

Taxonomy, biogeography and abundance of the horseshoe bats in Eastern Europe

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The family Rhinolophidae is represented in Eastern Europe by three rare species of *Rhinolophus*, namely *R. ferrumequinum* (RF), *R. hipposideros* (RH) and *R. euryale* (RE). A total of 275 collected specimens are represented by 187 RF, 87 RH and 1 RE? (coming from Crimea). All species have clearly distinct body and skull measurements (forearm 52–57 mm in RF, 48 in RE, 35–40 in RH) and distinctive sound frequencies (80–85 kHz in RF and 110–115 in RF). Differences between geographic samples of each species are not significant, and most expressed in a pair of Carpathian and Crimean RH (external features) and RF (skull dimensions). Detailed description of species ranges are presented by their marginal localities, and all the questionable records are discussed. During the 20th century their share in total bat samples continuously changed: a decrease in RF (32.8 to 4.7 %; category “endangered”) and an increase in RH (1.9 to 11.2 %, category “lower risk”).

Key words: Rhinolophidae, variation, diagnostics, distribution, protection.

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I. INTRODUCTION

Horseshoe bats (Rhinolophidae) are a very specialised mammalian group with a strict tendency towards extinction throughout the Western and Central Europe (FELDMANN 1967; WOŁOSZYN 1976; ROER 1984; KOKUREWICZ 1990). In Eastern Europe, the rhinolophids are characterised by relatively low taxonomic abundance and small ranges in the south (ABELENTSEV & POPOV 1956; STRELKOV 1963; ZAGORODNIUK 1998). Representatives of this family are relatively rare in Eastern Europe, and are included in the regional Red Data Books. Only four small publications specially devoted to this group exist (KROCHKO 1965; TATARINOV 1972; VASILIEV 1997; KOVALYOVA 1997). As a result, species composition of Eastern European Rhinolophidae thus far has not been revised; existing descriptions of species ranges were based on fragmentary and doubtful data, and the protection status of species was established without an analysis of their abundance. Preliminary results of this investigation were presented at the First Conference on the Carpathian Bats (Krakow, 7-8 Dec. 1996).

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II. MATERIALS AND METHODS

The geographic scope of the region studied includes a territory between the western border of the former Soviet Union and the eastern limit of Europe (Ural Mts. and the Kuma-Manych depression). Morphological materials were obtained from the main regional zoological museums: Ukrainian Natural History Museum (UNHM), Zoological Museum of Kyiv University (ZMKU), and the Lviv Natural History Museum (LNHM) [in the museums of the Odessa and the Kharkiv universities rhinolophids are absent]. A total of 275 specimens from about 70 sites of the Carpathian region, Podolia, Crimea and Northern Caucasus were investigated. The numbers of studied specimens are summarized in Table I. Total of 11 body and skull measurements of 140 skins and 121 skulls were analysed. These are: LB – body length, Ca – length of tail, Pl – length of foot, Au – ear length, W – body weight, FA – forearm length (FA' – on dry skin), Cra – skull length, CBL – condylobasal length, CM³ – length of upper tooththrow, and Mand – length of mandible (except for Cra, the anterior point of skull dimensions were the front side of canine).

Table I

Studied samples of Eastern European *Rhinolophidae* in some zoological museums

Sample	Acronym	UNHM	LNHM	ZMKU	Total	Share
Total collected bats	–	840	293	298	1431	100.0 %
Total Rhinolophidae, i. e.:	–	206	49	20	275	19.2 %
<i>Rhinolophus hipposideros</i>	RH	52	32	3	87	6.1 %
<i>Rhinolophus</i> cf. <i>euryale</i>	RE	1	0	0	1	0.1 %
<i>Rhinolophus ferrumequinum</i>	RF	153	17	17	187	13.0 %

Species ranges are described by marginal localities using original and published data, museum collections, and personal communications. Changes in species abundance are analysed using their share in collections accumulated during long-term periods of fauna investigations (ZAGORODNIUK & TKACH 1996). Field investigations were carried out in the caves of Podolia (Mlynky, Ugryn, Kryshaleva: 02.1976, 02.1999) and the Transcarpathians (Grebin, Druzhba, Dovgarunya: 10.1995, 02.1996, 07.1996). Bat sounds were studied using the “D-100 Pettersson” ultrasound detector.

III. SPECIES COMPOSITION AND VARIATION

Species of Eastern European Rhinolophidae

Eastern European horseshoe bats are represented by the single genus *Rhinolophus* LACEPEDE, 1799. According to a traditional point of view, there are two species in the fauna of the region, namely *R. ferrumequinum* SCHREBER, 1774, and *R. hipposideros* BECHSTEIN, 1800 (ABELENTSEV

& POPOV 1956; AVERIN & LOZAN 1965; KRYZHANOVSKY & EMELIANOV 1985). In the closest regions, there are 5 *Rhinolophus* species, and BRAUNER (1911) and STRELKOV (1963) also assumed the presence of *R. euryale* BLASIUS, 1853 in Crimea. The same assumption can be made for the Transcarpathian region also.

Analysis of variation in main diagnostic characters has shown, that *Rhinolophus* makes two compact groups: the lesser *R. hipposideros* and the greater *R. ferrumequinum* (Fig. 1) that present 2/3 and 1/3 of the total sample, respectively. The only "intermediate" specimen appeared in the sample from Crimea (grotto Myshyna Shchel: ANNEX). Its main features are: FA=48 mm, CBL=18, and both P_2 and P^1 are present and situated outside the tooththrow, age ca. 1 year. All its significant dimensions (Table II) are higher than in those of any species of the "intermediate" group (see: Table III) but the presence of *R. euryale* is the most probable in the region (STRELKOV 1963). An attempt to reveal the same species in the Transcarpathians was unsuccessful, and only RF (n=52) and RH (n=25) were identified in the total bat sample from this region.

