Acta zoologica cracoviensia, **44**(2): 93-106, Kraków, 29 June, 2001

The taphonomy of Sub-Atlantic bird remains from Bazhukovo III, Ural Mountains, Russia

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Received: 7 Mar., 2001

Accepted for publication: 30 Apr., 2001

BOCHEŃSKI Z. M., NEKRASOV A. E. 2001. The taphonomy of Sub-Atlantic bird remains from Bazhukovo III, Ural Mountains, Russia. *Acta zoologica cracoviensia,* **44**(2): 93-106.

Abstract. The paper includes a taphonomic analysis of Sub-Atlantic bird remains from a cave called Bazhukovo III, Middle Ural Mountains, Russia. It is highly probably that the remains were deposited by a large owl, possibly the Eagle Owl *Bubo bubo*.

Key words: Taphonomy, bird remains, Holocene, *Bubo bubo*.

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I. INTRODUCTION

In order to understand the biases in species composition archaeozoologists and palaeontologists usually try to determine factors responsible for the accumulation of animal remains. For the last ten years there have been increasing numbers of methodological studies that focus on the way certain avian predators damage their victims' bones and which indicate differences between human and animal "signatures". The techniques derived from the experimental studies were then successfully used to determine the origin of assemblages containing remains of birds (BRAMWELL et al. 1986; WORTHY & HOLDAWAY 1994, 1995, 1996) and mammals (ANDREWS 1990a; CRUZ-URIBE & KLEIN 1998; FERNANDEZ-JALVO & ANDREWS 1992).

In the present study, a taphonomic analysis of osteological remains from the sediments in Bazhukovo III Cave was made.

A c k n o w l e d g m e n t s. We are very grateful to Trevor WORTHY of the Palaeofaunal Surveys, New Zealand and Alicja LASOTA-MOSKALEWSKA of the Warsaw University, Poland for helpful comments on an earlier draft of the manuscript, and to Nikolai G. EROHIN of the Institute of Plant and Animal Ecology, Ekaterinburg, Russia for giving us unpublished data on Bazhukovo III. The study was supported by a grant RFBR 99-05-65659 received by A. E. NEKRASOV

II. MATERIAL AND METHODS

Bazhukovo III is situated in the Middle Ural Mountains, 48 m above the level of the Serga River (56°32' N, 59°16' E). The entrance faces northeast and has an overhanging rock above it. The sediments of the cave were rich in bird and small rodent remains (NEKRASOV 1996; SMIRNOV 1993) and contained also some fish and reptile bones. The pH of the sediments is 5.3. Wet sieving techniques applying a set of two sieves (5×5 mm and 1×1 mm) were used during the excavations. For this study, only the layers 0-IV (i.e. up to 20 cm in depth) dated to the Sub-Atlantic of the Holocene (i.e. comprising the last 2.5 kyrs BP) were analyzed. Older layers contained too few remains. Until recently a pair of Eagle Owls nested at the entrance to the cave (NEKRASOV 1996).

Bones were categorized into classes of fragmentation as proposed in studies of owl pellet taphonomy (BOCHEŃSKI et al., 1993: Figs. 1-5). Bones from the left and right side of the body were pooled within each category.

The bone surfaces were examined by light microscope to study damage. The following categories of surface damage were distinguished after BOCHEŃSKI & TOMEK (1997): (1) Bone surface (articular parts and shafts): A – undamaged; B – "rounded" (i.e. modified by digestion): holes and depressions with rounded edges. It looks like a piece of plastic whose edges melted in heat; C – "sharp" (i.e. modified by weathering): holes and depressions with sharp and rough edges and bottoms. (2). Breakage: A – "sharp" (i.e. old breakage modified by weathering): sharp and rough at right angles to the shaft axis; B – "rounded" (i.e. modified by digestion): rounded and often thinned. The surface of the breakage is smooth.

