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Species diversity of bats in underground roosts of the Western Stara Planina Mts. (Bulgaria)

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Abstract. Species richness of bats in 36 underground roosts (shallow and deep natural caves, abundant mines) of the Western Stara Planina Mts. was investigated in 1991–1998. The roosts are situated in a wide altitudinal range (from the Pre-Balkan to the high mountain areas, between 300 and 1450 m). Twenty-one bat species were found; 15 of them hibernated in this area and 18 were observed or mistnetted in summer quarters and during autumn "roaming movements". Species diversity varied in different roosts, and the highest values (H'= 1.39–1.85) were estimated for deep natural caves and artificial mines during the hibernation period. We observed a positive gradient of atmospheric temperatures and humidity in the inner part of hibernacula. The abandoned mines were not permanently inhabited by bats but some shallow and warm caves were used as nursery roosts. The most of bat communities were concentrated within 350 and 700 m a. s. l. The colonial species *Miniopterus schreibersii* (1000–2000 individuals), *Myotis myotis / blythi* (400–1500 individuals), *M. capaccinii* (200–600 individuals), *Rhinolophus ferrumequinum* and *R. euryale* (up to 250 individuals) dominated at these altitudes. *R. hipposideros* (with the 80% relative occurrence) followed by *R. ferrumequinum* and *M. myotis* (found in 62% and 43% of the roosts correspondingly) were most frequently found in the hibernation quarters. The species *M. blythi*, *M. capaccinii*, *Plecotus auritus* and *M. schreibersii* occurred in 29%, respectively, and *R. euryale* in 19% of the roots. Only solitary individuals of other 7 bat species were rarely found to hibernate in the monitored underground shelters what can be explained with their status of "rare species" in the investigated area and/or with their weak preference to underground shelters. In autumn (September–October) solitary juveniles of *Myotis nattereri*, *M. bechsteini*, *Hypsugo savii*, *Barbastella barbastellus* and *Nyctalus noctula* were captured in front of cave entrances. Hibernation quarters of these species have not been yet studied.

Bats, species diversity, Western Stara Planina Mts.

Introduction

The initial research on bats of Western Stara Planina Mts. was performed in the 1960's, and only seven bat species were recorded mainly in large caves (Beron & Gueorguiev 1967, Gueorguiev & Beron 1962, Beron 1994). First data concerning the abundance of bats in about 90 important large bat colonies were reported by Beshkov (1998). This paper reports the new data on bat richness collected in different

types of roosts on the territory of the Western Stara Planina Mts. and it is focused on the following main goals:
– to establish seasonal changes in the species composition and abundance of bats in different types of underground roosts;
– to study microclimatic preferences of dominant species in hibernation sites;
– to determine sites with a high species diversity and numerous colonies important for bat conservation.

Material and methods

The Western Stara Planina Mts. (Western Balkan) is a border area of 3396 km^2 between Bulgaria and Yugoslavia with well-developed surface and deep karstic forms. The altitude ranges between 300 and about 2000 m. Many long cave systems have been formed in large karstic areas of Triassic, Jurassic and Apt limestones.

The data were collected in 1991 and 1998 in 36 bat roosts (23 deep natural caves, 5 mine systems, 6 shallow caves and 2 abandoned buildings) (Fig. 1). Bats were counted in deep and shallow natural caves and in artificial mines used as hibernation quarters (XII–IV) and/or as reproductive shelters. Mist netting in front of entrances to caves and galleries were performed during the summer and autumn months.