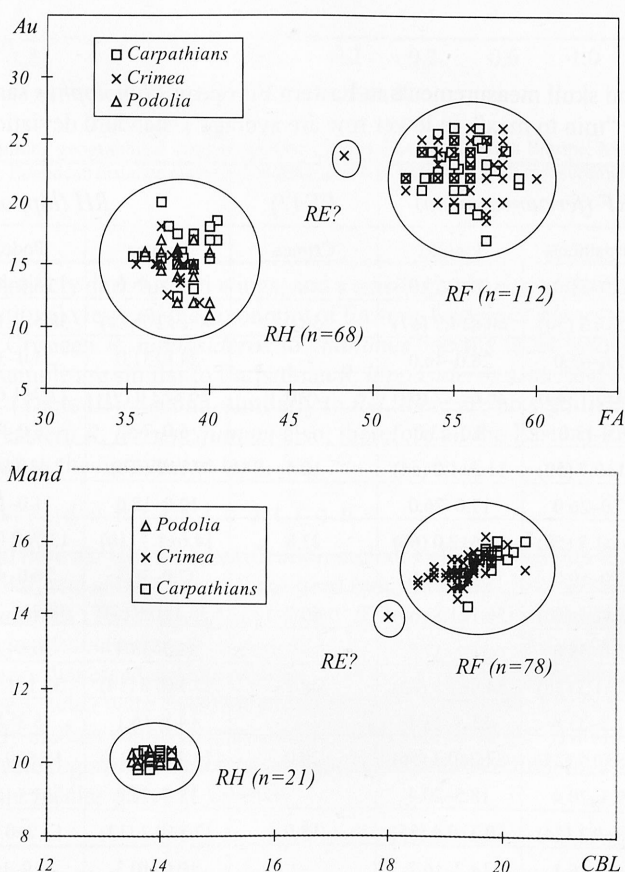


Fig. 1. Distribution of main body (above) and skull (below) measurements in the geographical samples of Eastern-European Rhinolophidae (average values of these characters see in Table II).

¹This specimen was also examined by Drs. WOŁOSZYN, UHRIN, POKYNCHEREDA, and DZEVERIN: by traditional criteria (KUZYAKIN 1965 etc.) this representative of an "intermediate" group is more likely to pair *bocharicus-mehelyi* than *euryale*; but Dr. STRELKOV supposes it is a young RF.

Trends in morphological variation

The existence of two centres of bat fauna abundance, in the west (Carpathians and Podolia) and the east (the Crimea and Caucasus), allows us to expect distinctions among geographic samples of *Rhinolophus*. No *Rhinolophus* intra-species taxa were established from Eastern Europe (ZAGORODNIUK 1998). In spite of this, ABELENTSEV & POPOV (1956), STRELKOV (1963) and KOVALYOVA (1997) considered these two geographic samples of each species as different subspecies, the nominative in the western regions and the other one in the East: *R. f. colchicus* SATUNIN, 1914, and *R. h. minimus* HEUGLIN, 1861.

Analysis of variations in six *Rhinolophus* samples (Table II) shows the existence of two compact clusters. Relatively distant samples are the Carpathian *RF* and the Podolian *RH*, so intra-species distance is minimal in the Southeast (Crimea; Fig. 2). Southern *Rhinolophus* (primarily Cri-

Table II

Body and skull measurements in Eastern European *Rhinolophus* samples (in upper row are "min to max", in lower row are average \pm standard deviation (n))

Measur. (mm).	<i>RF (ferrumequinum)</i>		<i>RE (?)</i>	<i>RH (hipposideros)</i>		
	Carpathians	Crimea	Crimea	Crimea	Podolia	Carpathians
LB	52.0–71.0	50.0–73.0	–	37.0–45.0	36.0–43.0	34.0–49.0
	62.5 \pm 4.3 (50)	60.8 \pm 4.7 (67)	56.0	40.2 \pm 2.7 (11)	38.5 \pm 2.1 (38)	39.2 \pm 3.7 (22)
CA	31.0–45.0	28.0–46.0	–	24.0–31.0	25.0–31.0	23.0–30.0
	37.9 \pm 3.1 (49)	36.6 \pm 3.2 (67)	29.0	26.8 \pm 2.0 (9)	27.7 \pm 1.6 (39)	26.8 \pm 2.1 (23)
PL	9.5–13.0	8.0–13.0	–	6.0–7.5	6.0–9.2	6.5–9.0
	11.1 \pm 0.7 (50)	11.3 \pm 1.0 (54)	10.4	7.1 \pm 0.6 (6)	7.4 \pm 0.8 (37)	7.6 \pm 0.5 (23)
AU	17.0–26.0	17.0–26.0	–	12.0–18.0	11.0–17.0	12.5–20.0
	22.6 \pm 1.7 (50)	22.6 \pm 2.0 (66)	23.8	14.6 \pm 1.7 (10)	13.7 \pm 2.0 (39)	16.2 \pm 1.7 (23)
FA	52.0–59.0	52.0–60.0	–	37.0–39.4	36.0–40.0	35.3–40.5
	55.2 \pm 1.5 (50)	56.1 \pm 1.8 (64)	50.7	38.1 \pm 0.9 (5)	38.7 \pm 1.2 (37)	38.3 \pm 1.5 (21)
FA'	53.0–58.0	51.1–57.5	–	35.5–38.4	36.6–39.5	35.5–40.2
	55.2 \pm 1.3 (35)	54.9 \pm 1.5 (62)	48.2	37.3 \pm 0.8 (14)	38.1 \pm 1.0 (8)	38.1 \pm 1.3 (20)
CRA	21.8–23.8	21.5–23.4	–	14.8–16.1	15.3–15.6	15.1–15.9
	22.8 \pm 0.5 (24)	22.2 \pm 0.4 (56)	20.0	15.4 \pm 0.3 (13)	15.5 \pm 0.1 (8)	15.6 \pm 0.2 (11)
CBL	19.3–20.4	18.5–20.4	–	13.5–14.2	13.5–14.0	13.6–14.2
	19.8 \pm 0.3 (24)	19.3 \pm 0.4 (55)	18.0	13.8 \pm 0.3 (13)	13.7 \pm 0.2 (6)	13.9 \pm 0.2 (11)
Mand	14.3–16.1	14.2–16.2	–	10.0–10.3	9.9–10.3	9.7–10.3
	15.6 \pm 0.4 (25)	15.2 \pm 0.3 (59)	14.0	10.2 \pm 0.2 (2)	10.0 \pm 0.2 (7)	10.1 \pm 0.2 (15)
CM3	8.3–8.7	7.7–8.6	–	5.2–5.5	5.2–5.5	5.3–5.6
	8.5 \pm 0.1 (24)	8.1 \pm 0.2 (48)	7.5	5.4 \pm 0.2 (2)	5.3 \pm 0.1 (5)	5.4 \pm 0.1 (15)
Weight	13.0–27.0	14.8–17.0	–	–	4.2–6.3	3.4–6.7
	19.6 \pm 3.8 (33)	15.7 \pm 0.9 (5)	7.7	5.7 (1)	4.8 \pm 0.5 (16)	4.8 \pm 1.0 (18)
N (max)	50	67	1	14	39	23

