

**Bat diversity in two large towns of the Upper Thrace, Bulgaria (Chiroptera)**

Diversita netopýřů ve dvou velkých městech Horní Thrákie, Bulharsko (Chiroptera)

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**Abstract.** Bats of the Upper Thracian valley in southern Bulgaria were poorly studied, and the information on urban fauna in the Balkan Peninsula was scarce. Therefore, our study was aimed at the two largest towns of this region – Plovdiv and Stara Zagora. Nine bat species were newly recorded in Plovdiv (*Myotis emarginatus*, *M. daubentonii*, *Plecotus* spp., *Nyctalus leisleri*, *Pipistrellus pygmaeus*, *P. nathusii*, *Hypsugo savii*, *Vespertilio murinus*, *Tadarida teniotis*) and four in Stara Zagora (*Myotis myotis/Myotis blythii*, *Myotis daubentonii*, *Nyctalus leisleri*, *Tadarida teniotis*), respectively. Species diversity and habitat use were studied using a variety of methods (ultrasound detectors, mist netting and searching for roosts and dead individuals). Most of the species were found in areas between blocks of flats covered by tree vegetation and in dense park woods with low anthropogenic pressure. Most of the species roosted inside inhabitable buildings, a group of species was also found in crevices in the facade of these buildings and only one species (*Nyctalus noctula*) was found in tree hollows and in crevices in bridges. Habitat use was studied using a bat detector during the warm period of 2007. The most important habitats with the highest flight activity of bats were reservoirs with banks covered by dense park woods, a small river in a wooded area and a canal situated near a block of flats.

**Key words.** Bats, towns, habitats, Bulgaria, Balkan Peninsula.

## INTRODUCTION

Towns are preferred by many bat species, as they can find new roosts, feeding and breeding sites there (GAISLER et al. 1998, SCHMIDT 2002, BARTONIČKA & ZUKAL 2003, BIHARI 2004, SIMON et al. 2004). Although many surveys of bats were carried out in urban habitats, there was no study aimed specifically at the Balkan Peninsula. Only single records of bats from different towns in Bulgaria were available (BENDA et al. 2003, PANDOURSKI 2004, TILOVA et al. 2005, 2008, PANDOURSKI & KARAIVANOV 2007).

Considering bat fauna of Bulgaria, that of the Upper Thracian valley (southern Bulgaria) is one of the least studied (BENDA et al. 2003). The largest towns in this region are Plovdiv and Stara Zagora with human populations of 376,914 and 152,829 inhabitants, respectively. The northern part of Stara Zagora is situated on the slopes of the Sarnena Sredna Gora Mts. and in Plovdiv there are specific hills of volcanic rocks. Eight bat species have been known from

Plovdiv: *Myotis blythii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*, *P. kuhlii*, *Myotis mystacinus* species complex, *Nyctalus noctula*, *Nyctalus lasiopterus* and *Barbastella barbastellus* (BÄČVAROV 1963, SKURATOWICZ et al. 1982, BENDA et al. 2003, TILOVA et al. 2005, 2008). Seven species – *Myotis mystacinus* species complex, *Plecotus austriacus*, *Nyctalus noctula*, *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Hypsugo savii* and *Eptesicus serotinus* were reported by TILOVA et al. (2005) from Stara Zagora. Therefore, our study was aimed at bat fauna of these two towns, focusing on species diversity and habitat use.

## MATERIAL AND METHODS

The study was carried out during 2005–2008 and included all four seasons of the year. The species diversity was investigated by (1) searching and collecting of dead individuals of bats (20 individuals collected), (2) collecting and analysis of the content of owl pellets (over 100 pellets of *Asio otus*), (3) visual observations of flying bats (used as a supporting method to ultrasound detection and searching for the roosts), (4) mist netting (all captured bats were released back to the wild after identification) (20 individuals caught; the mist nets were exposed from sunset for about three hours, during five evenings), (5) active searching for individuals in potential roosts, such as various crevices, using a torch, (6) use of ultrasound detectors set on the time expansion mode (detectors Petterson Ultrasound Detector D240x and Tranquility Transect) (altogether 3955 bat calls were recorded – 2880 in Plovdiv and 1075 in Stara Zagora) – the sounds were recorded using digital recorders and later converted to the wav format and analysed by the Bat Sound software. The calls were recorded for 30 to 120 minutes in each habitat.

The bats were determined using the keys by DIETZ & VON HELVERSEN (2004), POPOV & SEDEFČEV (2003) and PEŠEV et al. (2004). Ultrasound recordings were identified according to the papers by PARSONS & JONES (2000), BARATAUD (2002), RUSSO & JONES (2002), PFALZER & KUSCH (2003), and OBRIST & BOESCH (2004).