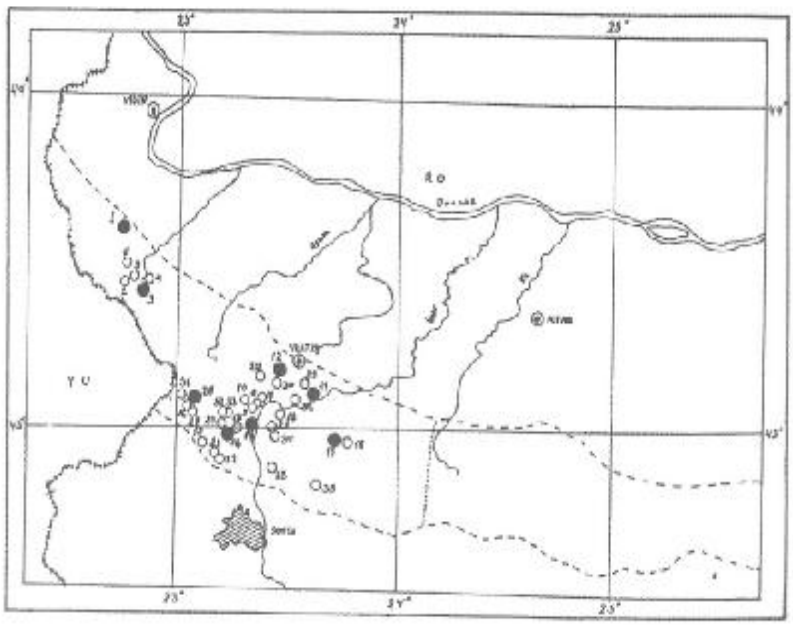

Fig. 1. Location of investigated bat roosts (black circles – numerous colonies).

List of the roosts where bats were found

(DC – deep cave, SC – shallow cave, M – artificial mine, B – building; W, S, TR –winter, summer and transient roost):

1. Suhi petch cave, station Oreshetz (350 m a. s. l., DC, W, S); 2. Desni suhi petch cave, village Dolni lom (400 m, DC, W); 3. Levi suhi petch cave, v. Dolni lom (400 m, DC, W); 4. Petch cave, v. Gorna luka (350 m, SC, W, S); 5. Mishin kamak cave, v. Gorna Luka (450 m, DC,W, S); 6. Temnata dupka cave, v. Targovishte (420 m, DC, W); 7. Razishkata cave, st. Lakatnik (470 m, DC W); 8. Svinskata cave, st. Lakatnik (450 m, DC, W); 9. Golyama vraza dupka cave, st. Lakatnik (450 m, SC, W, S); 10. river Proboinitza, Vratchanski Nat. Park (450 m, M, W); 11. Serapionovata cave, Vratchanski Nat. Park (300 m, DC, W, S); 12. Kalna matnitza cave, v. Glavatzi, Vratchanski Nat. Park (380 m, DC, W, S); 13. Javoretzka cave. v. Lakatnik (570 m, DC, W); 14. Vodnata cave, v. Cerovo (380 m, DC, W, S);15. Metcha dupka cave, v. Buchin prohod (850 m, SC, W); 16. Dushnika, v. Iskretz (460 m, DC, S, TR); 17. Kozarnica cave, v. Lipnitza (670 m, SC, S, TR); 18. Bozenishki Urvitch, v. Lipnitza (550 m, B, S); 19. Metcha poljiana, v. Iskretz (700 m, M, W); 20. Sokolskata cave, v. Ljutadzik, Vratchanski Nat. Park (DC, TR); 21. Jamkata cave, v. Drenovo (800 m, DC, W); 22. Kollibata, v. Belidie han (750 m, SC, S); 23. r. Batuljiska (580 m, M, W); 24. Metchata dupka cave, st. Bov (980 m, DC, W); 25. Travninata cave, v. Breze (1050 m, SC, W, TR); 26. Svetata voda cave, v. Gintzi (1050 m, DC, W); 27. Krivata pesht cave, v. Gintzi (1050 m, DC, W); 28. Dinevata pesht cave, v. Gintzi (110 m, DC, W, TR); 29. Bezimenna cave, Okoltchitza, Vratchanski Nat. Park (1180 m, SC, S); 30. v. Gorna Bjiala Rechka, distr. Varshetz (480 m, M, W, TR); 31. Goljiama Balabanova cave, v. Komshtitza (DC, S, TR); 32. Katzite cave, Ponor Planina mountain (1200 m, DC, W); 33. Elata cave, Ponor planina mountain (1120 m, DC, W, S); 34. pic Izdremetz (1420 m, M, W); 35. pic Murgash (1500 m, B, S); 36. Chetvartitata cave, Vratchanski Nat. Park (1430 m, SC, TR).

Results

The underground roosts inhabited by bats were found up to 1500 m but they were more numerous at about 800 m a. s. l. (Fig. 2). Twenty-one bat species were found during the present research, and changes of bat assemblages in different shelters were observed in the reproductive and wintering periods.