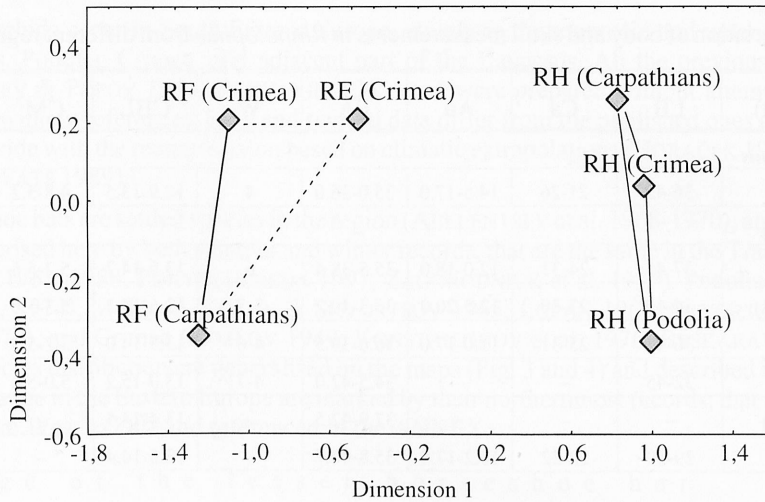


Fig. 2. Relationships among geographical samples of *Rhinolophus* from the Eastern Europe. Multi-dimensional scaling is carried out using the Euclidean distance matrix calculated for the 11 body and skull measurements (using data given in the Table II).

mean *RH*) have relatively dark fur and wings, and a smaller body size in comparison with the western samples. Traditional views on the taxonomy of Eastern-European *Rhinolophus* need correction. First, placing the Crimean *R. hipposideros* to “*minimus*” seems to be erroneous: morphological characters of this sample are similar to Carpathian *R. hipposideros* s. str. and essentially differ from the *minimus* s. str. (Table III). Second, similarly to *RH*, there are no significant differences among both western and eastern *R. ferrumequinum* also, therefore all the Eastern-European *Rhinolophus* should be identified as the nominative taxa.

Species identification

A key proposed here for species identification includes all the available diagnostic features: external, cranial, dental, and sound data. All the used morphological data are precise and were tested on the collected samples (Table II). [ABELENSEV & POPOV (1956) indicated a wide variation of *Rhinolophus*, and just forearm length varied from 31 to 45 mm in *RH* and from 52 to 70.2 in *RF*, which are twice more dispersed against our data, and covered the dimensions of the “intermediate” group]. Sound frequencies were established under field conditions (Uholka reserved area). Both species have clearly distinct sound frequencies, 80 to 90 kHz in *RF* (n=3) and 110–120 in *RH* (n=7). All *Rhinolophus* were registered in rocky sites near caves in the evening (at 21:30 to 24:00 p. m). In total, both available species differ as follows:

RH: forearm shorter than 41 mm (35–40); nose-leaf with a blunt and short superior process; sound frequency exceeding 100 kHz (110–120); skull length less than 14.5 mm (13.5–14.2); tooththrow less than 6 mm (5.2–5.6); upper small premolar acute and laying on central line of teethrow; its top reaching 1/3 of canine.

RF: forearm exceeding 50 (51–60) mm; superior process of nose-leaf elongated and rounded; sound frequency less than 100 kHz (80–90); skull length exceeding 18 mm (18.5–20.5); tooththrow more than 7.5 mm (7.7–8.7); upper canine and large premolar closed: small premolar laying outside teethrow or absent.