The minimum number of individuals (MNI) was calculated for each element separately, treating the whole fauna as a single species. The results are presented as absolute numbers and as percentages of the number of fragments of the element which provided the highest value of the MNI. The MNI values are certainly an underestimate of total numbers of birds that contributed bones to the deposit because they were calculated from the total sample analyzed (i.e. not from each layer separately), bones were not determined to species, and proximal and distal parts were not fitted together. The same procedure was used in previous studies (BOCHEŃSKI 1997; BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994). For the purpose of deducing the identity of the predator that accumulated the assemblage, this procedure saves much time. The error introduced by not identifying taxa, pooling data for all layers, and not attempting to repair broken bones is believed to be similar for each element.

The proportion of proximal and distal parts of bones was calculated from the total number of proximal and distal fragments (i.e. whole bones plus proximal parts and whole bones plus distal parts).

The proportion of all long bone fragments that the wing and leg elements represented was calculated. Wing elements were humerus, ulna, carpometacarpus, and leg elements were femur, tibiotarsus and tarsometatarsus (ERICSON 1987; LIVINGSTON 1989).

The proportion that proximal and distal elements of the skeleton represented of all long bones was calculated, where proximal skeletal elements were scapula, coracoideum, humerus, femur and tibiotarsus, and distal skeletal elements were the ulna, radius, carpometacarpus and tarsometatarsus.

Bone ratio of the "core" to "limb" elements was calculated as the number of the "core" elements (sternum, pelvis, scapula, coracoideum) divided by the sum of core and "limb" elements (humerus, ulna, radius, carpometacarpus, femur, tibiotarsus, tarsometatarsus), expressed as percent (BRAMWELL et al. 1986).

A chi-square test was used to evaluate the significance of differences in survivorship of particular skeletal elements or their fragments.

The data from the Bazhukovo III faunal assemblage were compared with that in the methodological studies describing species-specific damage to bird bones done by the following owls and diurnal birds of prey: Snowy Owl *Nyctea scandiaca* (LINNAEUS, 1758), Eagle Owl *Bubo bubo*

(LINNAEUS, 1758), Tawny Owl *Strix aluco* LINNAEUS, 1758, Long-eared Owl *Asio otus* (LINNAEUS, 1758), Gyrfalcon *Falco rusticolus* LINNAEUS, 1758, Imperial Eagle *Aquila heliaca* Savigny, 1809, White-tailed Eagle *Haliaeetus albicilla* (LINNAEUS, 1758) and Golden Eagle *Aquila chrysaetos* (LINNAEUS, 1758) – (BOCHEŃSKI 1997; BOCHEŃSKI et al 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994; BRAMWELL et al. 1987; MLIKOVSKY 1996). Of these studies that on the Snowy Owl (BOCHEŃSKI 1997) was preliminary and based on few data and its results often differ from those of other owls, and therefore the species was excluded from some of the present comparisons.

III. RESULTS

Taxa recovered

The skeletal remains from Bazhukovo III are from a variety of taxa including medium-sized species such as grebes, ducks (*Anas*, *Clangula*), falconiforms (*Accipiter*, *Buteo*), owls (*Bubo*, *Strix*), galliforms (*Tetrastes, Tetrao*), and smaller birds such as Corncrace, Woodcock, pigeons, woodpeckers, thrushes (*Turdus*) and corvids (*Pica*, *Corvus*). Medium-sized birds – among which ducks and galliforms clearly prevailed – built up about 50 percent of the remains.

Fragmentation patterns

S k u l l, m a n d i b l e, s t e r n u m a n d p e l v i s (Table I). The elements were heavily fragmented and relatively seldom found. Skulls were represented mostly by the category "end of beak", mandibles by "articular parts", sterna by small fragments with rostrum, and pelvis by "acetabulum region".

L o n g b o n e s (Table II). With the exception of the phalanx I dig. maj. alae, all skeletal elements suffered great fragmentation – whole bones were much less numerous than their fragments. Shafts separated from articular parts were very rare.

