Acta zoologica cracoviensia, **46**(1): 73-84, Kraków, 28 March, 2003

Late Pleistocene and Holocene bats (Chiroptera) from the Komarowa Cave (Cracow-Częstochowa Upland, Poland) – preliminary results

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Received: 21 Feb., 2003
Accepted for publication: 3 March, 2003

OCHMAN K. 2003. Late Pleistocene and Holocene bats (Chiroptera) from the Komarowa Cave (Cracow-Częstochowa Upland, Poland) – preliminary results. *Acta zoologica cracoviensia*, **46**(1): 73-84.

Abstract. Excavations in the Komarowa Cave in the "Sokole Góry" Natural Reserve (Cracow-Częstochowa Upland, Poland) yielded the Pleistocene and Holocene remains of bats (NISP=270, MNI=167) belonging to 16 species. In most layers *Myotis bechsteinii*, *M. nattereri*, and *M. daubentonii* predominated. The fossils contained interesting and rare bats *Rhinolophus hipposideros, M. emarginatus*, *Vespertilio murinus*, *Plecotus* cf. *austriacus* as well as *Pipistrellus nathusii* which remains were found in Poland for the first time. In most sediments (in the case of layers A, C, D, Ft, Gt, J) bat assemblages indicated the presence of forests in the vicinity of the cave and a relatively warm and humid climate. The Holocene-Recent succession of bats in the "Sokole Góry" Natural Reserve is discussed.

Key-words: thanatocenosis, fossil bats, Late Quaternary.

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I. INTRODUCTION

The Komarowa Cave is situated on the northern slope of the Puchacz Hill in the "Sokole Góry" Natural Reserve (northern part of Cracow-Częstochowa Upland, Olsztyn community, Poland) about 10 km in a south-eastarly direction from Częstochowa. In the Reserve about 90 other caves and rock-shelters are known.

A broad, main entrance to the Komarowa Cave is located about 340 m above sea level. An open terrace, directed northword, is situated before the entrance. The cave forms a corridor 20 m long, in the south-west direction, gradually narrowing towards the end. The corridor is composed of a few small chambers (Fig. 1).

The Komarowa Cave was excavated during 1998-2002 by the Polish Geological Institute in Warsaw, Institute of Archaeology, Warsaw University, in collaboration with the Museum of the Earth, Polish Academy of Sciences in Warsaw and Institute of Systematics and Evolution of Animals, Polish Academy of Sciences in Cracow. The cave had not been previously explored.

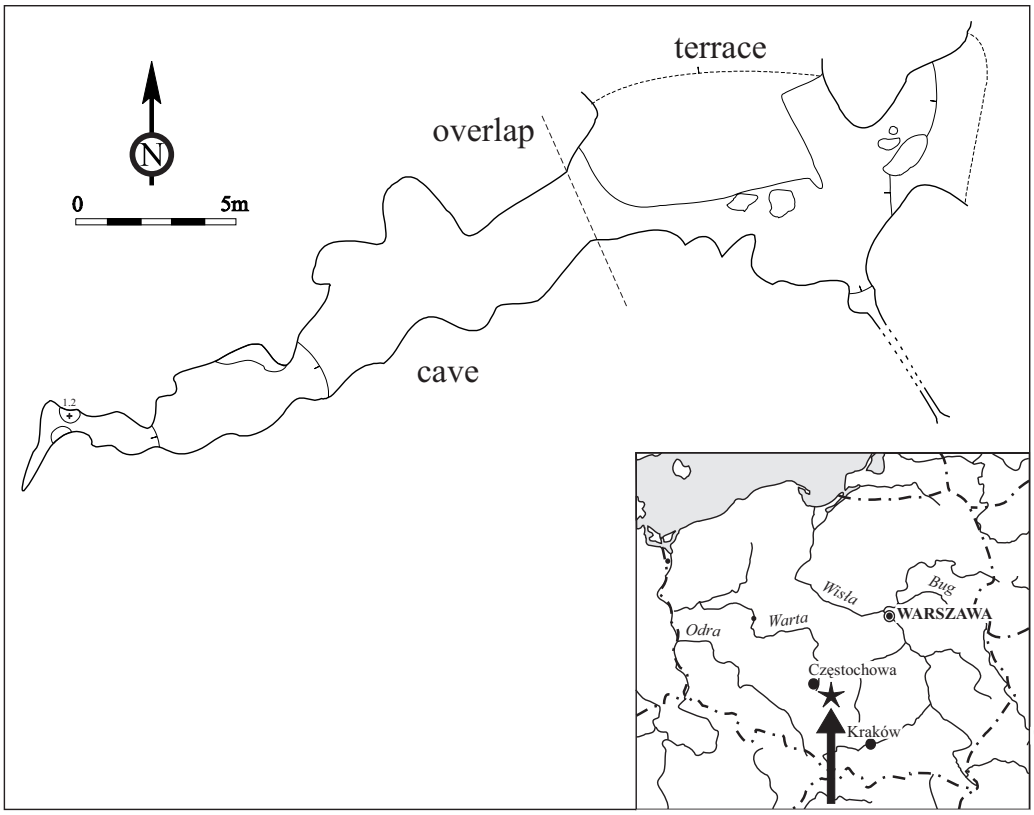

Fig. 1. The plan and location of the Komarowa Cave (after J. ZYGMUNT, modified).

The Komarowa Cave is the only locality in this area in which long-term excavations have been undertaken. The cave contained the Holocene and Late Pleistocene sediment sequence with a relatively complicated stratigraphy. The locality yielded abundant remains of molluscs and vertebrates, including rodents which are good indicators of climatic and environmental changes.

Excavations were carried out inside the cave and on the terrace in the front of the cave (Fig. 2). Probably the terrace formed a part of the cave in the past, but the roof of the chamber collapsed. After this disaster a series of eolian sand was accumulated therefore only here – at the terrace – is a very thick layer B present (ŻARSKI 2000).

The cave floor was covered with clayey-loamy sediment and admixture of limestone rubble with layer of humus at the top. During the excavations one longitudinal profile and four transversal profiles were openned.