Table III

Variation of body and skull measurements in *Rhinolophus* from different regions

Sample (n)	LB	Ca	Au	FA	W	CBL	CM ³	Ref.
<i>R. (hip.) minimus</i>								
N-Africa (7)	36-42	21-26	14.5-17.0	35.0-36.0	4	12.9-13.5	4.8-5.2	KK'91
<i>R. hipposideros</i>								
Crimea (14)	37-45	24-31	12.0-18.0	35.5-38.4	6	13.5-14.2	5.2-5.5	Orig.
Carpathians (23)	34-49	23-30	12.5-20.0	35.5-40.2	3-7	13.6-14.2	5.3-5.6	Orig.
Podolia (39)	36-43	25-31	11.0-17.0	36.6-39.5	4-6	13.5-14.0	5.2-5.5	Orig.
USSR (n-?)	32-45	—	—	34.5-42.0	4-7	13.0-15.2	5.0-5.8	St'63
W-Europe (n-?)	—	—	—	37.0-42.5	—	13.4-14.5	—	SG'89
Balkans (49)	39-50	22-32	13.2-17.4	35.8-40.7	—	13.5-14.4	—	Kr'91
<i>R. blasii</i>								
USSR (?)	46-54	—	—	43.5-49.0	—	15.8-16.9	6.4-6.9	St'63
N-Africa (23)	55-58	22-31	10.0-21.0	43.0-48.0	9-12	16.2-17.0	6.5-6.9	KK'91
W-Europe (n-?)	—	—	—	45.0-48.0	—	15.8-16.7	—	SG'89
Balkans (10)	54-63	23-31	17.8-19.5	45.2-49.5	9-12	16.4-17.2	—	Kr'91
<i>R. euryale</i>								
USSR (n-?)	43-51	—	—	45.0-49.0	—	15.5-16.5	6.1-6.6	St'63
N-Africa (13)	50-54	22-28	18.5-22.0	46.0-49.5	8-11	15.2-16.5	5.7-6.4	KK'91
W-Europe (n-?)	—	—	—	43.0-51.0	—	16.0-17.6	—	SG'89
Balkans (23)	49-62	23-32	17.5-21.5	46.4-51.0	9-12	16.0-16.8	—	Kr'91
<i>R. mehelyi</i>								
USSR (n-?)	55-64	—	—	50.0-55.0	—	16.6-17.6	6.6-7.2	St'63
N-Africa (81)	49-63	25-37	19.0-23.0	47.5-53.0	11-18	16.5-17.7	6.5-7.1	KK'91
W-Europe (n-?)	—	—	—	50.0-55.0	—	16.6-17.5	—	SG'89
<i>R. "intermediate"</i>								
Crimea (1)	56	29	23.8	48.5	7.7	18.1	7.5	Orig.
<i>R. ferrumequinum</i>								
Carpathians (50)	52-71	31-45	17.0-26.0	53.0-58.0	13-27	19.3-20.4	8.3-8.7	Orig.
Crimea (67)	50-73	28-46	17.0-26.0	51.1-57.5	15-17	18.5-20.4	7.7-8.6	Orig.
USSR (n-?)	52-70	—	—	53.0-60.5	13-27	19.0-22.0	8.0-9.5	St'63
N-Africa (53)	58-71	30-42	19.0-25.0	51.0-59.0	13-22	18.9-20.1	7.6-8.7	KK'91
Balkans (20)	53-71	37-44	18.6-24.0	55.0-59.4	—	19.5-20.6	—	Kr'91
W-Europe (n-?)	—	—	—	54.0-61.0	—	20.0-22.0	—	SG'89

References: KK'91 – KOWALSKI & RZEBIK-KOWALSKA 1991 (Algeria; North-African "*minimus*" seems to be a separate species of the *hipposideros* group); Kr'91 – KRSTUFEEK 1991 (Slovenia); SG'89 – SCHÖBER & GRIMMBERGER 1989 (Western Europe); St'63 – STRELKOV 1963 (former USSR).

IV. SPECIES DISTRIBUTION

Rhinolophids occur in South Eastern Europe, mainly in the mountain and upland areas of the Carpathians, Podolia, Crimea, and adjacent part of the Caucasus. All the previous publications (ABELENITSEV & POPOV 1956; KUZYAKIN 1965 etc.) were prepared without attempts to outline ranges and without references. New and revised data differ from the published ones (loc. cit.), and do not coincide with the reconstruction based on climatic extrapolations (HORAČEK 1984; KOKUREWICZ & KOVATS 1989).

Horseshoe bats are settled species in the region (ABELENITSEV et al. 1968-1970), and their ranges are characterised here by both summer and winter records, that are the same in the Transcarpathians (KROCHKO 1965, 1988; POKYNCHEREDA 1997; ZAGORODNIUK et al. 1997), Podolia (TATARINOV 1962, 1972, 1974), Moldova (LOZAN & SKVORTSOV 1965; LOZAN 1966; SKVORTSOV & DOROSHENKO 1974), and Crimea (KOZLOV 1949; KONSTANTINOV et al. 1976; BESKARAVAJNY 1988). Data on species distribution are generalised on the maps (Fig. 3 and 4) and described below. Limits of species range in the Eastern Europe are marked by their northernmost records, that are numbered in order from West to East and referenced in the ANNEX.

Range of the lesser horseshoe bat

All the verified records form a continuous range from Western Ukraine through the Podolia and the Crimea up to Northern Caucasus (Fig. 3). This area continues along the Polish part of the species range (see: PUCEK & RACZYŃSKI 1983), and reaches more northern latitudes, than was mentioned earlier (STEBBINGS 1988). The northernmost *RH* records are arranged along the Dniester river, but just few modern records from the Podolia are known (Table IV and ANNEX). Populations of the Northern Carpathians and Podolia are apparently separated from the Transcarpathian ones by the mountain ridges. *RH* was registered in the mountains at altitudes less than 600 m (ZAGORODNIUK et al. 1997), but in the northern slope it is absent in the caves on much lower altitudes (TATARINOV 1988). The second part of the *RH* range lies in the Crimea and Caucasus, where northern limits of