The most numerous fragments were those of the humerus followed by ulna, coracoideum, tarsometatarsus and tibiotarsus.

Proximal ends outnumbered distal ends for the carpometacarpus whereas distal ends were more numerous than proximal ends for the tibiotarsus and the tarsometatarsus, and scapular ends prevailed over sternal ends for the coracoideum (in all cases $p<0.01$). For the remaining bones, proximal and distal ends exhibited roughly equal abundances, differences being statistically insignificant.

M i n i u m u m n u m b e r o f i n d i v i d u a l s. The Element MNI and the percentage it represented of Total MNI for the fauna was calculated separately for every element, see the last two columns of Tables I and II. The highest values for the MNI were obtained with coracoids (Element MNI=86, Total MNI(%)=100), followed closely by tarsometatarsi and humeri (Total MNI(%)=97 and 91, respectively). Five bones (sternum, scapula, ulna, carpometacarpus, tibiotarsus) were well represented (Total MNI(%)=71-88), the femur was moderately represented (Total MNI(%) around 50). The remaining five bones (skull, mandible, pelvis, radius, phalanx I dig maj. alae) scored poorly (Total MNI(%) well below 50).

W i n g / l e g r a t i o. Wing bones represented 54% of the sum of wing and leg bones. The deviation (wing elements prevailed) from the expected 50% (1:1 proportion) was statistically significant ($p<0.01$, df=1).

P r o x i m a l e l e m e n t s / d i s t a l e l e m e n t s r a t i o. Proximal elements of the skeleton represented 60% of the sum of proximal and distal elements. The predominance of proximal elements was statistically significant ($p<0.01$, df=1).

C o r e e l e m e n t s / l i m b e l e m e n t s r a t i o. Core elements represented 28% of the sum of core and limb elements. The underrepresentation of core elements was statistically significant ($p<0.01$, df=1).

Table I

Fragmentation of the skull, mandible, sternum and pelvis in the material from Bazhukovo III (for categories of fragmentation see BOCHEŃSKI et al. 1993: Figs 1-4). Total MNI% is the percentage that the Element MNI represents of the Total MNI for the fauna (obtained from the coracoid)

Skull

Number of fragments	Whole skull %	Skull with beak and brain case without back part %	Brain case without back part %	Brain case %	Whole beak %	End of beak %	Other fragments %	Element MNI (N)	Total MNI (%)
N = 33	0	3	0	0	9	55	33	22	26

Mandible

Number of fragments	Whole %	One branch %	Articular part %	Tip of mandibula %	Middle part of branch %	Element MNI (N)	Total MNI (%)
N = 49	0	6	67	16	10	18	21

Sternum

Number of fragments	More than 1/2 with rostrum %	Less than 1/2 with rostrum %	Fragments without rostrum %	Element MNI (N)	Total MNI (%)
N = 104	2	71	27	76	88

Pelvis

Number of fragments	Synsacrum with 1 or 2 ilium-ischii-pubis bones %	Ilium-ischii-pubis bone %	Synsacrum whole or partial %	Acetabulum region %	Element MNI (N)	Total MNI (%)
N = 76	3	3	36	59	29	34

Surface damage

A r t i c u l a r p a r t s. Nearly all articular parts – regardless of which element – were somehow modified (Table III); damage to the bone surface of almost all of the fragments were classified in one of the two categories: C or B+C (i.e. modified by erosion or digestion and erosion). Traces of digestion were found almost always together with traces of weathering (category B+C rather than B alone). Altogether (categories B and B+C jointly), 46-63% of articular parts were affected by digestion, depending on the element. Traces of weathering were either associated with

Table II

Fragmentation of long bones in the material from Bazhukovo III expressed as percentages of the total number of fragments for the element found (for categories of fragmentation see BOCHEŃSKI et al. 1993: Fig. 5). In scapula: distal part and shaft are shown jointly in the category "shaft". In coracoideum: proximal=sternal, distal=scapular. *, indicate statistically significant predominance of proximal ends (whole bones + proximal parts) or distal ends (whole bones + distal parts). For MNI(%), see Table I

