Balkan Peninsula there are not been conducted any researches for this problem. Only such research, screening, by its nature is that of Stoicheva (2008), which presents the results of a study of the chiropterofauna in the two largest cities in Bulgaria – Plovdiv and Stara Zagora.

The research was conducted over the 2005-2008 years, covering all annual seasons and is based on a comparison of the species diversity of the chiropterofauna in the mentioned cities and their surrounding geographic areas. Data on the species of bats and the importance of their roosts and habitats in the area under the research have been received. The study also provides valuable information on the flying, nutritional and social communication behavior of certain species of bats in urban areas and their dependence on some environmental factors.

There are two main reasons for choosing the place of study – the lack of detailed bats studies in the urban environment in Bulgaria and the poor study of the region of „Gornotrakiiskata nizina“ as a whole for this group of mammals.

The species composition of chiropterofauna has been studied using a variety of methods such as:

– Searching for and gathering dead species around and in different buildings and caves;

– Collection and analyzing the composition of pellets from night birds;

– Surveillance and sound recording of flying individuals and colonies. This method is used for determination of species with daily active as: *Nyctalus noctula, Nyctalus lasiopterus* as well for registration of colonies of *N. noctula*. With this method are registered also *Rhinolophus hipposideros* and *Rh. ferrumequinum;*

– Capture with vertical ornithological nets;

– Capturing individuals in daytime roosts in buildings after lighting with a flashlight;

– Bat roosts were detected by observing entangle places during dusk or dawn with subsequent recording of the emitting ultrasounds for species identification.

A total of 26 bat species (78,8% of all species in Bulgaria and 74,3 of all species in Europe) were found in the area of research. In Plovdiv were found 17 species (51,5% from all species in Bulgaria) and in surroundings – 25 (75,8% from all species in Bulgaria). The species in the flat areas and surrounding area of the city are at least 11, and in the surrounding mountainous areas the number is bigger than in the city – 20.

In Stara Zagora the registered species are 11 (33,3% of all species in Bulgaria), in surroundings 16 (48,5% of all species in Bulgaria). Species in the flat areas and surroundings of the cities are 6, while in the surrounding mountain areas their number is 13.

A high-quality similarity (over 50%) of the chiropterafauna in the two studied cities was established, compared to both the flat areas and the mountainous surrounding geographical areas.

The similarity between the qualitative compositions of the chiropterafauna of the two cities, as well as between the two mountainous environments is great, whereas between the two flat areas is low. The highest is the similarity in the qualitative composition of the chiropterofauna between two cities and between Plovdiv and its surrounding flat areas.

Data about the species composition and fauna similarity in the area of research suggest that the exploration of the flat area cities are with specific forms, rich in species, whose chiropterofauna

is close to that of their surrounding flat and mountainous areas.

For city of Plovdiv the most common (from data, from received ultrasound recordings, finding colonies and roosts, capturing in ornithological nets, finding dead species etc.) are Common noctule, Kuhl's pipistrelle, Common pipistrelle, Soprano pipistrelle and Serotine bat. Relative less data is for the Geoffroy's bat, Daubenton's bat, long-eared bats (*Plecotus* sp.), Lesser noctule, Nathusius's pipistrelle and particoloured bat.

All 11 species, which are established in city of Stara Zagora, are for the first time reported in the city. The most common ones are: Common noctule and common pipistrelle. There are relatively few registrations for Whiskered bat, Daubenton's bat, Grey long-eared bat, Lesser noctule.

In urban region, most of the species found are in roosts inside of inhabited buildings (*Pl. austriacus, N. noctula, P.kuhlii, H. savii*), less in fugues or other crevices in the façade of the inhabited building (*N. noctula, P. pipistrellus, H.o savii*) and only one species in hollow of old growth trees (*N. noctula*) and in fugues of bridges. In the first group roosts are found most species, but most individuals are found in the second and the last type of roosts. Many colonies from Common noctule (more than 100) are found in fugues of panel buildings in Stara Zagora during all seasons. In city of Plovdiv, they are a bit less and most often inhabit fugues and other crevices (total 10) in facades of high panel buildings (14-16 floors). The colonies can number from 10 till 50 individuals. In Plovdiv are registered colonies in bridge above Maritsa river and bridge above railroad with numbers from 30 till 125 individuals in one fugue. In total for the bridge above the Maritsa river are counted around 1000 individuals from the hibernation colony of Common noctule.

Most species in urban environments are located in habitats – between block spaces with dominant woodland vegetation and forest type parks, followed by habitats in the vicinity of two cities, most species used roosts in uninhabited, partly destroyed buildings (*Rh. ferrumequinum, Rh. hipposideros, Pl. austriacus,*

P.pipistrellus, P. nathusii, H. savii).

Most species are found over houses with courtyards in the vicinity of the two cities (generally for mountain and flat areas). Many species are also observed over rives with woodland riverside in mountainous and flat areas, grassy rivers in mountainous areas and canals in flat areas.

Sources of information used

BARTONIČKA & ZUKAL 2003. Flight activity and habitat use of four bat species in a small town revealed by bat detectors. Folia Zool., 52 (2), 155–166.