The presence of different species in the recorded roosts was as follow:
Rhinolophus hipposideros (Bechstein, 1800) (N: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 19, 20, 23, 24, 25, 27, 28, 30, 31, 33, 34);
Rhinolophus ferrumequinum (Schreber, 1774) (N 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 15, 16, 21, 22, 24, 26, 28, 33);
Rhinolophus euryale (Blasius, 1853) (N 1, 6, 7, 17, 18);
Myotis myotis (Borkhausen, 1797) (N 1, 2, 4, 5, 8, 9, 11, 12, 13, 14, 16, 17, 25, 26, 28, 29, 30, 31, 33, 34);
Myotis blythi (Thomes, 1857) (N 1, 5, 7, 11, 12, 13, 14, 16, 22, 26, 28, 29, 30, 32, 34);
Myotis capaccinii (Bonaparte, 1837) (N 1, 2, 4, 5, 11, 14, 28);
Myotis emarginatus (Geoffroy, 1806) (N 16, 17, 18, 22, 28, 31, 20);
Myotis daubentoni (Kuhl, 1819) (N 28, 30);
Myotis nattereri (Kuhl, 1818) (N 16, 25, 28, 29, 30, 34);
Myotis bechsteini (Kuhl, 1818) (N 25, 28);
Myotis mystacinus (Kuhl, 1989) (N 16, 28, 31, 35);

Tab. 1. Relative occurence (%) and species diversity (H') of bats in different types of winter quarters (SC – shallow caves, M – artificial mines, DC – deep caves, AT – all types)

Quarter	SC		M		DC		AT	
N	23		45		4408		4476	
Species	n	%	n	%	n	%	n	%
R. hipposideros	7	30.43	35	77.7	99	2.25	141	3.16
R. ferrumequinum	15	65.21	3	6.6	193	4.38	211	4.71
R. euryale					44	0.90	46	1.03
M. myotis			2	4.4	53	1.20	53	1.18
M. blythi					15	0.30	15	0.30
M. mystacinus					1	0.02	1	0.02
M. capaccinii					237	5.37	237	5.31
M. daubentoni			1	2.2	1	0.02	2	0.04
M. nattereri			1	2.2			1	0.02
M. brandti			1	2.2			1	0.02
P. auritus			1	2.2	2	0.04	3	0.06
P. austriacus	1	4.34	1	2.2	9	0.20	11	0.25
M. schreibersii					3750	85.00	3750	84.04
E. serotinus					1	0.02	1	0.02
P. pipistrellus					3	0.06	3	0.0
H'	0.85		0.83		1.39		1.85	

Myotis brandti (Eversmann, 1845) (N 28);
Eptesicus serotinus (Schreber, 1774) (N 16, 17, 25, 28, 30, 31, 36);
Hypsugo savii (Bonaparte, 1837) (N 16, 17, 22, 28, 30, 36);
Pipistrellus pipistrellus (Schreber, 1774) (N 7);
Nyctalus noctula (Schreber, 1774) (N 16);
Vespertilio murinus Linnaeus, 1758 (N 28);
Plecotus austriacus Fischer, 1829 (N 2, 4, 7, 8, 18, 17, 22, 25, 27, 28, 30, 31, 36);
Plecotus auritus Linnaeus, 1758 (N 25, 28, 31, 34, 35);
Barbastella barbastellus (Schreber, 1774) (N 17, 30);
Miniopterus schreibersi (Kuhl, 1819) (N 1, 2, 4, 5, 8, 11, 12, 14, 17, 28).

Although the microclimate (air temperature and humidity) in deep shelters was comparatively constant, the seasonal changes of bat richness were more distinct in artificial mines than in deep natural caves. The latter were used mainly as hibernation sites.