Bones (Total number of fragments)	Whole bone %	Proximal part %	Distal part %	Shaft %	Element MNI (N)	Total MNI (%)
Scapula (N = 132)	1	98	–	1	72	84
Coracoideum (N = 205)	23	19	58*	0	86	100
Humerus (N = 289)	4	45	47	4	78	91
Ulna (N = 210)	9	42	47	2	61	71
Radius (N = 74)	8	47	40	4	21	24
Carpometacarpus (N = 170)	25	49*	25	1	70	81
Phalanx I dig maj. alae (N = 43)	88	9	2	0	25	29
Femur (N = 181)	3	45	50	2	50	58
Tibiotarsus (N = 195)	0	29	61*	10	64	74
Tarsometatarsus (N = 201)	16	17	61*	6	83	97

those of digestion (category B+C) or occurred on their own (category C). Articular parts affected by weathering (categories C and B+C jointly) made up 94-100%, depending on the element.

S h a f t s. Most shafts (85-98%) were affected only by weathering (category C), whereas very few shafts were undamaged or showed traces characteristic of digestion.

B r e a k a g e. With the exception of the femur, sharp edges of breakage (category A) clearly predominated in all types of bones, constituting 56-84%. The breakage looked old, thus it is unlikely that it was caused by excavation. Rounded edges of breakage (category B) were observed less frequently, mostly in association with sharp edges (category A+B). The only exception was the femur whose broken edges were mostly of the category A+B (sharp and rounded edges).

Table III

Percentage of long bones affected by digestion and/or weathering and erosion. Categories of damage follow those described by BOCHEŃSKI & TOMEK (1997)

Bones (Number of fragments)		Bone surface				Breakage		
		A undamaged	B "rounded" (modified by digestion)	C "sharp" (modified by erosion)	B+C "rounded" & "sharp" (modified by digestion and erosion)	A sharp	B "rounded" (modified by digestion)	A+B variations (sharp and modified by digestion)
Scapula	articular ends, n=135	–	1	54	45			
	shafts, n=68	–	–	96	4			
	breakage, n=116					68	9	22
Coracoideum	articular ends, n=252	1	–	43	56			
	shafts, n=101	1	2	93	4			
	breakage, n=156					56	11	33
Humerus	articular ends, n=295	1	1	43	55			
	shafts, n=90	3	–	95	2			
	breakage, n=289					75	2	23
Ulna	articular ends, n=222	2	2	48	48			
	shafts, n=95	5	–	94	1			
	breakage, n=189					80	2	18
Radius	articular ends, n=76	–	–	43	57			
	shafts, n=60	–	–	98	2			
	breakage, n=66					80	3	17
Carpometacarpus	articular ends, n=211	1	1	39	58			
	shafts, n=108	5	1	85	9			
	breakage, n=126					69	6	25
Femur	articular ends, n=177	2	–	48	50			
	shafts, n=53	4	–	92	4			
	breakage, n=174					27	2	71
Tibiotarsus	articular ends, n=177	–	1	43	56			
	shafts, n=80	5	–	94	1			
	breakage, n=218					78	–	22
Tarsometatarsus	articular ends, n=217	–	2	37	61			
	shafts, n=132	1	2	94	3			
	breakage, n=180					84	2	14