The layer A is built up by the Holocene humus (GIERLIŃSKI et al. 1998, ŻARSKI 2000) mixed with limestone rubble, sand, and loam. At the terrace below layer A, a series of thick sediments (layer B) was deposited (Fig. 3). Layer B is formed by eolian sands most probably of Late Glacial age with clayey-rubble insertions (marked with Z) as a result of the slope solifluction processes. Deeper parts of the profile are composed of residual clay and loam with rubble (layers B/F', Ft, Gt, Ht, Jt, and Kt), an autochthonous components of the cave filling probably of much older age (Early Vistulian?). Layers Ht, Jt, and Kt did not contain bat remains and are not visible in the longitudinal

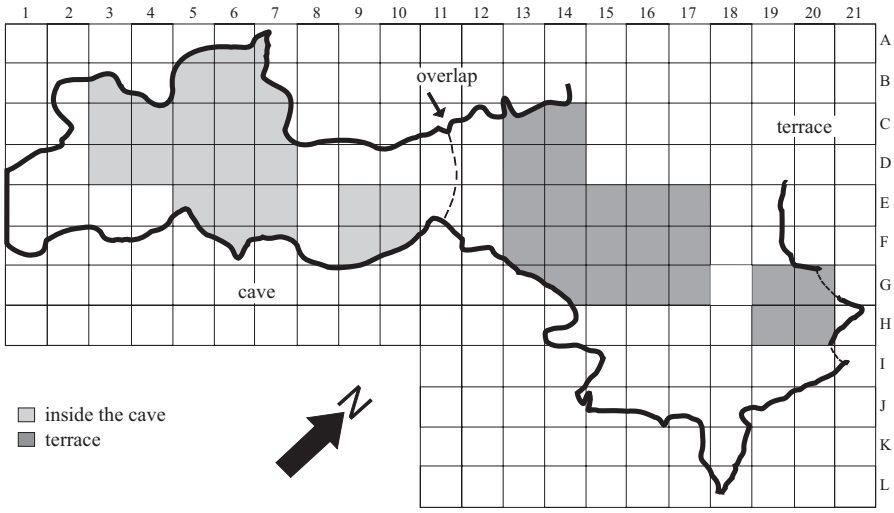

Fig. 2. The Komarowa Cave localization of trenches (after URBANOWSKI 2002).

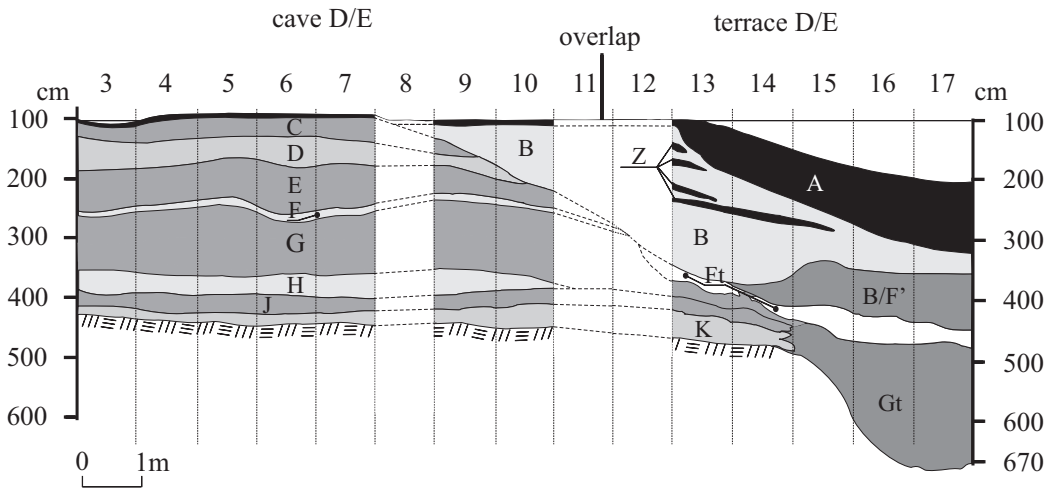

Fig. 3. The Komarowa Cave – longitudinal profile. Numbers depict exploration meters and letters – successive layers (after M. ŻARSKI, simplified).

profile (compare Fig. 3). Inside the cave the thickness of layer A is about 15 cm while layer B is present only in the entrance (Fig. 3). Layers C, D, E, F, G, H, J, and K are built by autochthonous residual clay with limestone rubble of Interplenivistulian and/or Early Vistulian age. In layer D the limestone rubble is covered by incrustations of calcium carbonate, while in layers F and Ft by manganese incrustations, which caused the black colour of many bones found here.

Bat bones are frequently found in Polish cave sediments. They are accumulated as a result of the death of bats which hibernate in the cave winter colonies (WOŁOSZYN 1970). The first and very fragmentary information concerning subfossil bat fauna of "Sokole Góry" Natural Reserve comes

from SKALSKI and WÓJCIK (1968) who described bat remains from the Pod Sokolą Górą and Studnisko caves belonging to the 8 following species: *Myotis nattereri*, *M. daubentonii*, *M. bechsteinii*, *M. myotis*, *M. dasycneme*, *M. mystacinus*, *Plecotus auritus* and *P. austriacus*. Studies of the Holocene bat remains from the Pod Sokolą Górą Cave and other caves of this area were later undertaken by OCHMAN and WOŁOSZYN (2000, 2001).

The aim of this paper is to describe fossil and subfossil bat fauna of the Komarowa Cave and comparison with other similar thanatocenoses from southern Poland.

A c k n o w l e d g m e n t s. This study was partly supported by grant 6 P04C 09720 of the Polish Scientific Committee. The author is especially grateful to Prof. Adam NADACHOWSKI, Msc. Grzegorz LIPECKI and Dr. Piotr WOJTAL for their help while preparing the manuscript, Dr. Marcin ŻARSKI, MSc. Mikołaj URBANOWSKI, MSc. Mirosław KRAWCZYK, and Dr. Barbara MIĘKINA for the collecting of material in the field, stratigraphic data, and permission for the use of profile figure in this paper.