The abundance of bats negatively correlated with the altitude and the most numerous bat colonies of cave-dwelling species inhabited deep caves situated between 350 and 700 m (Fig. 3). A transitory colony of *M. schreibersi* was found at higher altitude (Dinevata cave, 1100 m, N 28)

Species composition of hibernating bat assemblages

Fifteen bat species hibernated in underground roosts of the investigated area, however, only 8 species can be considered permanent cave-dwellers. The most frequently

observed species were *R. hipposideros*, *R. ferrumequinum*, *M. myotis*, *M. blythi* (in 30–80% of the roosts). *M. capaccinii*, *M. schreibersii*, *P. austriacus* and *P. auritus* hibernated in about 25% of the roosts but only solitary individuals of the latter two species were found. Only few hibernating individuals of *M. nattereri*, *M. mystacinus*, *M. daubentoni*, *P. pipistrellus* and *E. serotinus* were observed in deep caves or mines (Tab. 1).

The highest values of bat species diversity (Shannon-Weaver Index, H') were estimated in deep (more than 100 m length) shelters where the typical cave-dwelling species *R. hipposideros*, *R. ferrumequinum*, *M. myotis / blythi*, *M. schreibersii* were most abundant. The numerous mixed bat colonies of these species were concentrated in five long caves at 400–500 m a. s. l. The mean ambient temperature was 9 °C and the humidity ranged between 80% and 96% what corresponds to the estimated optimums of the above mentioned species (Pandurska, 1993). Only solitary individuals of *R. hipposideros*, *M. myotis / blythi*, *M. mystacinus*, *M. nattereri* and *P. auritus* were found to hibernate above 1000 m a. s. l. *Myotis blythi* was more frequent than *M. myotis* at these altitudes (Fig. 4). Most of the species hibernated in deep caves or artificial mines with comparatively low winter ambient temperatures (up to 7 °C).

The choice of hibernating sites and suitable shelters by different species was in accordance with the specific temperature's preference. The warm caves (with the mean temperature 9–13 °C) were inhabited predominately by *R. hipposideros*, *R. ferrumequinum*, *M. capaccinii* and *M. schreibersii*. These species were observed in a wide temperature range but they preferred the temperature near to 8 °C (Tab. 2). *R. euryale* hibernated in the innterior parts of warm natural caves (11.5 °C). Other investigated species hibernated in colder underground roosts at higher altitudes or

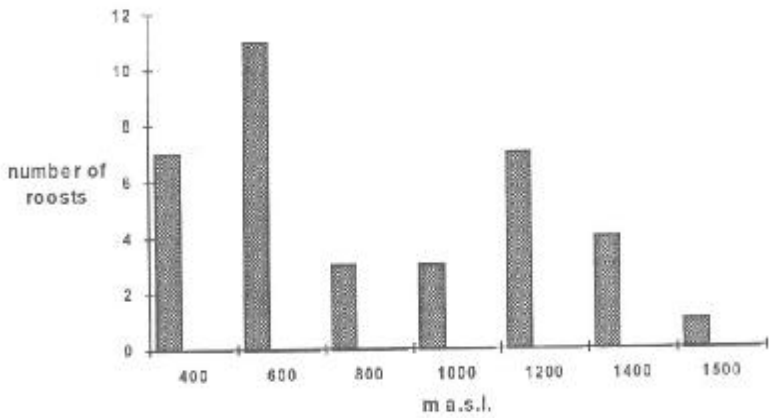

Fig. 2. Dispersal of bat roosts at different altitudes.

Tab. 2. Preferred ambient temperatures (Ta) in winter quarters

Species	n	mean Ta	min Ta	max Ta
R. hipposideros	137	8.8	3.8	12.8
R. ferrumequinum	180	8.0	5.0	13.0
R. euryale	18	11.5	10.6	12.8
M. myotis	37	6.2	0.2	11.6
M. blythi	15	5.0	1.0	10.6
M. capaccinii	32	8.0	3.6	13.0
M. nattereri	5	7.0	5.6	7.8
P. auritus	3	4.3	1.8	9.2
P. austriacus	11	4.8	1.8	8.8
M. schreibersii	43	6.5	4.0	10.0

in the outer holes near to the caves' entrances. *M. myotis / blythi* and *P. auritus / austriacus* preferred lower roost temperatures – near to 0 °C but the mean measured temperatures were 6.2/5.0 °C and 4.8/4.3 °C correspondingly. Rarely found bat species hibernated at varied air temperatures (*M. nattereri* – 7.0° C, *M. daubentoni* – 11.8 °C , *M. mystacinus* and *E. serotinus* – 3.8 °C).