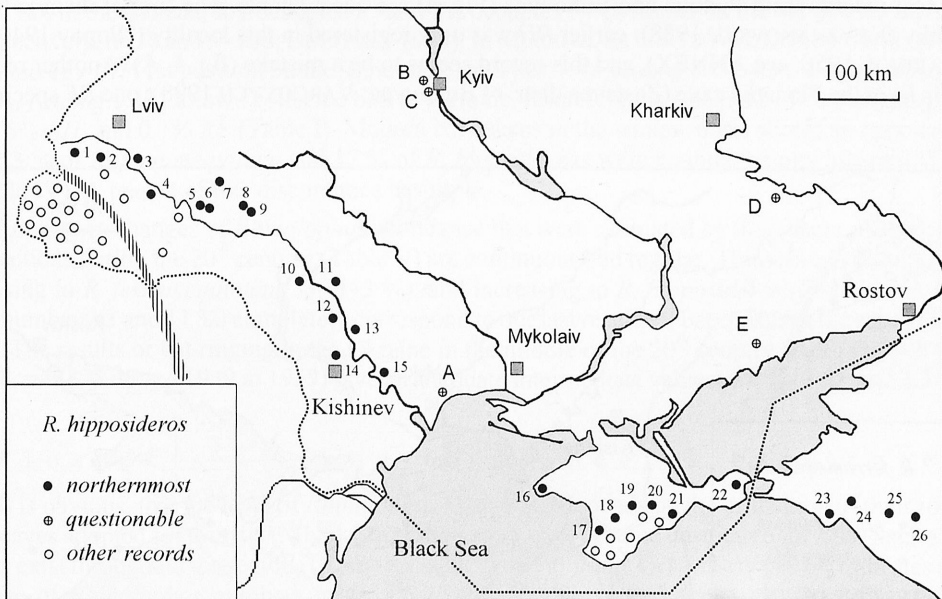


Fig. 3. Geographical distribution of *Rhinolophus hipposideros* in Eastern Europe. Numbered characters mark the marginal (northernmost) records. References to numbered localities are given in the ANNEX; lettering characters correspond to questionable data discussed in the text. Geographic limits of the region under study correspond to the border of the former Soviet Union on the West and the Kuma-Manych Depression in the Southeast; stripped line marks the main Carpathian ridge.

species range are described by 11 records (ANNEX). Most *RH* findings in the Crimea belong to its southern (mountain) part, from Tarkhankut to the Kerch peninsula (VOLOKH & KROCHKO 1994). In the adjacent part of the Caucasus, this species is recorded in a few localities of the Krasnodar Kray (DUVAROVA 1980; KAZAKOV & YARMYSH 1974).

E r r o n e o u s a n d q u e s t i o n a b l e r e c o r d s . There are 5 marginal records, that were not confirmed by any collected materials, detailed descriptions, or new reliable records in the same or adjacent regions: (A; Fig. 3) Odessa city ("BRAUNER in lit." in: MYGULIN 1938; without details: ABELENTSEV & POPOV 1956); (B-C) vicinity of Kyiv (KESSLER 1851; CHARLEMAGNE 1915). (D) Sloviansk in the Donetsk oblast (SOMOV 1897; for details see: MYGULIN 1938); (E) Ossipenko in Zaporizhzhia oblast (ABELENTSEV & POPOV 1956). A mentioned record of *RH* in Odessa was not confirmed by BRAUNER's (1910; 1923) publications and contradicts the data of ZUBKO (1937) and VOLIANSKY (1967), which do not register *Rhinolophus* in the different parts of the mainland Black Sea region. Records of *RH* in the vicinity of Kyiv were discussed earlier (LIKHOTOP et al. 1990) and are erroneous. The only record of *RH* in the Northern Azov region (Ossipenko) was based on the observation of one migrant specimen in the autumn of 1940. This fact was cited without details by ABELENTSEV (ABELENTSEV & POPOV 1956: 281) but not mentioned by POPOV (1941) in his special article on bat migrations.

R a n g e o f t h e g r e a t e r h o r s e s h o e b a t

This species is characterized by a more restricted range, and is known from the most southern parts of the region, namely the Transcarpathians, Crimea and Northern Caucasus (Fig. 4). In the Western region, this species occurs in the Transcarpathian lowlands only (see also: HORAČEK & CERVENY 1984), and penetrates in the mountains just up to 600 m in altitude. Known samples were collected in 1948–1950 (ZAGORODNIUK 1998a) and described by ABELENTSEV (1950; ABELENTSEV & POPOV 1956) and KROCHKO (1965; 1988). New data was obtained during a bat census in the Carpathian biosphere reserve (POKYNCHEREDA 1997; ZAGORODNIUK et al. 1997), but northernmost localities are confirmed mainly by the old findings (ANNEX).

Most records from Podolia and Bukovyna (Fig. 4) are questionable. The first of them is from Lokitky (KRYZHANOVSKY 1988): earlier *RH* was only registered in this locality ("Popov 1940" in TATARINOV 1956: see ANNEX), and this record seems to be a mistake (fig. 4, A). Another record "B" is from the Pionerka cave (Zastavna distr. of Bukovyna: VARGOVYCH 1998): one *RF* specimen

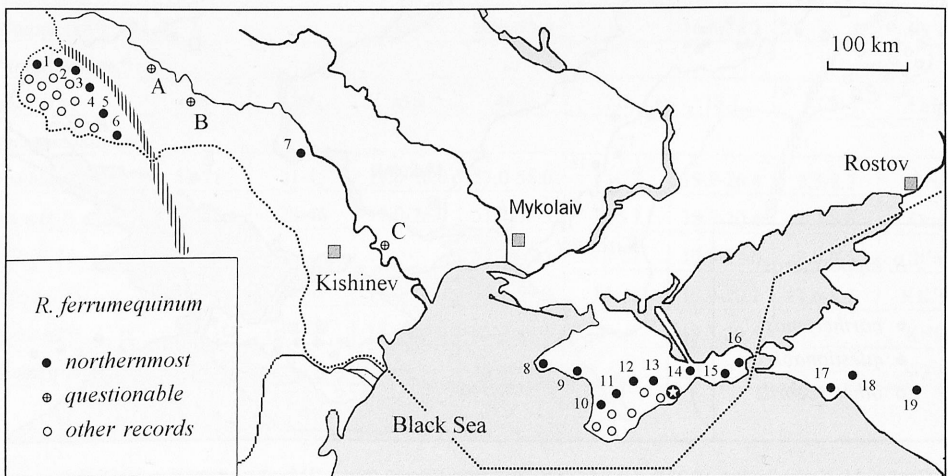


Fig. 4. Geographical distribution of *Rhinolophus ferrumequinum* and *R. cf. euryale* (asterisk) in Eastern Europe. For details see: Fig. 3.

was listed in the table, but not mentioned in the text and on the checklist of species. Other doubtful information came from Moldova. The only *RF* specimen was mentioned (without details²) together with 139 *RH* collected during 12 years (SKVORTSOV & DOROSHENKO 1974); and a new finding of a *RF* breeding colony in the La Beci cave (VASILIEV 1997: see ANNEX) is the only reliable record.