II. MATERIALS AND METHODS

Bone remains from particular layers were cleaned and determined. The colour of the bones is yellowish (layer A), light brown to brown-grey (layers B, D, Ft, and G), and yellow-brown with black pigment (layers Gt, H, and J). The material shows various degrees of preservation, some bones (from deeper layers) are considerably fragmented. Many isolated bat's teeth were found. The Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI) were calculated. The MNI is the maximum number of one category remains of one species in a given layer and was calculated according to KLEIN and CRUZ URIBE (1984). In diagrams that show bat species composition in particular layers, the MNI was used. The following bat species names and acronyms were used:

Acronym	English Name	Latin Name
Family: horseshoe bats Rhinolophidae		
RHIP	Lesser Horseshoe Bat	*Rhinolophus hipposideros* (BECHSTEIN, 1774)
Family: common bats Vespertilionidae		
MMYO	Mouse-eared Bat	*Myotis myotis* (BORKHAUSEN, 1797)
MBEC	Bechstein's Bat	*Myotis bechsteinii* (KUHL, 1818)
MNAT	Natterer's Bat	*Myotis nattereri* (KUHL, 1818)
MEMA	Geoffroy's Bat	*Myotis emarginatus* (GEOFFROY, 1806)
MMYS	Whiskered Bat	*Myotis mystacinus* (KUHL, 1819)
MBRA	Brandt's Bat	*Myotis brandtii* (EVERSMANN, 1845)
MMYS/MBRA	Whiskered/Brandt's Bat	*Myotis mystacinus/brandtii*
MDAU	Daubenton's Bat	*Myotis daubentonii* (KUHL, 1819)
MDAS	Pond Bat	*Myotis dasycneme* (BOIE, 1825)
VMUR	Parti-coloured Bat	*Vespertilio murinus* LINNAEUS, 1758
ESER	Serotine Bat	*Eptesicus serotinus* (SCHREBER, 1774)
ENIL	Northern Bat	*Eptesicus nilssonii* (KEYSERLING et BLASIUS, 1839)
PPIP	Pipistrelle Bat	*Pipistrellus pipistrellus* (SCHREBER, 1774)
PNAT	Nathusius' Pipistrelle Bat	*Pipistrellus nathusii* (KEYSERLING et BLASIUS, 1839)
PAUR	Common Long-eared Bat	*Plecotus auritus* (LINNAEUS, 1758)
PAUS	Gray Long-eared Bat	*Plecotus austriacus* (FISHER, 1829)
BBAR	Barbastelle Bat	*Barbastella barbastellus* (SCHREBER, 1774)

Because *Myotis brandtii* and *Myotis mystacinus* constitute a pair of sibling species difficult for differentiation, some of the very damaged fragments of their remains were identified to the species group: *Myotis mystacinus/brandtii* (marked by acronym – MMYS/MBRA).

Because of the various genesis and different sedimentation processes involved, the material studied was analysed separately in the cave and terrace sequences (Fig. 3).

Bat remains are housed in the collection of the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences in Cracow.

III. RESULTS AND DISCUSSION

As a result of excavations, 361 bat remains from 16 species were found, from which 235 were determined to the species level. The Minimum Number of Individuals (MNI) is 167. For the cave sequences this number counts 47 and for the terrace 120 individuals (NISP making up 66 and 204, respectively). The bat osteological material was found in layers: A*, A, B, C, D, Ft, G, Gt, H, and J (Table I).

In both analysed sequences of the Komarowa Cave (the cave and the terrace) three bat species predominate *M. bechsteinii* (with the exception of layers Ft, H, and J); *M. nattereri* and *M. daubentonii* (Table I) are also numerous. Other species are represented by a rather small number of remains (MNI from 1 to 4).

The cave sequence

In layer A* only three remains belonging to two species, *Myotis bechsteinii* and *M. daubentoni* (Table I), were found.

Layer C is characterized by a not so distinct predomination of *M. bechsteinii* (MNI=3) over other species as in some other levels. *M. nattereri* and *M. daubentonii* show here equal proportions. The presence of species connected with forest environments, e.g. *M. bechsteinii*, *Plecotus auritus*, and *Barbastella barbastellus*, may suggest a considerable development of forests in the cave surroundings.

In layer D a small number of bats were found. The most numerous species is *M. bechsteinii.* A thermophilous *Rhinolophus hipposideros* and *M. daubentonii* preferring a warmer climate, were recorded in this layer. Also *M.* cf. *dasycneme*, *M. daubentonii*, and *B. barbastellus*, species that prefer humid environments and hunt in riparian areas and or/over the open water pools (STEBBINGS 1986), are present in the assemblage. Probably at the time of formation of this layer mild climatic conditions (humid and warm) prevailed. *R. hipposideros* and *M. dasycneme* are at present rare in Poland and occur in thanatocenoses not very often.

Layer G contains only three bone bat fragments: *M. bechsteinii*, *M. dasycneme*, and *P. auritus*.

In layer H small number of remains were preserved. The most part of material belongs to *M. daubentonii*. *M. bechsteinii* is not a predominant species here. A record of *Vespertilio* cf. *murinus* is very interesting. In cave sediments in Poland this species appears sporadically. *Vespertilio murinus* and *Eptesicus serotinus* that occur in the discussed layer suggest the presence of an open areas or parklands in the vicinity of the Komarowa Cave at that time. A rare species *M. dasycneme* was also found.

Layer J contains 27 remains (MNI=16) identified to the species and genera levels. Most of them belong to *M. daubentonii* (or *M.* cf. *daubentonii*) (MNI=5). In this layer, as in the previous one, *Vespertilio murinus* was identified. Three species connected with forest environment occurred here (*M. bechsteinii, P. auritus*, *B. barbastellus*) and two more which hunt in riparian habitats (*M. daubentonii*, *M. dasycneme*). They all suggest a relatively moderate, warm, and humid climate.