Species richness of bats during the activity season

Eighteen bat species were observed between May and early November. The most numerous mixed colonies of *M. myotis / blythi*, *M. capaccinii* and *M. schreibersii* (with more than 3000 reproductive females) were concentrated in 8 long caves situated up to 700 m a. s. l.

Three new localities of nursing colonies of *M. emarginatus* were recorded at altitudes between 570 m and 780 m, and only pregnant and lactating females were netted in June–July (N 16, 17, 22). The number of females of *M. emarginatus* in Kozarnika cave (N 17) varied between 80–100 and usually they were mixed with *R. euryale* and *R. ferrumequinum*. The period of births was between 20 and 25 June and the development of newborns proceeded about four weeks. The colonies started to break up in late August and the species left the roosts prior to the two horseshoe bat species. Only males of *M. emarginatus* were captured at higher altitude (900–1300 m) (N 20, 28, 31).

Mistnetting were usually performed in karstic regions at roosts which were not inhabited by numerous colonies. Twelve bat species were netted in May–July, and females of *R. ferrumequinum* and *R. euryale* and individuals of *H. savii* and *E. serotinus* were more intensively captured in this period. Sixteen species were captured in September – early November, most frequently the males or juveniles of *M. myotis / blythi*, *Plecotus* spp. and individuals of *M. nattereri*, *M. bechsteini*, *M. mystacinus / brandti*, *V. murinus*, *N. noctula*, *B. barbastellus*. High species diversity (10 captured species for one night and 17 for one roosts, N 28) was recorded in September in karstic regions at 1000–1300 m a. s. l..

Localities with regional and national importance for bat conservation
Eight of the investigated bat roosts in the Western Stara Planina Mts. are inhabited by numerous colonies. The typical cave-dwelling species (*M. myotis / blythi* and *M. schreibersii*) dominated there (Tab. 3). Three of these caves are protected by law and are included in the list of the most important bat roosts in Bulgaria (Beshkov, 1998). We proposed for legal protection other two vulnerable nursery roosts (Serapionovata cave and Kalna matnitza cave, Vratchanski Natural Park).

Discussion

The increase in the abundance of bats at middle altitudes of the Western Stara Planina Mts. could be explained by the availability of many warm natural caves which are occupied by reproductive colonies of south-European species *R. ferrumequinum*, *R. hipposideros*, *M. emarginatus*, *M. capaccinii*, *M. schreibersi* and *M. myotis / blythi*. *R. hipposideros* hibernated most frequently in underground roosts but its reproductive colonies (up 60 pregnant females) inhabited abandoned buildings located near the wintering quarters. Similar "hemisynanthropic behaviour" was described in this species in Czechoslovakia and Ukraine (Gaisler 1963a, b, Kovalyova 1997). Only few lactating females of *P. austriacus*, *H. savii* and *E. serotinus* were netted in the area investigated. The reproductive status of rarely found species is unknown.

The autumnal increase of captured bat species is connected with seasonal migrations and choice of winter quarters (Řehák et al. 1994, Hanzal & Průcha 1996). More intensive activity of *M. nattereri*, *M. mystacinus*, *V. murinus* and *B. barbastellus*

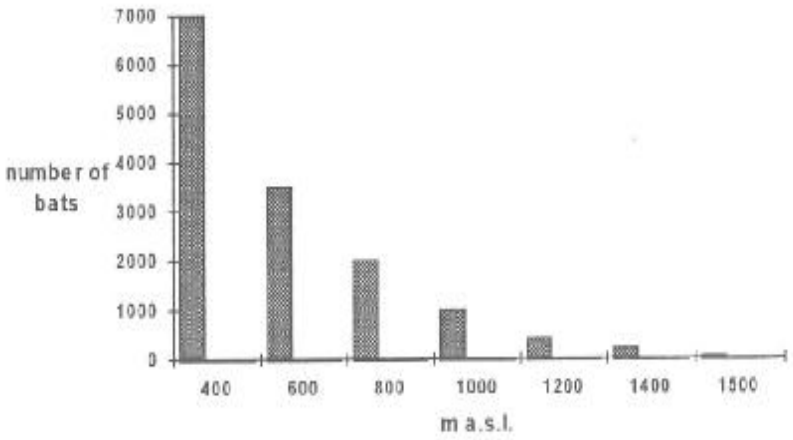

Fig. 3. Changes of bat number with the altitude.