IV. DISCUSSION, COMPARISONS AND COMMENTS

Taxa recovered

None of the bones recovered from Bazhukovo III bore any traces that could be attributed to human activities (cut-marks, burning). Moreover, the bones recovered represented mainly rodents and birds typical of faunas deposited by avian predators. Mammals could be ruled out because they digest and destroy bones to a much larger degree (ANDREWS 1990a). Judging from the list of identified taxa, the predator fed to a great extent on medium-sized birds. Thus, smaller predators such as the Long-eared Owl and the Tawny Owl may be ruled out because they feed mainly on smaller prey (CRAMP 1985). The same applies to the Ural Owl whose prey seldom exceeds the size of the Woodpigeon. Of the owl species known to prey mainly on medium-sized birds, the Snowy Owl and the Eagle Owl are most likely candidates. The latter species is more likely to be the predator because it still occurs in the Ural Mountains and its diet is broad and includes birds (CRAMP 1985). Snowy Owls – if they take birds at all – tend to select either grouse of the genus *Lagopus* or waterbirds (ducks, grebes, gulls), depending on their hunting area (CRAMP 1985; GLUTZ VON BLOTZHEIM & BAUER 1980).

Theoretically, the material could have been deposited by diurnal birds of prey. However, diurnal raptors usually leave only their uneaten food remains because their pellets contain very few bones that are heavily damaged through digestion (ANDREWS 1990a; BOCHEŃSKI et al. 1998, 1999). The White-tailed Eagle takes mainly waterbirds and not the diverse range of terrestrial species in the present material (CRAMP & SIMMONS 1980). The Imperial Eagle, which is also present in the Ural Mountains, seldom feeds on such large prey as grouse and ducks whose remains were numerous in the present material. The Golden Eagle can take grouse and ducks but rarely feeds on smaller prey whose remains are also present in our material. The only diurnal raptor likely to have accumulated the range of taxa present in the Bazhukovo III fauna is the Gyrfalcon.

Of the two most probable predators – the Eagle Owl and the Gyrfalcon – the first one is more likely due to its feeding and nesting habits. The Gyrfalcon nests in trees or on cliff ledges and scatters its food remains over a relatively large area (CRAMP & SIMMONS 1980). On the contrary, the Eagle Owl nests both on rocks and on ground, and leaves large amount of food remains around its nest (CRAMP 1985). Until recently it nested in the cave of Bazhukovo III and according to NEKRASOV (1996) it is also the most likely species to have deposited older material at that site.

Fragmentation patterns

S k e l e t a l   e l e m e n t s. The scarcity of skull and mandible remains in the present study is seen in the low share of those elements in studied pellet assemblages of the Eagle Owl (BOCHEŃSKI et al. 1993), the Gyrfalcon (BOCHEŃSKI et al. 1998) and uneaten food remains of the Golden Eagle (BOCHEŃSKI et al. 1999). This contrasts to pellet materials of other owl species (Tawny Owl, Long-eared Owl, Snowy Owl) and the Imperial Eagle where the remains of the victims' head were considerable more numerous (BOCHEŃSKI 1997; BOCHEŃSKI et al. 1993, 1997; BOCHEŃSKI & TOMEK 1994).

Humerus, ulna and coracoid are often the most numerous elements in fragments found in pellets and uneaten food remains of various species of owls and diurnal raptors. On the contrary, sterni and scapulae are frequently found only in uneaten food remains; their share in pellets is usually lower (Table IV – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994; BRAMWELL et al. 1987; MLIKOVSKY 1996). The conclusions must be treated with caution because we lack data for certain bones in two species of eagles.

The relative proportions of the skeletal elements in the present material is more similar to that found in Eagle Owl pellets (BOCHEŃSKI et al. 1993) than in that of any other species compared (Table IV). In both the fossil assemblage and foe eagle owls: (i) the humerus is the most numerous ele-

Table IV

Relative proportions of the skeletal elements found in Bazhukovo III (in descending order), on the background of their proportions in pellets and food remains of various species of owls and diurnal birds of prey. * – the highest score within particular species; shaded background – scores of 10% or higher; double lines – similar groups (see text); ??? – no data