Table I

Number of Identified Specimens (first number in a column refers to NISP) and Minimum Number of Individuals (second number in a column refers to MNI) of bat species. The NISP was calculated as a sum of remains identified to the species and genera levels. A* – layer "A" inside the cave

Species	Layer										Total	MNI [%]
	Cave						Terrace					
	A*	C	D	G	H	J	A	B	Ft	Gt		
Rhinolophus hipposideros	–	–	1-1	–	–	–	–	–	1-1	–	2-2	1.2
Myotis myotis	–	–	–	–	–	–	1-1	–	–	–	1-1	0.6
Myotis bechsteinii	2-1	5-3	3-2	1-1	1-1	4-2	49-26	8-4	2-1	9-7	84-48	28.6
Myotis cf. *bechsteinii*	–	–	2-1	–	–	1-1	4-3	–	–	1-1	8-6	3.6
Myotis nattereri	–	2-2	–	–	–	3-2	29-22	6-2	4-3	–	44-31	18.6
Myotis cf. *nattereri*	–	–	–	–	–	–	1-1	–	–	–	1-1	0.6
Myotis emarginatus	–	–	–	–	–	–	–	–	–	1-1	1-1	0.6
Myotis cf. *emarginatus*	–	–	–	–	–	–	–	–	–	1-1	1-1	0.6
Myotis mystacinus	–	–	–	–	–	1-1	1-1	–	1-1	1-1	4-4	2.4
Myotis brandtii	–	1-1	1-1	–	1-1	–	2-1	1-1	–	–	6-5	3.0
Myotis mystacinus/brandtii	–	–	–	–	–	–	1-1	–	2-1	1-1	4-3	1.8
Myotis daubentonii	1-1	3-2	2-1	–	3-2	6-4	16-7	2-2	4-2	3-1	40-22	13.2
Myotis cf. *daubentonii*	–	–	–	–	–	2-1	–	–	–	–	2-1	0.6
Myotis dasycneme	–	–	–	1-1	1-1	1-1	3-2	–	1-1	1-1	8-7	4.2
Myotis cf. *dasycneme*	–	–	1-1	–	–	–	–	–	–	–	1-1	0.6
Myotis sp.	–	–	–	–	–	1	7	–	–	1	9	–
Vespertilio murinus	–	–	–	–	–	2-1	1-1	–	–	–	3-2	1.2
Vespertilio cf. *murinus*	–	–	–	–	1-1	–	–	–	–	–	1-1	0.6
Eptesicus serotinus	–	–	–	–	1-1	–	2-1	–	–	1-1	4-3	1.8
Eptesicus nilssonii	–	–	–	–	–	–	6-2	1-1	1-1	1-1	9-5	3.0
cf. *Eptesicus nilssonii*	–	–	–	–	–	–	1-1	–	–	1-1	2-2	1.2
Pipistrellus nathusii	–	–	–	–	–	–	–	1-1	–	–	1-1	0.6
Pipistrellus sp.	–	–	–	–	–	–	–	1	–	–	1	–
Plecotus auritus	–	1-1	1-1	1-1	–	2-1	11-4	–	–	2-1	18-9	5.4
Plecotus cf. *auritus*	–	–	–	–	–	2-1	–	–	–	–	2-1	0.6
Plecotus cf. *austriacus*	–	–	–	–	–	–	–	–	–	1-1	1-1	0.6
Plecotus sp.	–	–	–	–	–	1	–	1	–	–	2	–
Barbastella barbastellus	–	1-1	1-1	–	–	1-1	6-4	–	–	1-1	10-8	4.8
Total NISP-MNI	3-2	13-10	12-9	3-3	8-7	27-16	141-78	21-11	16-11	26-20	270-167	100
Chiroptera indet.	–	1	–	–	1	16	38	13	3	19	91	

The terrace sequence

Layer A is abundant in bat remains (NISP=141 and MNI=78). The predomination of *M. bechsteinii* and high representation of *M. nattereri* in this layer is characteristic of the Holocene assemblages. Other species are very rare such as *Vespertilio murinus* and *Myotis dasycneme*. In the

discussed layer most species (*Myotis bechsteinii*, *Vespertilio murinus*, *Eptesicus nilssonii*, *E. serotinus*, *P. auritus* and *B. barbastellus*) are connected with forests. Species composition indicates moderate climates at the time of layer accumulation. Also one bone fragment belonging to *Myotis myotis* – a rare species in Late Pleistocene and early Holocene thanatocenoses – was found.

In layer B, twenty-one bat remains were identified (MNI=11). In the material studied *M. bechsteinii* (a predominant species) and *Eptesicus nilssonii* as well as *Pipistrellus nathusii,* bats connected with forests, are present. The discovery of a single tooth (M_2) of *Pipistrellus nathusii* is very interesting. This species is practically not recorded in the cave's thanatocenoses. As in the case of *Eptesicus* and *Vespertilio,* remains of *P. nathusii* probably appeared in the cave as an owl pellet component.

Most remains in layer Ft belong to *M. nattereri*. *Rhinolophus hipposideros* is also recorded. This fact and the presence of *M. daubentonii* and *M. daycneme* may suggest a warm climate and humid conditions. *E. nilssonii* and *M. bechsteinii*, which prefer woodlands, are additional species in the assemblage.

In layer Gt as many as 26 bat teeth and bones (MNI=20) were identified. In this layer, rich in bats, *M. bechsteinii* predominates distinctly. Other species are represented only by 1-3 bone fragments. There are species closely connected with forests (e.g. *Eptesicus nilssonii*, *Plecotus auritus*, and *Barbastella barbastellus*) and species hunting over water pools and in riparian habitats (e.g. *Myotis daubentonii*, *M. dasycneme*, and *Barbastella barbastellus*). Thermophilous *Myotis emarginatus* was found only in this layer, as well as *Plecotus* cf. *austriacus*. It seems that, as in layers D and Ft, the climate was humid and relatively warm.

Remarks on rare species of bats

In the sequence of the Komarowa Cave, the following five interesting and rare species of bats were found: *Rhinolophus hipposideros*, *Myotis emarginatus*, *Vespertilio murinus*, *Pipistrellus nathusii*, and *Plecotus* cf. *austriacus*.