Based on the investigations by GAISLER et al. (1998), SCHMIDT (2002), BARTONIČKA & ZUKAL (2003) and our own observations on the specific urban environment in Bulgaria, we identified the following main habitat types used in the survey (abbreviations in parentheses): (1) open grass areas between blocks of flats (Plovdiv and Stara Zagora) (BG); (2) areas between blocks of flats covered by tree vegetation (Plovdiv and Stara Zagora) (BT); (3) reservoirs with banks covered by dense park woods (small reservoir of Zagorka in Stara Zagora, Grebna Baza reservoir in Plovdiv) (DF); (4) canals with banks covered by tree or bush vegetation (in the north-west of Plovdiv and in the south of Stara Zagora) (C); (5) small river stretches with tree bank vegetation (Bedečka River, industrial zone, Stara Zagora) (SRI); (6) small river stretches with tree bank vegetation (Bedečka River, park wood area, Stara Zagora) (SRP); (7) large river (Maritza River in Plovdiv which has sand banks with small patches of tree vegetation) (LR); (8) river floods (Maritza River in Plovdiv) (RF); (9) urbanized park woods with numerous street lamps (parks near the railway station and the Natural History Museum in Plovdiv and near the Alana area in Stara Zagora) (UPF); (10) dense park woods with low anthropogenic pressure (on the western margin of Plovdiv and at Ayazmoto in Stara Zagora) (DPF); (11) hills in Plovdiv – rocky areas covered by bush and tree vegetation (Djendem tepe hill, Trihulmie hill, Bunardjik hill, Sahat tepe hill) (H); (12) house yards with street lamps (Plovdiv and Stara Zagora) (HY); (13) industrial zone (in Plovdiv and Stara Zagora) (IZ).

Bat fauna of the two south Bulgarian towns surveyed was compared with that of four European towns: Brno (Czech Republic) (GAISLER et al. 1998), Hoyerswerda (Germany) (SCHMIDT 2002), Moscow (Russia) (KARASEVA et al. 1999), and Vilnius (Lithuania) (BARANAUSKAS et al. 2005) by a qualitative similarity measure and cluster analysis using the software BioDiversity Professional, Version 2 (1997).

## RESULTS AND DISCUSSION

We recorded 14 species in the town of Plovdiv (42.4% of the known species of Bulgaria) and 9 species in Stara Zagora (27.3% of Bulgarian species), respectively.

Of the 14 species in Plovdiv, seven were new for the town (*Myotis daubentonii*, *Nyctalus leisleri*, *Pipistrellus pygmaeus*, *Pipistrellus nathusii*, *Hypsugo savii*, *Vespertilio murinus*, *Tadarida teniotis*), while eight were reported in previous publications (*Myotis blythii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii*, *Nyctalus noctula*, *Nyctalus lasiopterus*, *Barbastella barbastellus*). In addition, some unidentified taxa groups were detected in this town by ultrasound detectors (*Myotis myotis/blythii*, *Myotis emarginatus/alcaethoe* and *Plecotus* sp.) and as skull fragments in owl pellets (*Myotis mystacinus* species complex). Although BÄČVAROV (1963) reported one individual of *Barbastella barbastellus*, collected in Plovdiv, we did not register this species in this area. Neither we found *Nyctalus lasiopterus* reported for this area by BENDA et al. (2003). The most common species in Plovdiv (according to the data from ultrasound records, findings of colonies and roosts, mist netting, findings of dead individuals etc., Table 1) were the noctule bat (*Nyctalus noctula*), Kuhl's pipistrelle (*Pipistrelle kuhlii*), common pipistrelle (*P. pipistrellus*), soprano pipistrelle (*P. pygmaeus*) and serotine bat (*Eptesicus serotinus*). Limited data were obtained about the Daubenton's bat (*Myotis daubentonii*), long-eared bats (*Plecotus* spp.), Leisler's bat (*Nyctalus leisleri*), Nathusius' pipistrelle (*Pipistrellus nathusii*) and parti-coloured bat (*Vespertilio murinus*).

We registered three new species for Stara Zagora (*Myotis daubentonii*, *Nyctalus leisleri*, *Tadarida teniotis*), while the other six species we found (*Plecotus austriacus*, *Nyctalus noctula*, *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Hypsugo savii*, *Eptesicus serotinus*) were also reported by TILOVA et al. (2005). We also recorded one unidentified taxa group *Myotis myotis/Myotis blythii*. The most common species in Stara Zagora were *N. noctula* and *P. pipistrellus*. We registered very few individuals of whiskered bats (*Myotis mystacinus* complex), *M. daubentonii*, *P. austriacus*, and *N. leisleri*.

Most of the species were found in areas between blocks of flats covered by tree vegetation and in dense park woods with low anthropogenic pressure, using all methods mentioned.