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyr-falcon[3]	Imperial Eagle[4]		White-tailed Eagle[5]	Golden Eagle Uneaten food remains		
		Pellets	Pellets	Pellets	Pellets	Pellets	Uneaten	Uneaten	Contemporary remains[6]	Tjenberg's data[7]	Subfosil data[7]
	MNB= 1962 (%)	MNB= 2216 (%)	MNB= 5269 (%)	MNB= 2519 (%)	MNB= 271 (%)	MNB= 591 (%)	MNB= 520 (%)	MNB= 1160 (%)	MNB= 1867 (%)	MNB= 671 (%)	MNB= 267 (%)
Humerus	15*	16*	11*	11	10	5	19*	15*	16	18	9
Ulna	11	11	9	11	15*	9	8	10	4	4	1
Coracoideum	10	8	9	7	8	10	11	13	17*	18	29*
Tarsometatarsus	10	11	8	9	7	13	7	1	2	1	1
Tibiotarsus	10	11	9	12*	12	6	7	2	6	3	3
Femur	9	8	8	8	10	7	3	1	9	9	5
Carpometacarpus	9	8	8	7	14	6	6	9	2	2	1
Scapula	7	7	8	6	7	6	9	14	14	14	25
Sternum	5	6	4	5	3	2	8	11	14	19*	15
Pelvis	4	5	3	5	2	1	3	4	9	12	9
Radius	4	4	6	7	5	2	5	9	3	???	1
Mandibula	2	2	8	6	3	8	2	???	0	???	???
Phalanx I dig maj. alae	2	1	3	2	3	16*	4	7	2	???	???
Skull	2	2	5	4	1	9	6	4	1	???	???

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – MLIKOVSKY 1996; 6 – BOCHEŃSKI et al. 1999; 7 – BRAMWELL et al. 1987.

ment; (ii) four of the most numerous elements are the same (humerus, ulna, tarsometatarsus, tibiotarsus); (iii) the sequence of bones – from the most- to the least numerous ones – is nearly identical.

The relative proportion of the proximal and distal ends, the present material is more similar to pellet remains of owls and diurnal birds of prey than to uneaten food remains (Table V – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994). Pellet materials

Table V

Relative proportions of the proximal and distal parts of particular skeletal elements found in Bazhukovo III, on the background of their proportions in pellets and uneaten food remains of various species of owls and diurnal birds of prey. Only cases with statistically significant differences are shown

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyrfalcon[3]	Imperial Eagle[4]		Golden Eagle Uneaten food remains
		Pellets	Pellets	Pellets	Pellets	Pellets	Uneaten	Contemporary remains[5]
Coracoideum	scap>ster	scap>ster	scap>ster	–	scap>ster	scap>ster	–	–
Humerus	–	–	prox>dist	–	prox>dist	–	–	–
Ulna	–	–	–	–	prox<dist	–	–	–
Radius	–	prox>dist	prox>dist	–	–	–	–	–
Carpometacarpus	prox>dist	–	–	–	–	–	–	–
Femur	–	–	prox>dist	–	prox<dist	–	–	–
Tibiotarsus	prox<dist	–	–	prox>dist	prox>dist	–	prox<dist	–
Tarsometatarsus	prox<dist	–	prox<dist	–	prox<dist	prox<dist	–	–

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – BOCHEŃSKI et al. 1999.

– of owls and diurnal birds of prey – are characterized by several skeletal elements showing statistically significant differences in the share of their proximal/distal ends, whereas uneaten food remains are characterized by few, if any, such differences (the Long-eared Owl is an exception). Secondly, in pellet materials – of owls and diurnal birds of prey – scapular parts of the coracoideum and distal parts of the tarsometatarsus outnumber their counterparts (in all the cases with statistically significant differences).

M i n i u m u m n u m b e r o f i n d i v i d u a l s. The Bazhukovo III sample exhibits patterns of element survival in many aspects similar to that of the Eagle Owl (Table VI – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994). In both cases the shares of the MNI calculated from the following nine skeletal elements are very similar (differences up to ten percent only): cranium, mandibula, pelvis, humerus, ulna, radius, femur, tibiotarsus and tarsometatarsus. Somewhat larger differences (of about 20 percent) were observed in the case of two bones (carpometacarpus and phalanx I dig maj. alae), whereas the remaining three bones (sternum, scapula and coracoideum) differed considerably (differences between 34-54%). The second most similar species is the Imperial Eagle (uneaten remains). The differences between survival of elements in the present material compared to that in other species of owls and diurnal birds of prey were even larger.