The Lesser Horseshoe Bat (*Rhinolophus hipposideros*) is a species connected with woodlands, scrub, and grasslands that hibernates in caves (STEBBINGS 1986). *Rhinolophus hipposideros*, like other European horseshoe bats, is a thermophilous species. In the Pleistocene of Poland it was found in the Sudeten Mts in Wschodnia w Połomie Cave (ZOTZ 1939), in the Radochowska Cave deposits (as cf.) probably from the last glaciation (WOŁOSZYN 1989) and in the Carpathians (OCHMAN and WOŁOSZYN – in press) in the Obłazowa Cave (layer VIII – Interplenivistulian, and layer V – Late Vistulian). In the Holocene deposits *R. hipposideros* was identified only in a few localities: in layer 3 of the Duża Cave at Mączna Skała (DAGNAN-GINTER et al. 1992), in the Late Holocene sample W-3 of the Cave in the Sobczański Gully in the Pieniny Mts (ALEXANDROWICZ et al. 1985), and in the Late Holocene sediments of the U ródła Cave, Na Tomaszówkach Górnych Cave, and Nietoperzowa Cave (WOŁOSZYN 1989). The presence of this species in layers D and Ft of the Komarowa Cave is very interesting, because until now *Rhinolophus hipposideros* had been found only in the Cracow-Częstochowa Upland in Late Holocene assemblages (WOŁOSZYN 1981). It is the oldest and most northern fossil locality of *R. hipposideros* in Poland. At present, the Cracow-Częstochowa Upland area is the northern distribution boundary of this species in Poland. *R. hipposideros* hibernates in the Studnisko, Olsztyńska, Koralowa, and W Zielonej Górze caves (KOWALSKI 1953, POSTAWA and ZYGMUNT 2000).

Geoffroy's Bat (*Myotis emarginatus*) is also a thermophilous species, wintering in caves. It feeds in woodlands, parklands, scrublands, and pasture (STEBBINGS 1986). In the Pleistocene assemblages it was found in the Sąspowska Zachodnia Cave in layer 2 (Interpleniglacial) – as *M.* cf. *emarginatus* (MADEYSKA 1981), and in Przymiłowice 5 and 6 of probably Middle Pleistocene age (NADACHOWSKI et al. 1991) where it distinctly predominated in the assemblages (55% and 31% of the identified bat bones, respectively). In the Pod Sokolą Górą Cave, which is located a few hundred meters to the south from the Komarowa Cave, subfossil materials of *M. emarginatus* were recorded (OCHMAN and WOŁOSZYN 2000). The Komarowa Cave (layer Gt) is the fourth fossil locality of

Myotis emarginatus in Poland. In the Late Holocene it became less numerous and recently is also a very rare species. At present the northern distribution boundary of this species crosses the Częstochowa Upland (WOŁOSZYN 1992, 2001a, 2001b), precisely in the "Sokole Góry" area where it was found twice in the Koralowa Cave in 1951 (1 individual – HARMATA and TRZASKA 1958) and in 1998 (POSTAWA and ZYGMUNT 2000).

Parti-coloured Bat (*Vespertilio murinus*) occurs in forest margins and open areas, sometimes hibernating in caves. Its remains in Pleistocene sediments of Poland were recorded twice in Przymiłowice 1 (NADACHOWSKI et al. 1991) of Early Pleistocene age and in Upper Pleniglacial (layer VII) and Late Glacial (layer V) of the Obłazowa Cave (OCHMAN and WOŁOSZYN – in press). Holocene bone remains of this species were also found in Early and Middle Holocene deposits (sample W-8 and W-6) in a Cave of the Sobczański Gully, Pieniny Mts. (ALEXANDROWICZ et al. 1985). The presence of *Vespertilio murinus* in the Komarowa Cave (layers A and J), is the fourth fossil record of this species in Poland.

Associated with deciduous and mixed forests, Nathusius' Pipistrelle Bat (*Pipistrellus nathusii*) is a species that lives in parklands and mixed light woodlands, hunting on forest margins and also in riparian habitats (STEBBINGS 1986, WOŁOSZYN 2001a). As a rule *P. nathusii* does not hibernate in caves, but in tree hollows. For this reason, remains of *P. nathusii* are found in caves only exceptionally. The Komarowa Cave (layer B) is the first fossil record of this species in Poland.

In layer Gt a mandible fragment of *Plecotus* cf. *austriacus* was found. This species was also recorded in Late Pleistocene localities of the Duża Cave at Mączna Skała (layers 4 and 5) in the Cracow-Częstochowa Upland (DAGNAN-GINTER et al. 1992) and Obłazowa Cave (the Carpathians) in layer VIII (Interplenivistulian – OCHMAN and WOŁOSZYN – in press). The Komarowa Cave is the third Pleistocene locality of *Plecotus austriacus* in Poland. The Holocene remains of *Plecotus austriacus* are more numerous and were recorded from the Cave in the Sobczański Gully (ALEXANDROWICZ et al. 1985), Obłazowa Cave (OCHMAN and WOŁOSZYN – in press), Zbójecka w Łagowie Cave in the Holy Cross Mts and in layer 3 of the Duża Cave at Mączna Skała near Cracow. WOŁOSZYN (1965) supposed that expansion of this species into the Cracow-Częstochowa Upland area took place only in the Late Holocene, perhaps in historical times, but records of this species in the Duża Cave at Mączna Skała near Cracow (DAGNAN-GINTER et al. 1992) and in the Komarowa Cave suggest an earlier appearance of this species in the area.

Comparison of the Holocene and recent bat faunas

In the "Sokole Góry" Natural Reserve, in which the Komarowa Cave is situated, subfossil material from the Pod Sokolą Górą Cave was studied (OCHMAN and WOŁOSZYN 2000, 2001). A comparison of the Komarowa Cave thanatocenosis from the Holocene layer A with the Holocene fauna from the Pod Sokolą Górą Cave shows some important differences (Table II, Fig. 4). In the Komarowa Cave (layer A) 12 bat species were recorded, and 11 in subfossil material from the Pod Sokolą Górą Cave. *M. myotis* distinctly increases its frequency from 0.2%, in probably an older Pod Sokolą Górą Cave assemblage, through 1.3% in layer A of the Komarowa Cave to 67.6% in recent bat fauna of Sokole Góry. This confirms an earlier supposition of BOCHEŃSKI et al. (1983) of a distinct expansion of *M. myotis* in this area from the Late Holocene up to recent times. In Europe *M. myotis* probably became more numerous only in the Late Pleistocene or even the Holocene (WOŁOSZYN 1995). In contrast, the *M. nattereri* percentage decreases successively from 69.3% in the Pod Sokolą Górą Cave, 28.2% in layer A of the Komarowa Cave, to 21.7% in the recent fauna of "Sokole Góry". Proportions of *M. bechsteinii* remains fluctuate from 9.8% in the Pod Sokolą Górą Cave to 33.2% in layer A of the Komarowa Cave. At present this species in very rare in the "Sokole Góry" Natural Reserve (0.1%).