### **Large *Myotis*: *Myotis myotis* (Borkhausen, 1797) and/or *M. blythii* (Tomes, 1857)**

Calls of the large *Myotis* species were recorded in both towns surveyed. According to the criteria of BARATAUD (2002) and the literature data on their distribution we identified the species registered as “cf *Myotis myotis/Myotis blythii*”. Calls of this type were recorded above a large river, in a park with low anthropogenic pressure, in river floods in Plovdiv and above a small reservoir in an urbanized park in Stara Zagora.

### ***Myotis emarginatus* (Geoffroy, 1806) and/or *M. alcaethoe* von Helversen et Heller, 2001**

Being the only *Myotis* species group identifiable by its ultrasounds, it was registered using bat detectors in the area of Trihalmie Hill in Plovdiv (hill of volcanic rocks covered partly by park woods and house yards). It was the first record of such bat ultrasounds in the Upper Thracian Valley.

### ***Myotis* cf. *daubentonii* (Kuhl, 1817)**

We registered this species by a combination of observations (foraging individuals above water surface) and ultrasound records made in the regions of Zagorka reservoir in Stara Zagora and Grebna Baza reservoir in Plovdiv. Although a similar hunting behaviour is known in *M. capaccini*, its occurrence in urban areas is unlikely (it is a cave-dwelling species according to POPOV & SEDEFČEV (2003), therefore we identified our records as of *Myotis* cf. *daubentonii*. The Daubenton's bat is widespread in southeastern Bulgaria, showing high feeding activity above water surfaces in natural habitats.

Table 1. Bat species diversity in the two towns, estimated by all methods used: BD – bat-detecting; MN – mist-netting; PA – pellet analysis; VO – visual observation; RS – finding in a roost site; FI – finding of dead or injured individual; PD – published data. \* – complexes unidentified to the species level

Tab. 1. Diversita netopýrů ve dvou bulharských městech zjištěná různými metodami: TE – detekce ultrazvuku; MN – odchty do sítí; PA – rozbor sovích vývržků; VO – vizuální pozorování; RS – nálezy v úkrytech; FI – nálezy mrtvých či poraněných kusů; PD – publikované údaje; \* – neurčené druhové komplexy

species \ method	BD	MN	PA	VO	RS	FI	PD
Plovdiv							
1 <i>Myotis blythii</i>							+
2 <i>Myotis daubentonii</i>	+			+			
3 <i>Barbastella barbastellus</i>							+
4 <i>Nyctalus lasiopterus</i>							+
5 <i>Nyctalus noctula</i>	+	+		+	+	+	+
6 <i>Nyctalus leisleri</i>	+						
7 <i>Pipistrellus pipistrellus</i>	+				+		+
8 <i>Pipistrellus pygmaeus</i>	+						
9 <i>Pipistrellus nathusii</i>	+						
10 <i>Pipistrellus kuhlii</i>	+	+		+		+	
11 <i>Hypsugo savii</i>	+				+	+	
12 <i>Eptesicus serotinus</i>	+			+			+
13 <i>Vespertilio murinus</i>	+						
14 <i>Tadarida teniotis</i>	+						
* <i>Myotis myotis</i> / <i>M. blythii</i>	+						
* <i>Myotis emarginatus</i> / <i>M. alcathoe</i>	+						
* <i>Myotis mystacinus</i> complex			+				
* <i>Plecotus</i> spp.	+						
Stara Zagora							
1 <i>Myotis daubentonii</i>	+			+			
2 <i>Plecotus austriacus</i>					+		+
3 <i>Nyctalus noctula</i>	+	+	+	+	+	+	+
4 <i>Nyctalus leisleri</i>	+						
5 <i>Pipistrellus pipistrellus</i>	+	+				+	+
6 <i>Pipistrellus pygmaeus</i>	+	+					+
7 <i>Hypsugo savii</i>	+	+					+
8 <i>Eptesicus serotinus</i>	+	+					+
9 <i>Tadarida teniotis</i>	+					+	
* <i>Myotis myotis</i> / <i>M. blythii</i>	+						
* <i>Myotis mystacinus</i> complex							+
* <i>Plecotus</i> spp.	+						

### Unidentified smaller species of *Myotis* (*Myotis* spp.)

Although some data about echolocation calls of *Myotis* species were published in the last years (PARSONS & JONES 2000, OBRIST & BOESCH 2004, TOFFOLI 2006), most of them cannot be determined unambiguously. Only the differentiation between “large” (*M. myotis* / *M. blythii*), “small” *Myotis* species (all the rest with smaller size) and *Myotis emarginatus* / *M. alcathoe* is possible.