W i n g / l e g r a t i o. All species of owls and diurnal birds of prey studied so far can be divided into the following four groups (Table VII – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994; BRAMWELL et al. 1987; MLIKOVSKY 1996): (i) wing and leg elements occur with approximately equal frequencies (pellets of: Long-eared Owl and Gyrfalcon); (ii) wing elements moderately prevail – their share is 53-57% (pellets of: Eagle Owl,

Table VI

Comparison of the values of the Total MNI(%) calculated separately for each skeletal element found in Bazhukovo III with the Total MNI(%) values obtained from pellet and food remains of various species of owls and diurnal birds of prey. Shaded background - differences of up to 10% only (between the material from Bazhukovo III and that of particular owl/raptor). For Total MNI(%), see Table I

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyrfalcon[3]	Imperial Eagle[4]		Golden Eagle Uneaten food remains
	Total MNI (%)	Pellets Total MNI(%)	Pellets Total MNI(%)	Pellets Total MNI(%)	Pellets Total MNI(%)	Pellets Total MNI(%)	Uneaten Total MNI(%)	Contemporary remains[5] Total MNI(%)
Cranium	**26**	22	96	59	13	100	33	5
Mandibula	**21**	14	90	74	20	89	22	0.4
Sternum	**88**	34	67	38	13	25	84	100
Pelvis	**34**	36	56	49	13	5	24	53
Scapula	**84**	50	63	31	73	33	49	62
Coracoideum	**100**	58	76	46	80	47	53	68
Humerus	**91**	100	100	96	67	18	100	66
Ulna	**71**	70	84	100	93	24	47	16
Radius	**24**	34	60	56	20	7	29	14
Carpometacarpus	**81**	63	78	64	87	24	33	9
Phalanx I dig maj. alae	**29**	9	32	21	40	85	24	7
Femur	**58**	60	69	58	73	25	18	40
Tibiotarsus	74	72	54	70	100	16	35	22
Tarsometatarsus	**97**	96	76	74	47	56	41	11

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – BOCHEŃSKI et al. 1999.

Tawny Owl; uneaten remains of: Golden Eagle – studied by BOCHEŃSKI et al. 1999 and BRAMWELL et al. 1987); (iii) wing elements strongly prevail – their share is 66-89% (uneaten remains of: Imperial Eagle, White-tailed Eagle and Golden Eagle – studied by Tjenberg (BRAMWELL et al. 1987)); (iv) leg elements prevail (pellets of Imperial Eagle). The present material fits well to group II, comprising the pellet materials of the Eagle Owl and the Tawny Owl on the one hand, and two of the three assemblages of uneaten food remains of the Golden Eagle on the other hand.

P r o x i m a l e l e m e n t s / d i s t a l e l e m e n t s r a t i o. The species whose pellet and uneaten food remains have been studied so far can be divided into the following three categories (Table VIII – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999;

Table VII

Relative proportions of the "wing" elements (humerus, ulna, carpometacarpus) and "leg" elements (femur, tibiotarsus, tarsometatarsus) found in Bazhukovo III, on the background of their proportions in pellets and uneaten food remains of various species of owls and diurnal birds of prey. Percentages are given only for species that showed statistically significant differences between the number of "wing" and "leg" elements. N – total number of wing and leg elements

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyrfalcon[3]	Imperial Eagle[4]		White-tailed Eagle[5]	Golden Eagle Uneaten food remains		
		Pellets	Pellets	Pellets	Pellets	Pellets	Uneaten	Uneaten	Contemporary remains[6]	Tjenberg's data[7]	Subfosil data[7]
	N=1246 (%)	N=1468 (%)	N=2940 (%)	N=1456	N=186	N=269 (%)	N=267 (%)	N=444 (%)	N=744 (%)	N=183 (%)	N=56 (%)
Wing	54	53	54	1:1	1:1	44	66	89	55	87	57
Leg	46	47	46			56	34	11	45	13	43

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – MLIKOVSKY 1996.; 6 – BOCHEŃSKI et al. 1999; 7 – BRAMWELL et al. 1987.