In sediments of layer A in the Komarowa Cave *Myotis bechsteinii* and *M. nattereri* predominate, but the second species shows a distinctly lower frequency. A co-predominated species is *Myotis daubentonii*, which has nearly constant proportions in both discussed subfossil faunas. In the Pod Sokolą Górą Cave *M. nattereri* is a super-predominant species (69.3%) while *M. bechsteinii* and

M. daubentonii make 9.8% and 8.9% of the fauna, respectively (Table II). The super-predomination of *M. nattereri* in the Pod Sokolą Górą Cave is the most important difference between these faunas. Some species are present only in one locality or are represented by a few remains (0.1%-2.3%, Table II). The Komarowa Cave layer A assemblage, contains remains of *Vespertilio murinus*, *Eptesicus serotinus*, and *Eptesicus nilssonii,* species closely connected and hibernated in forests. In the Pod Sokolą Górą Cave these species are absent (Fig. 4). A distinct super-predomination of *M. nattereri*, that prefers hibernation in cool places, is probably connected not only with external climatic conditions of the cave environment, but also with the cold microclimate of the Pod Sokolą Górą Cave as a result of cold air accumulation (OCHMAN and WOŁOSZYN 2000, POSTAWA 2000).

In spite of the very close geographical position of the two localities their subfossil assemblages differ distinctly.

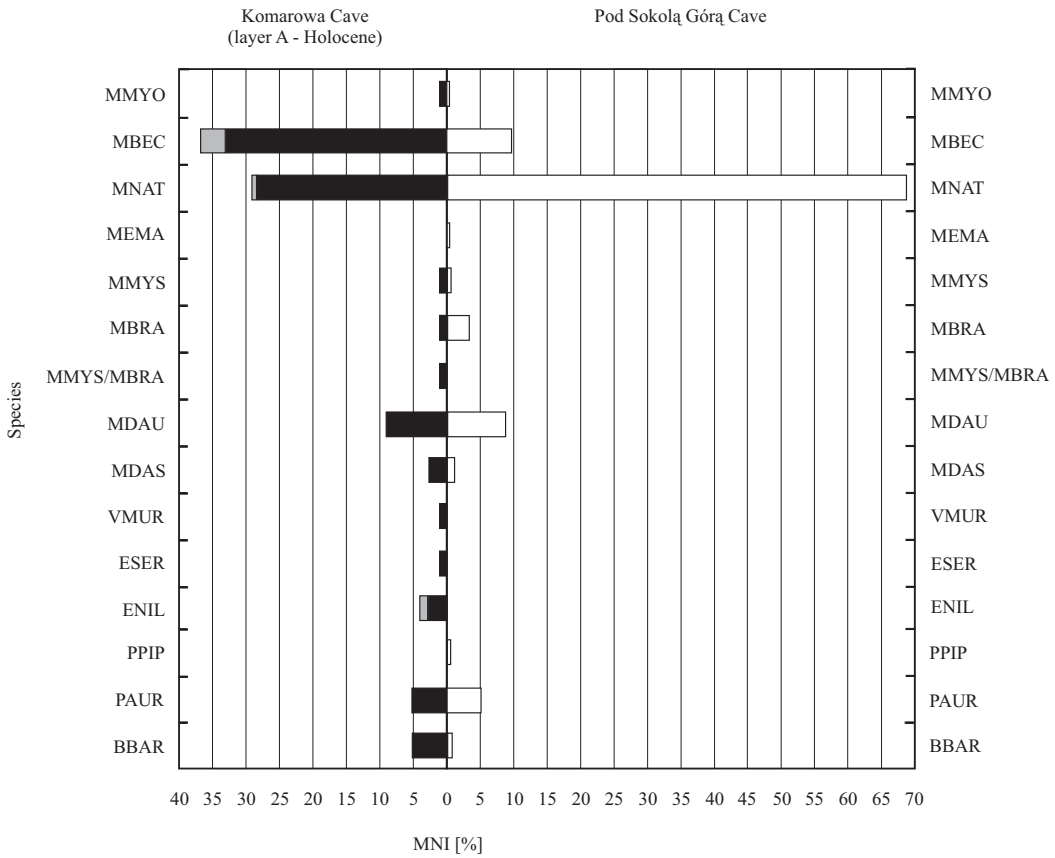

Fig. 4. Comparison of species composition of bat faunas from the Komarowa Cave (layer A) and the Pod Sokolą Górą Cave. Proportions of the remains identified as a "cf.", are given as a grey part of the chart.

Table II

Comparison of the Pod Sokolą Górą Cave (OCHMAN and WOŁOSZYN 2000) and Komarowa Cave (layer A) thanatocenoses with recent bat fauna of the "Sokole Góry" Natural Reserve (POSTAWA and ZYGMUNT 2000).

Species	Pod Sokolą Górą Cave MNI [%]	Komarowa Cave layer A MNI [%]	"Sokole Góry" recent [%]
Rhinolophus hipposideros	–	–	0.4
Myotis myotis	0.2	1.3	67.6
Myotis bechsteinii	9.8	33.2	0.1
Myotis cf. *bechsteinii*	–	3.8	–
Myotis nattereri	69.3	28.2	21.7
Myotis cf. *nattereri*	–	1.3	–
Myotis emarginatus	0.2	–	0.1
Myotis mystacinus	0.5	1.3	0.1
Myotis brandtii	3.3	1.3	0.1
Myotis mystacinus/brandtii	–	1.3	3.6
Myotis daubentonii	8.9	9.0	3.5
Myotis dasycneme	1.2	2.6	0.1
Vespertilio murinus	–	1.3	–
Eptesicus serotinus	–	1.3	0.1
Eptesicus nilssonii	–	2.6	0.1
cf. *Eptesicus nilssonii*	–	1.3	–
Pipistrellus pipistrellus	0.6	–	–
Plecotus auritus	5.2	5.1	2.2
Plecotus austriacus	–	–	0.1
Barbastella barbastellus	0.8	5.1	0.2
Total	100.0	100.0	100.0