We found the “small” *Myotis* species in Plovdiv only rarely. They were registered by bat detector mostly near a canal with tree bank vegetation, in a park with low anthropogenic pressure, near a large river (Maritza river) and near a reservoir with banks covered by dense park woods in the western margin of Plovdiv. Calls of “small” *Myotis* were also registered in the river floods and in an urbanized park, while no calls were recorded in the other investigated habitats (Table 1). In the pellets of *Asio otus* collected in Plovdiv, we found 5 skulls of bats referred to *Myotis mystacinus/Myotis aurascens* (TILOVA et al. 2005).

In Stara Zagora we recorded the small *Myotis* species mostly in park woods with a river (Krairečen Park). In the same park we registered the *Myotis mystacinus/Myotis aurascens* by mist netting (TILOVA et al. 2005).

### ***Plecotus austriacus* (Fischer, 1829)**

We registered one wintering female in the entrance-hall of a block of flats in Stara Zagora.

We recorded some calls of *Plecotus* sp. in both towns (in open grass areas between blocks of flats, dense park woods with low anthropogenic pressure and small river stretches in an industrial zone). The calls recorded in Plovdiv probably belong to this species and not to *P. auritus* because the latter one is considered to occur only in the high mountain areas of Bulgaria (BENDA et al. 2003). We are convinced that the very low number of records in Plovdiv was not due to low abundance of long-eared bats, but due to noiseless sounds they produce (BARATAUD 2000).

### ***Nyctalus noctula* (Schreber, 1774)**

This species was repeatedly found in all investigated areas with all methods used and it is obviously abundant in both towns. It was registered in all seasons during our study. We collected 11 dead individuals in Stara Zagora and 3 in Plovdiv. In Stara Zagora, 53 individuals were netted above a small river in the Krairechen park during the spring-summer period.

Roosts of this species were registered in both towns and during all seasons of the year. They included crevices in panel blocks of flats, various fissures in brick houses and mixed type of buildings, crevices in a bridge over the Matizta river in Plovdiv, crevices in a bridge over railroad in Plovdiv, tree hollows in *Populus* sp., *Platanus orientalis*, *Fraxinus* sp., *Robinia pseudoacacia* which (according to our observations) were occupied mainly during the migration period. Many colonies (more than 100) in crevices on the facade of blocks of flats (6–8 floors) were recorded in Stara Zagora. In Plovdiv they were often found in crevices on the facade of 14–16 floor blocks of flats (10 colonies found). The colonies included from 10 to 50 individuals. In Plovdiv we registered noctule colonies in fissures in bridges over the Maritza river and over a railroad, with 30–125 individuals in one fissure. We also found one skull of this species in a pellet of the long-eared owl (*Asio otus*) collected in Stara Zagora.

### ***Nyctalus leisleri* (Kuhl, 1817)**

This species was registered using a time expansion detector together with supporting observations. We found that some records from the Grebna Baza reservoir and areas between blocks of flats covered by tree vegetation in Plovdiv belonged to this species.

### ***Pipistrellus pipistrellus* (Schreber, 1774)**

The species was registered in all habitats surveyed in the two towns. In Plovdiv, an especially high flight activity was recorded in the area of the Grebna Baza reservoir, but the species was also obviously abundant in the urbanized park, river floods and areas between blocks of flats covered by tree vegetation.

Table 2. Number of recorded bat calls in different habitats in Plovdiv (see Material and Methods for abbreviations)

Tab. 2. Počet zaznamenaných hlasů netopýrů v různých biotopech města Plovdiv (zkratky viz Material and Methods)

species	BT	BD	GV	GR	RA	KA	KD	PGR	PGO	IZ	T
small <i>Myotis</i> sp.	0	0	2	5	2	11	0	2	9	0	0
<i>Plecotus</i> sp.	1	0	0	0	0	0	0	0	0	0	0
<i>N. noctula</i>	218	44	133	58	64	16	14	18	103	6	356
<i>N. leisleri</i>	0	1	0	0	0	0	0	0	1	0	0
<i>V. murinus</i>	0	0	0	0	0	0	0	0	2	0	0
<i>E. serotinus</i>	0	5	0	2	0	1	1	188	5	1	276
<i>M. myotis</i> / <i>M. blythii</i>	0	0	0	1	0	0	0	0	2	0	0
<i>M. emarginatus</i> / <i>M. alcaethoe</i>	0	0	0	0	0	0	0	0	0	0	1
<i>P. pipistrellus</i>	0	59	123	16	58	20	18	38	7	2	23
<i>P. pygmaeus</i>	0	0	89	6	51	4	0	3	2	0	92
<i>P. kuhlii</i>	0	1	1	0	0	0	0	0	0	0	0
<i>P. nathusii</i>	0	1	0	0	0	0	0	0	0	0	0
<i>P. kuhlii</i> / <i>P. nathusii</i>	8	125	252	8	91	14	9	60	12	35	126
<i>Pipistrellus</i> sp.	1	9	42	1	17	0	0	1	1	0	0
<i>H. savii</i>	3	0	10	12	3	0	1	12	1	15	40
<i>T. teniotis</i>	0	0	7	0	2	0	0	47	5	0	11
unidentified (13–16,5 kHz)	1	0	5	0	1	0	0	3	0	0	1
unidentified (22–32 kHz)	26	12	66	81	7	29	17	25	14	3	83
unidentified (35–38 kHz)	0	3	68	1	3	0	0	4	0	0	14
unidentified	0	17	24	10	2	9	0	2	3	0	15
total	258	277	822	201	301	104	60	403	167	62	1038
recording duration, min	110	140	50	90	90	100	90	90	90	100	370