In Crimea this species is distributed wider than *R. hipposideros*, and is known from both natural and artificial habitats: caves, grotto, quarries, and buildings (MYGULIN 1938; KOZLOV 1949; ABELTSEV & POPOV 1956; BESKARAVAJNY 1988). From the Tarkhankut peninsula (west of Crimea) to the Kerch peninsula (east) it settles in rocky seaside massifs and old buildings (KRYZHANOVSKY 1988; VOLOKH & KROCHKO 1994; ZMKU and UNHM). Similarly to *RH*, the greater horseshoe bat is known in the Northern Caucasus from the Kuban distr. to Daghestan (YARMYSH et al. 1980; AMIRKHANOV 1980). The records closest to the studied region are from the Krasnodar Kray (DUVAROVA 1980; KAZAKOV & YARMYSH 1974; UNHM; see: ANNEX).

Record of *Rhinolophus cf. euryale*

The closest record is known from all the southern neighbours of the studied region, from Pan-Donia and the Southern Carpathians to the Western Caucasus (KUZYAKIN 1965; STRELKOV 1976; YAVRUNIAN 1990; HORAČEK et al. 1995).

The only questionable record is from Crimea (see Fig. 4). The only specimen of *RE* was captured in a seaside grotto Myshyna Shchel ["Bat Crack"] in the Karadagh natural reserve (near Shchebetovka, Theodosia distr., 13.08.1988, leg. BESKARAVAJNY, female N 12379 in UNHM).

V. SPECIES ABUNDANCE AND PROTECTION STATUS

Modern state of *Rhinolophus* populations

Populations of *Rhinolophidae* are in a decline throughout the Europe (DAAN 1980; VIERHAUS 1984; ROER 1984), and HORAČEK (1984) explains this fact by the changes in position of suitable isotherms. Eastern-European *Rhinolophus* populations are commonly described as relatively abundant. So, in the Crimea, *RH* occupies 5th and *RF* occupies 3rd positions on the bat abundance scale (respectively, $n=38$ and $n=106$: DULITSKY 1974). In Moldova, SKVORTSOV & DOROSHENKO (1974) counted 139 *RH* (1st position on the same scale) and just 1 *RF* among 865 bats collected during 12 years. Among 1,431 known collected bats in Ukraine, *Rhinolophidae* occupies 1/5, including 13% *RF*, 6% *RH*, and 0.1% *RE* (Table I). Modern bat census in the winter roosts shows an opposite result: 3 % of *R. ferrumequinum* and 12 % of *R. hipposideros* were counted among hibernated bats (Table IV). A reason of this discordance is simple.

Long-term changes of *Rhinolophus* abundance that were estimated by their share in zoological collections during the 20th century (Table V) are continuous and regular. This share is promptly decreasing in *R. ferrumequinum* (33–9–3 %), and increasing in *R. hipposideros* (2–4–11 %). Both last numbers (3 and 11 %) completely correspond to our last results of bat census in the caves (Table IV). The results of bat ringing in the Ukraine in the middle of the 20th century (ABELTSEV et al. 1968; $n=3875$ during 1939 to 1959) give an adequate intermediate values: 6.0 % of *RF* and 2.3 % of *RH*.

Prospects of long-term species existence

It is obvious, that the level of *Rhinolophus* abundance depends on the protection of their roosts. All caves adopted for tourists (Mlynky, Kryshaleva-1 etc.) became unsuitable for bats. Such situations exist throughout the region (DULITSKY et al. 1986 etc.), and TATARINOV (1974) indicates a decrease of *Rhinolophus* numbers in the Podolian caves about 2–3 times for 3 decades, that he

²It was 1 male from a quarry in Bychok (Grigoriopol distr., 1962: DOROSHENKO 1975) (Fig. 4, C).

Table IV

Rhinolophidae abundance in winter roosts (caves) of the Carpathians and Podolia

Species	Carpathians ('95/96)		Podolia ('98/99)		Total	
	Druzhba	Grebin	Mlynky & Ugryn	Kryshtaleva-1,2	absolute	percent
<i>Rhinolophus hipposideros</i>	85	6	0	73	164	11.5
<i>Rhinolophus ferrumequinum</i>	25	12	0	0	37	2.6
<i>Myotis (Myotis) myotis</i> (s. l.)	969	160	39	16	1184	83.0
<i>Myotis (Selysius) mystacinus</i>	1	0	0	0	1	0.1
<i>Myotis (Leuconoe) daubentoni</i>	11	0	1	0	12	0.8
<i>Myotis</i> indet. (small)	13	1	0	0	14	1.0
<i>Barbastella (barbastellus)</i>	7	0	0	0	7	0.5
<i>Plecotus (auritus+austriacus)</i>	0	0	3	5	8	0.6
Total bats	1111	179	43	94	1427	100%

explains by large speleological activity. In the protected ecosystems, the abundance of *Rhinolophus* is relatively stable. The comparison of a bat census in the largest reserved cave "Druzhba" in 1983 (CHYZHMAR & DOVGANYCH 1988) and 1997 (Table IV) showed an increase of *Rhinolophus* abundance 18 times over! Now *Rhinolophus* (first of all, *RH*) are the most distributed bats in the protected areas of the Carpathians, Podolia, and Crimea.

According to the European Red Data Book (1997), both *R. hipposideros* and *R. euryale* are included List 2 of globally threatened species, while *R. ferrumequinum* is on List 3 "species of special European concern". In Annex 2 of the Bern Convention (1979) and the Red Data Book of Ukraine (1994), both *RF* and *RH* have identical categories (Table V), which are incorrect. The decreasing of *RF* populations during the 20th century (10 times) should be stopped by special programs on cave

Table V

Rhinolophidae abundance during the 20th century based on the analysis of the UNHM and ZMKU collections, and their protection status in Eastern Europe