In the recent bat fauna of the "Sokole Góry" Natural Reserve, *Myotis myotis* is the superpredominant species (67.6%). There is an important difference between the Komarowa Cave thanatocenosis and recent fauna of "Sokole Góry". In the subfossil assemblage *M. myotis* is represented only by one mandible fragment (layer A). Other differences are the higher frequency of *M. daubentonii* and distinctly higher representation of *M. bechsteinii* in the Komarowa Cave where it is a predominant species. *Myotis nattereri* shows more or less the same frequency in both Komarowa Cave and recent bat assemblages (Table II). In the recent fauna *Rhinolophus hipposideros*, *Myotis emarginatus*, and *Plecotus austriacus* are present, while in layer A of the Komarowa and Pod Sokolą Górą caves these species are absent. Remains of *Vespertilio murinus* were recorded only in sediments of the Komarowa Cave while *Pipistrellus pipistrellus* was found only in the Pod Sokolą Górą Cave.

IV. CONCLUSIONS

The bat fauna of the Komarowa Cave is very rich (16 species) in comparison with other similar localities in south Poland. The bats wintering in caves as well as usually hibernating out of them, e.g. in the tree hollows, like *Pipistrellus nathusii* found in layer B, are recorded in the cave. The rare

species are represented in fossil assemblages by a small number of remains. For some of them (*Rhinolophus hippossideros* and *Plecotus austriacus*) Komarowa Cave is the most northern fossil locality in Poland. The occurrence of *R. hipposideros* in layer D and *Myotis emarginatus* in layer Gt are the first Late Pleistocene appearance dates of these species in Kraków-Częstochowa Upland.

Species composition of bat fauna in most layers of the Komarowa Cave (Table I) is a typical Late Pleistocene cave assemblage in Poland, were *M. bechsteinii* distinctly predominates, *M. nattereri* is a co-predominant form and *M. daubentonii* usually an accessorial species. The Pod Sokolą Górą Cave fauna in which *M. nattereri* is super-predominant species and *M. bechsteinii* is co-predominant is dated to the Atlantic period of the Holocene (POSTAWA 2001). A high number of "forest species" and especially the predominance of *M. bechsteinii* in layer A of the Komarowa Cave, suggests the age of Subboreal/Subatlantic period of the Holocene, when in south Poland the development of forests with admixture of *Fagus silvatica* was recorded (STARKEL 1999). *M. bechsteinii* is connected with deciduous or mixed forests with considerable representation of this tree. *Fagus silvatica* started its expansion in south Poland about 5000 – 4000 ^{14}C BP and was more common only 3000 ^{14}C BP (STARKEL 1999).

Other layers of the Komarowa Cave are probably of Late Pleistocene age. Most were accumulated in relatively warm and humid climate what is confirmed by the presence of thermophilous species and/or species indicative for humid environment. The warmest climate seems to occur at the time of accumulation of layer D and the most humid – in layers Ft, H and J. The most favourable climatic conditions prevail at the time of formation of layers D and Ft. Therefore it seems probable that layers D, Ft, H, and may by J were accumulated in early interstadials of last glaciation.

In deeper layers of the Komarowa Cave (Gt, J), a massif bat mandible fragments of *Myotis* cf. *bechsteinii* and *Plecotus* were found. These layers are probably of older age (Middle Pleistocene?) or the mentioned material was mixed with younger deposits at the time of accumulation.

REFERENCES

ALEXANDROWICZ S. W., NADACHOWSKI A., RYDLEWSKI J., VALDE-NOWAK P., WOŁOSZYN B. W. 1985. Subfossil fauna from a Cave in Sobczański Gully (Pieniny Mts., Poland). *Folia quarternaria*, Kraków, **56**: 57-78.

BOCHEŃSKI Z., MŁYNARSKI M., NADACHOWSKI A., STWORZEWICZ E., WOŁOSZYN B. W. 1983. Górnoholoceńska fauna z Jaskini Dużej Sowy (doniesienie wstępne). [Upper Holocene fauna from Duża Sowa Cave (preliminary notes)]. *Przegląd zoologiczny*, Wrocław, **27**(4): 437-455. (In Polish with English summary).

DAGNAN-GINTER A., DROBNIEWICZ B., GODAWA J., MIĘKINA B., SOBCZYK K., STWORZEWICZ E. 1992. Excavations in the Duża Cave at Mączna Skała near Cracow (southern Poland). *Folia quarternaria*, Kraków, **63**: 3-27.

GIERLIŃSKI G., JAKUBOWSKI G., PIASECKI K., URBANOWSKI M., ŻARSKI M. 1998. Nowe późnoplejstoceńskie stanowisko paleontologiczno-archeologiczne w Jaskini Komarowej na Wyżynie Częstochowskiej – sprawozdanie wstępne. [A new late Pleistocene paleontological and archeological site of the Komarowa Cave in southern Poland – preliminary report]. *Przegląd geologiczny*, Warszawa, **46**(10): 1019-1022. (In Polish with English summary).

HARMATA W., TRZASKA J. 1958. Nowe stanowiska nietoperza nocka orzęsionego (*Myotis emarginatus* GEOFFROY) w południowej Polsce. *Zeszyty Naukowe UJ. Zoologia*, Kraków, **3**: 19. (In Polish).

KLEIN R. G., CRUZ-URIBE K. 1984. The Analysis of Animal Bones from Archaeological Sites. Chicago, 1-100 pp.

KOWALSKI K. 1953. Materiały do rozmieszczenia i ekologii nietoperzy jaskiniowych w Polsce. [Materials relating to the distribution and ecology of cave bats in Poland], *Fragmenta Faunistica Musei Zoologici Polonici*, Warszawa, **6**(21): 541-567. (In Polish with English summary).

MADEYSKA T. 1981. Środowisko człowieka w środkowym i górnym paleolicie na ziemiach polskich w świetle badań geologicznych. [Le milieu naturel de L'Homme du Paléolithique moyen et supérieur en Pologne ues]. *Studia geologica polonica*, Warszawa, **59**: 1-125. (In Polish with French summary).