In Stara Zagora, the species showed the highest flight activity above a small river in park woods and in the urbanized park, on the other hand, it was not registered in the industrial zone.

### ***Pipistrellus pygmaeus* (Leach, 1825)**

We registered this species both in Stara Zagora and Plovdiv. Ultrasound calls were recorded in most of the urban habitats (except house yards and areas between blocks of flats covered by grass or trees).

In Plovdiv, we recorded this bat in the area of the Grebna Baza reservoir, in river floods and on hills, also in the two park types, over a canal and a large river. The species was missing in the other investigated habitats.

In Stara Zagora, this species was registered by an ultrasound detector over a small river in the industrial zone, a small river in a park and in an urbanized park.

### ***Pipistrellus nathusii* (Keyslering et Blasius, 1839)**

This species was confirmed to occur in Plovdiv – we recorded a clear social call near a block of flats in the northern part of the town. Numerous calls of the *P. kuhlii* / *P. nathusii* type were recorded in both towns. During migration, some of these calls might have belonged to *P. nathusii*, known to be abundant in Bulgaria in this period (BENDA et al. 2003).

### ***Pipistrellus kuhlii* (Kuhl, 1817)**

Our findings made in Plovdiv are the first record of this species in the study area. We found three dead bats and caught one juvenile near a maternity colony of the species, which included 45 individuals and was situated on the last eight floor of a new building in the industrial zone. One hibernating individual was found in a classroom of a school.

On dusk we often observed flying individuals of this species in areas between blocks of flats covered by tree vegetation – the white band on the edge of the wing membrane was well visible in flight.

Numerous calls of the *P. kuhlii* / *P. nathusii* type were recorded in both towns. In Plovdiv most of them probably belonged to *P. kuhlii*, as it seemed to be more frequent than the other species in this area (visual observations).

In Plovdiv we recorded calls of the *P. kuhlii* / *P. nathusii* type in all habitats investigated except the large river (Maritza river).

In Stara Zagora we recorded such sounds mostly in an urbanized park but also in all other habitats.

### ***Hypsugo savii* (Bonaparte, 1837)**

We recorded this species using an ultrasound detector in both towns. We found one breeding colony which included 30 individuals and was situated in a fissure on the lower side of a balcony on the first floor in a block of flats in Plovdiv. One adult female from the colony was caught. One dead individual was found in a churchyard on the Trihalmie hill. One hibernating male was found in an inhabitable building in Stara Zagora.

Table 3. Number of recorded bat calls in different habitats in Stara Zagora (see Material and Methods for abbreviations)

Tab. 2. Počet zaznamenaných hlasů netopýřů v různých biotopech města Satrá Zagora (zkratky viz Material and Methods)

species	BG	BT	DF	C	UPF	DPF	SRI	SRP	IZ	HY
small <i>Myotis</i> sp.	0	1	4	0	0	5	0	10	1	0
<i>Plecotus</i> sp.	0	0	0	0	0	4	0	0	0	0
<i>N. noctula</i>	93	86	80	248	87	10	143	87	37	74
<i>E. serotinus</i>	0	0	0	0	1	0	0	1	1	0
<i>P. pipistrellus</i>	2	14	51	48	87	10	74	321	0	4
<i>P. pygmaeus</i>	0	0	0	0	1	0	35	1	3	0
<i>P. kuhlii</i> / <i>P. nathusii</i>	3	4	2	6	14	1	2	1	3	3
<i>Pipistrellus</i> sp.	0	2	13	3	30	1	6	10	0	1
<i>H. savii</i>	0	2	0	5	0	0	0	0	0	1
<i>T. teniotis</i>	5	1	2	4	0	0	4	0	0	0
unidentified (13–16.5 kHz)	1	0	0	4	1	0	1	0	0	0
unidentified (22–32 kHz)	14	16	8	78	2	4	25	14	2	2
unidentified (35–38 kHz)	0	0	0	5	0	0	0	0	0	1
unidentified	0	2	1	16	0	0	1	2	0	0
total	118	128	161	417	223	35	291	447	47	86
recording duration, min	80	60	30	30	30	70	50	30	30	80

In Plovdiv we recorded the species in the area of the Grebna Baza reservoir, in an industrial zone, near a large river, in an urbanized park, on the hills, in areas between blocks of flats covered by grass vegetation, in river floods, house yards and in a park with low anthropogenic pressure. No calls of this species were recorded in the other surveyed habitats.