Tab. 3. Maximal numbers of bats registrated in the important numerous colonies of the Western Stara Planina Mts. (win – winter period; sum – summer period; + unknown number)

cave	season	*R. ferr*	*R. eur*	*M. my/bl*	*M. ema*	*M. cap*	*M. schr*
Suhi pech	win	isol.	50	20	–	12	1000
	sum	+	200	tens	–	600	3000
Mishin kam.	win	18	–	10	–	200	30
	sum	30	–	40	–	–	350
Serapionova	win	150	–	20	–	50	1000
	sum	–	–	1000	–	–	2800
K. matnitza	sum	+	–	800	–	–	2400
Kozarnik	sum	150	200	–	80	–	–
Kolibata	sum	30	–	400	+	–	–
Dinevata	sum	–	–	–	–	–	700
Dushnika	sum	+	–	600	+	–	–

was observed at cave entrances in September and October. Such an "intensive visitations" of caves during the migratory periods was described also in Central Europe as "swarming behaviour of bats" (Kallash & Lehnert 1996, Kazakiewicz 1997).

Microclimatic conditions in underground shelters limited dispersal of different species. The mean ambient temperatures in the caves were close to the mean annual values in the area investigated. The roost temperatures have changed in relation with the altitude and in the lowest altitudes they reached up 12° C. The mean winter air temperatures of the roosts located above 1000 m a. s. l. were 7–9° C. Bat species diversity and relative occurrence of warm-preferable species decreased at higher altitudes but north-European species *M. mystacinus* and *P. auritus* were more frequently found there. Dominance of *R. ferrumequinum*, *R. hipposideros*, *M. myotis*, *M. schreibersii* and *M. capaccinii* in winter quarters is geographically determined and the recorded species structure was more similar to some Pyrenean assemblages in southern France (Bertrand, 1989) than to Central-European communities hibernating in caves, mines or cellars (Fuszara et al. 1996, Nagel et al. 1987, Danko 1997).

M. myotis / blythi and *P. auritus* hibernated at lowest air temperatures (0–5 °C). Very similar temperatures have been ascertained for these species in southern Germany (Nagel & Nagel 1991). According to Nagel et al. (1984, 1991) the temperatures preferred by different species are influenced by the altitude and the seasonal migrations to higher altitudes are related to reduction of the effective metabolic rate. For example *R. hipposideros* hibernated in underground roosts in the Western Stara Planina Mts. at high altitudes (up to 1400 m) where the mean temperatures of 7 °C were close to the optimal (Pandurska 1997). *R. hipposideros* was recorded to hibernate at higher mean January temperature (9.3 °C) in Saxony (Nagel & Nagel 1997).

The established bat species diversity on the territory of the Western Stara Planina Mts. is the highest one for the whole territory of Bulgaria. The presence of numerous bat colonies which are important for conservation of European populations of the

most vulnerable species *R. ferrumequinum, M. myotis, M. schreibersii* and *M. capaccinii* determine the necessity of future international research in the area investigated.

Summary

Bat species diversity of hibernating and summer bat assemblages on the territory of the Western Stara Planina Mts. (Western Balkan) is reported. Deep natural caves or mines are more frequently inhabited by typical cave-dwelling species *R. ferrumequinum*, *R. hipposideros*, *M. myotis / blythi*, *M. capaccinii*, *M. schreibersii* . The dispersal of different species during hibernation periods is influenced by microclimatic conditions (air temperature and humidity) in winter quarters. The above mentioned species prefer warm sites and they hibernate in deep underground roosts but *M. myotis / blythi*, *P. auritus / austriacus*, *M. mystacinus* and *E. serotinus* prefer lower winter temperatures (0–7 ° C). Rarely found species (*M. daubentoni*, *M. nattereri*, *M. bechsteini*, *M. brandti*, *H. savii*, *P. pipistrellus*, *B. barbastellus*, *V. murinus*, *N. noctula*) enter the cave entrances more frequently in the autumn months and their distribution is not strictly connected with underground shelters. The status and reproductive biology of these species was not investigated. Seven important numerous bat colonies consisting of hundreds to thousands of bats (*R. ferrumequinum*, *R. euryale*, *M. myotis / blythi*, *M. capaccinii*, *M. emarginatus*, *M. schreibersii*) are known in the area investigated.