Taxa	Collected specimens			Protection status (category)*					
	1900 1939	1940 1959	1960 1998	A2BC 1979	RDBU 1994	UPSU 1996	RDBE 1997	SRBM 1999	Proposed
<i>R. ferrumequinum</i>	32.8 %	9.3 %	3.3 %	+	II cat.	1 cat.	special concern	III (R)	EN
<i>R. euryale</i>	0.0 %	0.0 %	0.5 %	+	—	—	VU, 2ac	—	DD
<i>R. hipposideros</i>	1.9 %	4.1 %	11.2 %	+	II cat.	4 cat.	VU, 2ac	IV (VU)	LR
Total Chiroptera	320 ex.	604 ex.	214 ex.	25 sp.	12 sp.	15 sp.	10 sp.	14 sp.	—

References: A2BC – Annex 2 to Bern Convention (1979), RDBU – Red Data Book of Ukraine (VOLOKH & KROCHKO, 1994), UPSU – updated protection status in Ukraine (ZAGORODNIUK & TKACH 1996), RDBE – Red Data Book of European Vertebrates (1997); SRBM – Status of rarity of bats in Moldova (ANDREEV 1999).

protection. Thus, Eastern-European rhinolophids are conservation dependent taxa, and according to new IUCN categories (1994), *RH* is a species of "Lower Risk" of extinction (LR), *RF* is in an "Endangered" species (EN), and *RE* needs the category of "Data Deficient" (DD).

VI. DISCUSSION AND CONCLUSIONS

All *Rhinolophus* species are represented in Eastern Europe by their marginal populations. The most distributed is the lesser *R. hipposideros* (Carpathians, Podolia, Crimea, and Northern Caucasus); the area of *R. ferrumequinum* is narrower (Transcarpathians, Crimea, and Northern Caucasus); and *R. cf. euryale* is known from the only locality in Crimea. Taxonomic capacity of regions is increasing in the following order: (1) Northern Carpathians and Podolia (1 sp., *RH* [occasionally *RF* also]); (2) Transcarpathians, Crimea, Northern Caucasus (2 sp., *RH*+*RF*); and (3) seaside of Crimea (3 sp., *RH*+*RF*+?*RE*), where caves and grottoes are most warm and suitable for both winter hibernation, and summer breeding of the horseshoe bats.

Among five European rhinolophids, the two most different species are present as a rule in most regions. These are the greater *R. ferrumequinum* and the lesser *R. hipposideros* (fig. 5), while "intermediate" *R. euryale*, *R. mehelyi* and *R. blasii* are known in neighbouring regions, from Central Europe to Caucasus. Analysis shows that species of "intermediate" group penetrate northward by some order. A northernmost distributed species is *R. euryale*, clearly separated by morphological hiatus from both common species, *RH* and *RF*. Two other "intermediate" species (*R. mehelyi* & *R. blasii*) occur in more southern regions (Fig. 5), so their appearance in the higher latitudes corresponds to the level of their morphological differences from other species.

Analysis of long-term changes in Rhinolophidae number shows a regular tendency to decreasing abundances and extremely reduced numbers of *RF* (10 times per century). Taking into account their marginal distribution in the Eastern Europe, this family as a whole should be included in the List of vulnerable taxa. Their risk of extinction in this region completely depends on the strict protection and monitoring of their natural underground roosts.

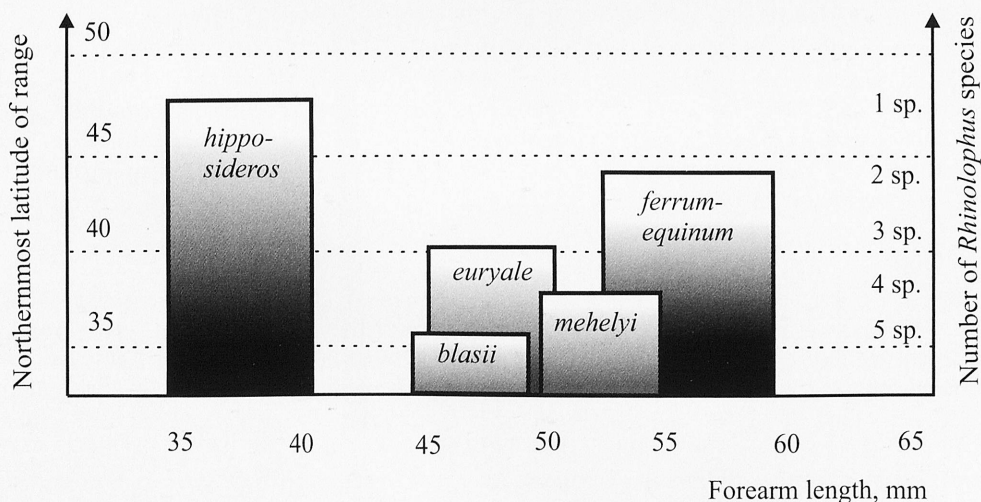


Fig. 5. Distribution of the forearm length in European Rhinolophidae known or supposed in Eastern Europe and neighbouring countries. Species order corresponds to the idea about "intermediate" species insetting in fauna. Northernmost altitudes of species ranges are given according to the results of this investigation and after KUZ'YAKIN 1965; limits of forearm length are given after Table III.

VII. ANNEX (MARGINAL RECORDS OF SPECIES)

Numbering of locality records correspond to the numbers on maps (Fig. 3–4). Abbreviations of administrative units: CRR – Crimean autonomy region, IFO – Ivano-Frankivsk oblast, KHO – Khmelnytsky obl., KRK – Krasnodar Kray, LVO – Lviv obl., MLD – Moldova, TEO – Ternopol obl., TRO – Transcarpathian obl. Frequent references to ABELENTSEV & POPOV (1956) are abbreviated as AP'56.