In Stara Zagora we recorded calls of *H. savii* above a canal near panel blocks of flats, in areas between blocks of flats covered by tree vegetation and in house yards. In the other habitats of the town we did not register any Savi's pipistrelles.

#### ***Eptesicus serotinus* (Schreber, 1774)**

In Plovdiv we recorded calls of this species in all studied habitats with the exception of open grass areas between blocks of flats, reservoirs with banks covered by dense park woods, and river floods.

In Stara Zagora, calls of this species were registered in three habitats: urbanized park, industrial zone and a small river in the park. In the other habitats no calls of the serotine bat were recorded.

#### ***Vespertilio murinus* Linnaeus, 1758**

We recorded typical social calls of two individuals in Plovdiv (in park woods with low anthropogenic pressure near the western margin of the town). We suppose that the species occurs in both towns, since numerous calls of the *Nyctalus noctula* / *Nyctalus leisleri* / *Vespertilio murinus* / *Eptesicus serotinus* type with the frequency range 22–32 kHz were recorded, some of which could have belonged to this species. In Stara Zagora one hibernating individual of *V. murinus* was found in a building (determined by A. HUBANČEVA).

#### ***Tadarida teniotis* (Rafinesque, 1814)**

This species was recorded in most of the studied habitats in both towns.

One dead individual was found near a panel block of flats in the southeastern part of Stara Zagora.

We registered high flight activity of the species in Plovdiv in an urbanized park, above the Grebna Baza reservoir, in a park with low anthropogenic pressure, above river floods and hills. In the other investigated habitats we did not record any calls of free-tailed bats.

In Stara Zagora, calls of the species were detected above a canal, above a small river in an industrial zone, above the Zagorka reservoir, in open grass areas between blocks of flats, and areas between blocks of flats covered by tree vegetation. The species was not registered in the rest of habitats surveyed.

### **Comparison of bat diversity**

Bat fauna of the two South Bulgarian towns under study showed high species diversity (14 and 9 species, respectively), compared to that of some other European towns (Moscow – 8 species, Brno – 7, Hoyerswerda – 9). This fact is a result of the northern geographic position of the latter towns, but possibly also of the different degree of urbanization, historical development, architectural features, management of natural resources, and a complex of many other factors. Besides the differences in the number of species, Plovdiv and Stara Zagora have a qualitatively different fauna from that of the towns compared (Fig. 1). This is because Mediterranean species, such as *Tadarida teniotis* and *Pipistrellus kuhlii*, do not occur in the northern areas, while psychrophilous species, such as *Eptesicus nilssoni* and *Myotis dasycneme*, are absent



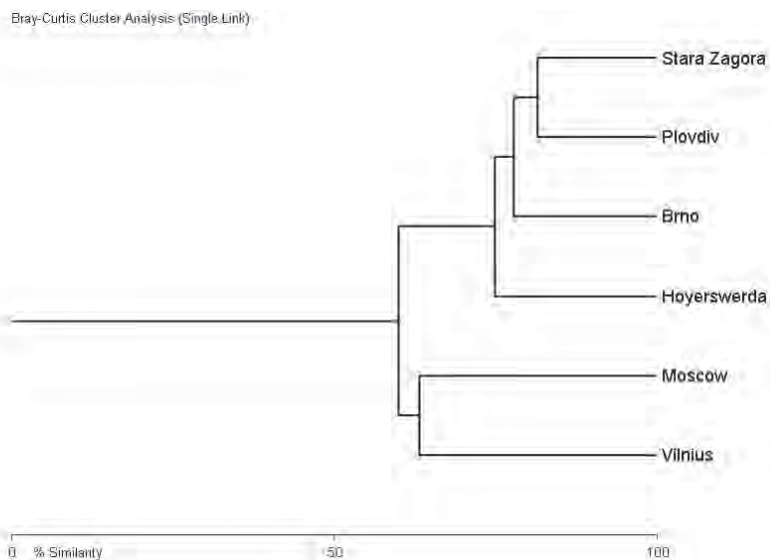


Fig. 1. Cluster analysis of qualitative similarity in species composition found in Plovdiv, Stara Zagora and some other European towns.