NADACHOWSKI A., WOLSAN M., GODAWA J. 1991. New localities of Late Cenozoic faunas from Przymiłowice in the Cracow-Wieluń Upland, Poland. *Acta zoologica cracoviensia*, Kraków, **34**(2): 425-435.

OCHMAN K., WOŁOSZYN B. W. 2000. Analiza holoceńskiej fauny nietoperzy (Chiroptera) z Jaskini Pod Sokolą Górą. [Analysis of the Holocene bat fauna (Chiroptera) from Pod Sokolą Górą Cave], *Studia chiropterologica*, Kraków, **1**: 57-72. (In Polish with English summary).

OCHMAN K., WOŁOSZYN B. W. 2001. The Results of Cranial Measurements of *Myotis nattereri* (KUHL, 1817) from the Pod Sokolą Górą Cave (Kraków-Częstochowa Upland, Poland): an Analysis of Microevolution Trends in the "Nattereri" Group. [In:] B. W. WOŁOSZYN (ed.) – Proceedings of the VIIIth EBRS, Publication of the Chiropterological Information Center, Institute of Systematics and Evolution of Animals PAS in Kraków, Kraków, **2**: 111-132.

OCHMAN K., WOŁOSZYN B. W. In press. Bats – Chiroptera. [In:] P. VALDE-NOWAK, A. NADACHOWSKI, T. MADEYSKA, Obłazowa Cave: Settlement, Stratigraphy and Palaeontology. Instytut Archeologii i Etnologii PAN.

POSTAWA T. 2000. A Cave Microclimate as Modelled by External Climatic Conditions and Its Effect on a Hibernating Bat Assemblage: A Case of the Jaskinia Pod Sokola Górą. [In:] B. W. Wołoszyn (ed.) Proceedings of the VIIIth EBRS. , Publication of the Chiropterological Information Center, Institute of Systematics and Evolution of Animals PAS in Kraków, **1**: 199-217.

POSTAWA T. 2001. Rekonstrukcja formowania się chiropterofauny w postglacjale na przykładzie Wyżyny Krakowsko-Częstochowskiej. Materiały konferencyjne, XV Ogólnopolska Konferencja Chiropterologiczna, Gdańsk 2001, Gdańsk, 18. (In Polish).

POSTAWA T., ZYGMUNT J. 2000. Zmiany liczebności nietoperzy (Chiroptera) w jaskiniach Wyżyny Częstochowskiej w latach 1975–1999. [Changes of bat numbers in Częstochowa Upland caves between 1975 and 1999], *Studia chiropterologica*, Kraków, **1**: 83-114. (In Polish with English summary).

SKALSKI A. W., WÓJCIK Z. 1968. Jaskinie rezerwatu Sokole Góry w okolicy Częstochowy. *Ochrona Przyrody*, Kraków, **33**: 237-279. (In Polish).

STARKEL L. 1999. Geografia Polski. Środowisko przyrodnicze. Wydawnictwo Naukowe PWN, Warszawa, 571 pp. (In Polish).

STEBBINGS R. E. 1986. Distribution and status of bats in Europe. Natural Environment Research Council, Institute of Terrestrial Ecology, Huntington, 142 pp.

URBANOWSKI M. 2002. Badania w Jaskini Komarowej w Zrębicach, województwo śląskie [In:] Badania archeologiczne na Górnym Śląsku i ziemiach pogranicznych w latach 1999-2000, Centrum Dziedzictwa Kulturowego Górnego Śląska, Katowice, 54-61. (In Polish).

WOŁOSZYN B. W. 1965. Współczesne występowanie *Plecotus auritus* (L., 1758) i *Plecotus austriacus* (FISCHER, 1829) w Polsce. Materiały na VIII Zjazd Polskiego Towarzystwa Zoologicznego, Olsztyn, 83-85. (In Polish).

WOŁOSZYN B. W. 1970. Holoceńska fauna nietoperzy (Chiroptera) z jaskiń tatrzańskich. [The Holocene bat fauna from Tatra caves], *Folia quarternaria*, Kraków, **35**: 1-52. (In Polish with English summary).

WOŁOSZYN B. W. 1981. Nietoperze i cywilizacja. *Rocznik Muzeum Okręgowego w Częstochowie, Przyroda 2*, Częstochowa, **5**: 97-108. (In Polish).

WOŁOSZYN B. W. 1989. Nietoperze – Chiroptera. [In:] K. KOWALSKI (ed.) – Historia i ewolucja lądowej fauny Polski. [History and evolution of the terrestrial fauna of Poland], *Folia quarternaria*, Kraków, **59-60**: 129-141. (In Polish with English summary).

WOŁOSZYN B. W. 1992. *Myotis emarginatus* (GEOFFROY, 1806). [In:] Z. GŁOWACIŃSKI (ed.) – Polska czerwona księga zwierząt, Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa, 42-43. (In Polish).

WOŁOSZYN B. W. 1995. Badania późnoplejstoceńskich i holoceńskich szczątków nietoperzy z jaskiń w Pieninach w aspekcie tafonomii i paleoekologii. *Pieniny – Przyroda i Człowiek*, Kraków, **4**: 33-41. (In Polish).

WOŁOSZYN B. W. 2001a. Bats of Poland. Distribution, habitat and conservation status. Publication of the Chiropterological Information Center, Institute of Systematics and Evolution of Animals Polish Academy of Sciences in Kraków, 25 pp.

WOŁOSZYN B. W. 2001b. *Myotis emarginatus* (GEOFFROY, 1806). [In:] Z. GŁOWACIŃSKI (ed.) – Polska czerwona księga zwierząt, Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa, 53-54. (In Polish).

ZOTZ L. 1939. Die Altsteinzeit in Niederschlesien. Kabitsch, Leipzig, 146 pp.

ŻARSKI M. 2000. Stratygrafia osadów górnoplejstoceńskich stanowiska archeologicznego w jaskini Komarowej na Wyżynie Częstochowskiej. Centralne Archiwum Geologiczne Państwowego Instytutu Geologicznego, Warszawa. (In Polish).