Rhinolophus hipposideros

Western range. Northern Carpathians (Ukraine): (1) Urizh in Sambir distr., LVO ("Popov 1940" in: TATARINOV 1956; AP'56); (2) Pidgirtsi in Stryj distr., LVO (ibid.); (3) cave in left bank of Svirzh river near Melnya in Rogatyn distr., IFO (TATARINOV 1972); (4) [cave Mokra] near Lokitky ("Popov 1940" in: TATARINOV 1956 and AP'56) and cave Dumka near Odajiv in Tlumach distr., IFO (UNHM, n=5, 1965). **Podolia (Ukraine):** (5) cave Verteba near Bilche-Zolote in Borshchiv distr., TEO (UMHN, n=4, 1965; Pyliavsky in: TATARINOV 1956, 1974; AP'56); cave [Optymistychna?] near Bilche-Zolote (LNHM, n=31, 1951-1952; ZMKU, n=2, 1951; UNHM, n=3, 1965; TATARINOV 1956; AP'56); (6) cave Vitryana, Koralivka [6-SW of Borshchiv], TEO (UNHM, n=1, 1965; AP'56); (7) cave Perlyna in the Medobory Natural Reserve, Krutylyv, Gusiatoryn distr., TEO (ca. n=20, 17.02.1997, RIZUN, pers. comm.); (8) Cave Karmelyuk on left bank of Smotrich river between Zaluchia and Karachkivtsi, Chemerivtsi distr., KHO (TATARINOV 1967); (9) Sokil Mt. near Nigyn, Kamianets-Podilsky distr., KHO (ibid.). **Middle Dnister region (Moldova):** (10) Soroky, MLD (OSTERMANN in: BRAUNER 1910; OSTERMANN 1912); (11) Khrustove in Kamenka distr., MLD (n=1; BRAUNER 1910); (12) artificial undergrounds near Sakharna, right bank of Dnister, MLD (LOZAN 1966); (13) undergrounds on left bank of Dnister near Zhura, MLD (wintering, LOZAN 1966); (14) Kishinev, MLD (BRAUNER in: AP'56); (15) quarries on left bank of Dnister, between Bychok and Krasnogorka, Grigoriopol distr., MLD (1995–1996, wintering and breeding colony, ANDREEV & VASILIEV 1997).

Eastern range. Crimea (Ukraine): (16) Tarkhankut peninsula (VOLOKH & KROCHKO 1994: on map only); (17) Chufut-Cale (Solonchik) in Bakhchisaray distr., CRR (ZMKU, n=1, 1956); (18) Sympheropol, CRR (AP'56); (19) cave Kyzyl-Koba near Perevalne in Zuya distr., CRR (AP'56); (20) "Karasu-Bashi" in Bilogirsk distr., CRR (UNHM, n=5, 1938); (21) Karadagh Mts in Sudak distr., buildings and grottoes, CRR (UNHM, n=11, 1980; n=2, 1981; AP'56; BESKARAVAJNY 1988); (22) Kerch, CRR (UNHM, n=2, 1907). **Northern Caucasus (Russia):** (23) vicinity of Novorossiysk, KRK (UNHM, n=2, 1907); (24) geological gallery near Derbent in Severska distr., KRK (DUVAROVA 1980); (25) cave Fanagoriyska in Goriachiy-Klyuch distr., KRK (DUVAROVA 1980); (26) vicinity of Kamenomostska, Kamyshki, Nikel and Dakhovska in Majkop distr., KRK (KAZAKOV & YARMYSH 1974).

Rhinolophus ferrumequinum

Western range. Transcarpathians (Ukraine): (1) Maly Berezny, TRO (UMHN, n=2, 1948, Abelehtsev; ABELENTSEV 1950); (2) Lyuta and "Begendianska Pastil" (?) in Velyky-Berezny distr., TRO (ibid.); (3) Verkhni Vorota and Pidpolozzia in Volovets distr., TRO (ibid.); (4) Kushnytsa in Irshava distr., TRO (ibid.); (5) Uglya, caves Druzhba, Grebin etc. in the Uholka massive, Tyachiv distr., TRO (AP'56; KROCHKO 1965, 1988; this article); (6) quarries in the Kuziy reserved massif, near Lough in Rakhiv distr., TRO (POKYNCHEREDA & POKYNCHEREDA 1997). **Middle Dnister region (Moldova):** (7) cave La Beci near Koseuts (10-N of Soroky), Soroky distr., MLD (breeding colony, n=14, 16.06.1995; VASILIEV 1997) [questionable records listed in the text above].

Eastern range. Crimea (Ukraine): (8) Olenivka in Tarkhankut peninsula, vicinity and Dzhangul coast, CRR (ZMKU, n=1, 1956; UNHM, n=1, 1982; KRYZHANOVSKY 1988); (9) Evpatoria, vicinity, CRR (KRYZHANOVSKY 1988; VOLOKH & KROCHKO 1994, on map without de-

tails); (10) Chufut-Kale in Bakhchisaray distr., vicinity, Solonchik, Starosillia and cave Golubyna, CRR (ZMKU, n=2, 1956; UNHM, n=3, 1965; KRYZHANOVSKY 1988); (11) Sympheropol, in buildings (UNHM, n=5, 1904, n=51, 1927; MYGULIN 1938); "Sabli" near Sympheropol, CRR (UNHM, n=2, 1915); (12) cave Kyzyl-Koba near Perevalne in Zuya distr., CRR (UNHM, n=1, 1905, n=4, 1911, n=30, 1913, n=1, 1982; AP'56); (13) "Karasu-Bashi" in Bilogirsk distr., CRR (UNHM, n=2, 1938; n=1, 1948); Kvitkove, Mizhgiria and Biyuk-Karasu river in Bilogirsk distr., CRR (KRYZHANOVSKY 1988); (14) Kamenske in Lenin distr., near basis of Arabatka Spit, CRR (ibid.; VOLOKH & KROCHKO 1994: on map without details); (15) cave in Opuk Mt., CRR (in colony of *M. myotis*, 1995, 1996, Tsvelykh, pers. comm.); (16) quarry near Kerch, CRR (KRYZHANOVSKY 1988; VOLOKH & KROCHKO 1994: on map without details). **Northern Caucasus (Russia):** (17) vicinity of Novorossiysk, KRK (UNHM, n=2, 1907); (18) Derbent in Severska distr., KRK (DUVAROVA 1980); (19) vicinity of Kamenomostska, Kamyshki and Dakhovska in Majkop distr., KRK (KAZAKOV & YARMYSH 1974).

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