Obr. 1. Shluková analýza kvalitativní podobnosti druhového složení nalezené ve dvou bulharských a některých dalších evropských městech.

from the southern areas. However, high similarities were found in species composition (always over 50%). The most similar faunas were those of the two nearest towns, Plovdiv and Stara Zagora. Their complex of species had the highest qualitative similarity to those of Brno and Hoyerswerda and the lowest similarity to those of Moscow and Vilnius, which formed an independent cluster group.

## CONCLUSIONS

Altogether 14 bat species (42.4% of the species of Bulgaria) were recorded in Plovdiv and 9 species (27.3% of the fauna of Bulgaria) in Stara Zagora, respectively. The species *Myotis daubentonii*, *M. emarginatus*, and *Tadarida teniotis* were new records for the region of the Upper Thracian lowland, and *T. teniotis* also for the region of the Sarnena Sredna Gora Mts.

According to our data, most of the species roosted inside inhabitable buildings (*P. austriacus*, *N. noctula*, *P. kuhlii*, *H. savii*), a group of species was also found in crevices on the facade of these buildings (*N. noctula*, *P. pipistrellus*, *H. savii*) and only one species (*N. noctula*) was found in tree hollows and in fissures of bridges. Although most species were found in the former roost type, a higher number of individuals was observed in the latter two roost types due to the great abundance of noctule bats. We found that the most important bat habitats in the studied towns were areas between blocks of flats covered by tree vegetation and dense park woods with low anthropogenic pressure, where the highest number of species was recorded.

## SOUHRN

Fauna netopýrů Horní Thracie v jižním Bulharsku byla prostudována jen slabě a také údaje o urbánních netopýrech na celém Balkánském poloostrově jsou velmi omezené. Naše studie byla zaměřena na výzkum netopýrů dvou největších měst bulharské Thracie, Plovdivu a Staré Zagory. Devět druhů netopýrů bylo nově zjištěno v Plovdivu (*Myotis emarginatus*, *M. daubentonii*, *Plecotus* spp., *Nyctalus leisleri*, *Pipistrellus pygmaeus*, *P. nathusii*, *Hypsugo savii*, *Vespertilio murinus*, *Tadarida teniotis*) a čtyři ve Staré Zagoře (*Myotis myotis* / *M. blythii*, *Myotis daubentonii*, *Nyctalus leisleri*, *Tadarida teniotis*). Diversita netopýrů a relativní využití městských biotopů bylo studováno různými metodami (detekce ultrazvuků, odchyty do sítí, vyhledávání netopýrů v úkrytech a uhynulých jedinců). Nejvíce druhů bylo zaznamenáno v územích mezi bloky činžovních domů pokryté stromovou a hustou parkovou vegetací s nízkým anthropogenním vlivem. Úkryty nejvíce druhů byly nalezeny v obytných budovách, řada druhů byla také nalezena ve šterbinách fasád takových budov a jen jeden druh (*Nyctalus noctula*) byl nalezen ve stromových dutinách a v dutinách mostů. Biotopové preference byly studovány s pomocí ultrazvukových detektorů v teplém období roku 2007. Biotopy s největší letovou aktivitou netopýrů se ukázaly být nádrže s břehy pokrytými hustými parky, menší řeky v lesnatých územích a kanály v blízkosti činžovní zástavby.

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## REFERENCES

- BARANAUSKAS K., BALČIAUSKAS L. & MAŽEIKYTĖ R., 2005: Vilnius city theriofauna. *Acta Zoologica Lituanica*, **15**: 228–238.
- BARATAUD M., 2002: *The World of Bats*. Sittelle Publ., Mens, 47 pp.
- BARTONIČKA T. & ZUKAL J., 2003: Flight activity and habitat use of four bat species in a small town revealed by bat detectors. *Folia Zoologica*, **52**: 155–166.
- BÄČVAROV G., 1963: Kām helminthofaunata na prilepīte (Chiroptera) v Bālgariā [On the helminthofauna of bats (Chiroptera) in Bulgaria]. *Trudove na Visšīā Pedagogičeski Institut, Plovdiv, Biologiā*, **1**(1): 99–101 (in Bulgarian, with a summary in Russian and French).
- BENDA P., IVANOVA T., HORÁČEK I., HANÁK V., ČERVENÝ J., GAISLER J., GUEORGUIEVA A., PETROV B. & VOHRALÍK V., 2003: Bats (Mammalia: Chiroptera) of the Eastern Mediterranean. Part 3. Review of bat distribution in Bulgaria. *Acta Societatis Zoologicae Bohemicae*, **67**: 245–357.
- BIHARI Z., 2004: The roost preference of *Nyctalus noctula* (Chiroptera, Vespertilionidae) in summer and the ecological background of their urbanization. *Mammalia*, **68**: 329–336.
- DIETZ C. & VON HELVERSEN O., 2004: *Illustrated Identification Key to the Bats of Europe. Version 1.0*. [http://www.uni-tuebingen.de/uni/bzt/Kontakt/mitarbeiter\\_seiten/dietz.htm](http://www.uni-tuebingen.de/uni/bzt/Kontakt/mitarbeiter_seiten/dietz.htm)
- GAISLER J., ZUKAL J., ŘEHÁK Z. & HOMOLKA M., 1998: Habitat preference and flight activity of bats in a city. *Journal of Zoology, London*, **244**: 439–445.
- KARASEVA E. V., TELICYNA A. Ū. & SAMOJLOV B. L., 1999: *Mlekopītaūšīe Moskvy v prošlom i nastoāšem* [The Mammals of Moscow in the Past and Present]. Nauka, Moskva, 246 pp (in Russian).
- OBRIEST M., BOESCH R. & FLÜCKIGER P., 2004: Variability in echolocation call design of 26 Swiss bat species: consequences, limits and options for automated field identification with a synergetic pattern recognition approach. *Mammalia*, **68**: 307–322.