BENDA, P., T. IVANOVA, I., 2003. Long-eared bats, genus Plecotus (Mammalia: Chiroptera), in Bulgaria: a revision of systematic and distributional status. *Čas. Nár. Muz., Ř. Přírodověd.* 172: 157–172.

BENDA, P., T. IVANOVA, I. HORACEK, J. CERVENY, J. GAISLER, A. GUEORGUIEVA, B. PETROV AND V. VOHRALIK. 2003. Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 3. Review of bat distribution in Bulgaria. – Acta Soc. Zool. Bohem., 67: 245-337.

DIETZ & Von HELVERSEN 2004. Illustrated identification key to the bats of Europe. Electronic Publication, Version 1.0. released on 15.12.2004, 73 pp.

GAISLER J., J. ZUCAl, Z. ŘEHÁK, M. HOMOLKA, 1998. Habitat preference and fight activity of bats in a city. Journal of Zoology, London, Cambridge University Press, 244: 439–445.

GRIMMBERGER E., 1993. Beitrag zur Fledermausfauna (*Chiroptera*) Bulgariens und Rumäniens mit besonderer Berücksichtigung der Variabilität der Langflügelfledermaus (*Miniopterus schreibersi* Kuhl, 1819). Nyctalus (N.F.), 4(6): 623–634.

IVANOVA T. 2005. Important bat underground habitats (IBUH) in Bulgaria. - Acta Zoologica Bulgarica, 57 (2): 197–206.

IVANOVA, T. 1998. First data on bats (Mammalia: Chiroptera) of Central Balkan Mts., Bulgaria. – Vespertilio, 3: 29 – 36.

IVANOVA, T., A. GUEORGUIEVA. 2001. Bats (Mammalia: Chiroptera) of Eastern Rhodopes (Bulgaria and Greece) – species diversity, zoogeography and faunal patterns. – In: Beron P.,

Popov A. (eds.), Biodiversity of Bulgaria. 2. Biodiversity of Eastern Rhodopes (Bulgaria and Greece). – Pensoft & Nat. Mus. Natur. Hist., Sofia: 907-927.

PAPADATOU, E., R. BUTLIN, J. ALTRINGHAM. 2008. Identification of bat species in Greece from their echolocation calls. – Acta Chiropterologica, 10 (1): 127 – 143.

PANDURSKA, R. 1997. Preferred roosts and dispersal of Rhinolophus hipposideros (BecHstein, 1800) and Rhinolophus ferrumequinum (Shreber, 1774) in Bulgaria. – Tagungsband: "Zur situation der Hufeisennasen in Europa", Nebra, 26 – 28 Mai 1995Arbeitskreis Fledermause Sachsen-Anhalt e VIFA Verlag, Berlin: 119 – 124.

PANDOURSKI I., 2004. Bats (*Mammalia*: *Chiroptera*) of the Burgas Wetlands, Bulgarian Black Sea Coast. Acta Zoologica bulgarica, 56(3): 283-298.

SCHMIDT C., 2002. The occurrence of bats in the town of Hoyerswerda. Przyroda Sudetów Zachodnich, 2: 71–78.

STEBBINGS, R. & WALSH, S. 1991. Bat Boxes. The Bat Conservation Trust, London. 24 pp. ISBN 1 872745 02 4.

WALSH, A., CATTO, C., HUTSON, A., RACEY, P., RICHARDSON, P. & LANGTON, S. 2001. The UK's National Bat Monitoring Programme, Final Report 2001. Department of Environment, Food and Rural Affairs, London. 155 pp.

Kalchev B., V. Beshkov, 1963. Tadarida teniotis Rafinesque - representative of a new family of bats in Bulgaria. Inst. with the Museum, Sofia, 14: 251–253.

PETROV, B. 2008. Bats - Methodology for Environmental Impact Assessment and Compatibility Assessment. Handbook for contracting authorities and environmental experts. National Museum of Natural History - BAS, 88 p.

PESHEV, TS., D. PESHEV, V. POPOV. 2004. FAUNA OF BULGARIA. MAMMALIA. VOLUME 27, INSTITUTE OF ZOOLOGY, BAS, ACAD. MARIN DRINOV, SOFIA: 632 p.

Popov, B, A. Sedefchev. 2003. Mammals in Bulgaria. Determinant. „Vitosha" Publishing House, 291 p.

POPOV, V., N. SPASOV, T. IVANOVA, B. MIKHOVA, K. GEORGIEV. 2007. MAMMALS IMPORTANT FOR CONSERVATION IN BULGARIA. – Dutch Mammal Society VZZ, ISBN 978-90-73162-93-8: 328 p.

STOYCHEVA S. 2008. ECOLOGICAL-FAUNISTIC STUDY OF BATS (*CHIROPTERA*) IN PLOVDIV AND STARA ZAGORA AREAS. Thesis, „Paisii Hilendarski" University of Plovdiv, 90 p.

STOYCHEVA, S., I. PANDOURSKI, E. STOYEVA, A. PAVLOVA. 2015. A guideline to determining the sounds of bats. Green Balkans - Stara Zagora, 91 p.