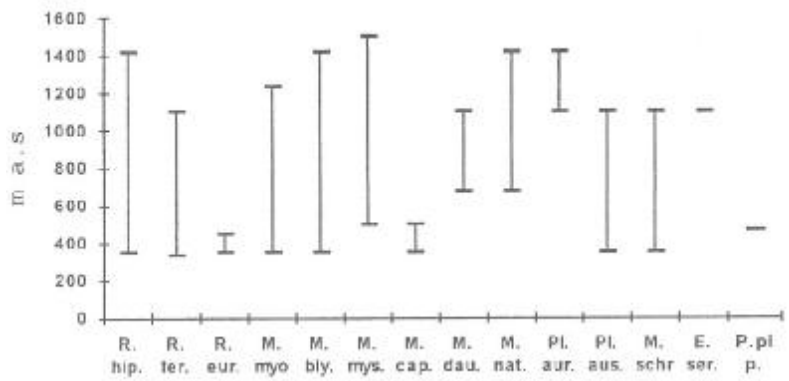

Fig. 4. Altitudinal dispersal of hibernating bat species in the investigated area.

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Súhrn

Druhová diverzita netopierov v podzemných úkrytoch Západnej Starej Planiny (Bulharsko). V období 1991–1998 bola sledovaná druhová pestrosť fauny netopierov v 36 podzemných úkrytoch (jaskyne, opustené bane) pohoria Západná Stará Planina v Bulharsku. Sledované úkryty sú situované v širokom výškovom rozpätí (od predhorí po vysokohorské oblasti 300–1450 m n. m.). Celkom bolo v sledovanej oblasti zistených 21 druhov netopierov. 15 druhov z tohto počtu v sledovanej oblasti zimuje, 18 druhov bolo pozorovaných alebo odchytených do sietí v letných úkrytoch alebo v priebehu jesenných preletov. Druhová diverzita v jednotlivých úkrytoch bola veľmi variabilná. Najvyšia bola zistená v hlbokých prirodzených jaskyniach a v opustených baniach v priebehu hibernácie (H'=13.9–1.85). Vo vnútorných častiach týchto úkrytov bol zistený pozitívny gradient vzdušnej teploty a vlhkosti. Opustené bane nie sú trvalo obývané netopiermi, naopak niektoré malé a teplé jaskyne sú využívané ako reprodukčné úkryty. Najväčšia časť nálezov sa koncentrovala do rozpätia 350–700 m n. m. Druhy tvoriace početné kolónie, *Miniopterus schreibersi* (1000–2000 jedincov), *Myotis myotis / blythi* (400–1500 jedincov), *M. capaccinii* (200–600 jedincov) *Rhinolophus ferrumequinum* a *R. euryale* (do 250 jedincov) v tejto nadmorskej výške dominovali. Na zimoviskách bol najčastejší *R. hipposideros* (80 % lokalít) nasledovaný druhmi *R. ferrumequinum* a *M. myotis* (62 % resp. 43 % všetkých úkrytov). Každý z druhov *M. blythi*, *M. capaccinii*, *Plecotus auritus* a *M. schreibersii* sa vyskytli v 29 % a *R. euryale* v 19 % úkrytov. Bola zaznamenaná hibernácia ojedinelých jedincov ďalších 7 druhov netopierov v podzemných priestoroch sledovanej oblasti. Toto môže byť vysvetlené buď vzácnosťou týchto druhov alebo skutočnosťou, že ich preferencia pre podzemné priestory je menšia. V jesennom období (septemeber – október) boli vo vchodoch do jaskýň zaznamenané ojedinele juvenilné jedince druhov *Myotis nettereri*, *M. bechsteini*, *Hypsugo savii*, *Barbastella barbastellus* a *Nyctalus noctula*. Lokality hibernácie týchto druhov neboli dosiaľ zistené.

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