- PANDOURSKI I., 2004: Bats (Mammalia: Chiroptera) of the Burgas Wetlands, Bulgarian Black Sea Coast. *Acta Zoologica Bulgarica*, **56**: 283–298.
- PANDOURSKI I. & KARAIVANOV N., 2007: Records of Bats (Mammalia: Chiroptera) from Vasilyovska Planina Mountain, Northern Bulgaria. *Acta Zoologica Bulgarica*, **59**: 283–288.
- PARSONS S. & JONES G., 2000: Acoustic identification of twelve species of echolocating bat by discriminant function analysis and artificial neural networks. *Journal of Experimental Biology*, **203**: 2641–2656.
- PEŠEV C. H., PEŠEV D. C. & POPOV V. V., 2004: *Fauna na Bălgariâ 27. Mammalia [The Fauna of Bulgaria 27. Mammalia]*. Marin Drinov, Sofiâ, 632 pp (in Bulgarian).
- PETROV B., 2008: *Bats – Methodology for Environmental Impact Assessment and Appropriate Assessment. A Manual for Developers, Environmental Experts and Planning Authorities*. National Museum of Natural History, Bulgarian Academy of Sciences, Sofia, 88 pp.
- PFALZER G. & KUSCH J., 2003: Structure and variability of bat social calls: implications for specificity and individual recognition. *Journal of Zoology, London*, **261**: 21–33.
- POPOV V. & SEDEFČEV A., 2003: *Bozajnicite v Bălgariâ. Opređelitel [The Mammals of Bulgaria. Identification Key]*. Vitoša, Sofiâ, 292 pp (in Bulgarian).
- RUSSO D. & JONES G., 2002: Identification of twenty-two bat species (Mammalia: Chiroptera) from Italy by analysis of time-expanded recordings of echolocation calls. *Journal of Zoology, London*, **258**: 91–103.
- SCHMIDT C., 2002: The occurrence of bats in the town of Hoyerswerda. *Przyroda Sudetów Zachodnich*, **2**: 71–78.
- SHIEL C. & FAIRLEY J., 1998: Activity of Leisler's bat *Nyctalus leisleri* (Kuhl) in the field in South-East County Wexford, as revealed by a bat detector. *Biology and Environment, Proceeding of the Royal Irish Academy*, **98B**: 105–112.
- SIMON M., HÜTTENBÜGEL S. & SMIT-VIERGUTZ J., 2004: *Ecology and Conservation of Bats in Villages and Towns*. Bundesamt für Naturschutz, Federal Agency for Nature Conservation, Bonn, 263 pp.
- SKURATOWICZ W., BARTKOWSKA K. & BATCHVAROV G. 1982: Fleas (Siphonaptera) of small mammals and birds collected in Bulgaria. *Fragmenta Faunistica*, **27**: 101–140.
- TILOVA E., STOYCHEVA S. & GEORGIEV D., 2005: New information on the distribution of some bat species (Mammalia: Chiroptera) from Bulgaria. *University of Plovdiv "Paisii Hilendarski", Scientific Studies: Biology: Animalia*, **41**: 135–144.
- TILOVA E., STOYCHEVA S., KMETOVA E., NEDYALKOV N. & GEORGIEV D., 2008: Discovery of a big hibernacula of Noctule bats, *Nyctalus noctula* (Schreber, 1774) (Chiroptera: Vespertilionidae) in the town of Plovdiv, Bulgaria. *Historia Naturalis Bulgarica*, **19**: 129–136.
- TOFFOLI R., 2006: Record of Brandt's bat *Myotis brandtii* (Eversmann, 1845) in Piedmont (Chiroptera, Vespertilionidae). *Hystrix, n. s.*, **17**: 167–171.