BOCHEŃSKI & TOMEK 1994; BRAMWELL et al. 1987; MLIKOVSKY 1996): (i) proximal and distal elements occur with approximately equal frequencies (pellets of Gyrfalcon and Imperial Eagle); (ii) proximal elements moderately prevail – their share is 56-64% (pellets of owls: Eagle Owl, Tawny Owl, Long-eared Owl; uneaten remains of: Imperial Eagle and White-tailed Eagle); (iii) proximal elements strongly prevail – their share is 84-94% (uneaten remains of Golden Eagle). The present material fits well to group II, comprising pellets of owls on the one hand and uneaten food remains of the Imperial Eagle and the White-tailed Eagle on the other hand.

Core elements/limb elements ratio. The species whose pellet and uneaten food remains have been studied so far can be divided into the following two categories (Table IX – based on data from BOCHEŃSKI et al. 1993, 1997, 1998, 1999; BOCHEŃSKI & TOMEK 1994; BRAMWELL et al. 1987; MLIKOVSKY 1996): (i) the share of "core elements" is 21-29% (pellet materials of owls and diurnal birds of prey); (ii) the share of "core elements" is 36-78% (uneaten food remains of diurnal birds of prey). The present material belongs in category I.

Surface damage

The fact that some of the bones studied had traces typical of digestion points to a pellet origin of the material. The low frequencies of such damage found on shafts and much higher frequencies observed on articular parts confirm the conclusion (BOCHEŃSKI 1997; BOCHEŃSKI et al. 1998; BOCHEŃSKI & TOMEK 1997). Theoretically, some of the traces could be produced by attrition and/or soil corrosion which can be mistaken for traces of digestion (ANDREWS 1990a, 1990b; BOCHEŃSKI & TOMEK 1997) but it is unlikely that we made the same mistake in all the cases.

Although the relatively low frequencies of digestion traces on articular parts and on shafts would indicate "category I" predator – comprising Snowy Owl and Long-eared Owl – (BOCHEŃSKI et al. 1998), we are unwilling to ascribe the material to this category. The reason is simple: in

Table VIII

Relative proportions of the proximal elements (scapula, coracoid, humerus, femur, tibiotarsus) and distal elements (ulna, radius, carpometacarpus, tarsometatarsus) found in Bazhukovo III, on the background of their proportions in pellets and uneaten food remains of various species of owls and diurnal birds of prey. Percentages are given only for species that showed statistically significant differences between the number of "proximal" and "distal" elements. N – total number of proximal and distal elements

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyrfalcon[3]	Imperial Eagle[4]		White-tailed Eagle[5]	Golden Eagle		
									Uneaten food remains		
		Pellets	Pellets	Pellets	Pellets	Pellets	Uneaten	Uneaten	Contemporary remains[6]	Tjenberg's data[7]	Subfosil data[7]
	N=1657 (%)	N=1899 (%)	N=4245 (%)	N=1965 (%)	N=240	N=375	N=400 (%)	N=866 (%)	N=1388 (%)	N=465 (%)	N=205 (%)
Proximal	60	59	59	56	1:1	1:1	64	61	84	90	94
Distal	40	41	41	44			36	39	16	10	6

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – MLIKOVSKY 1996; 6 – BOCHEŃSKI et al. 1999; 7 – BRAMWELL et al. 1987.

Table IX

Relative proportions of the "core" elements (sternum, pelvis, scapula, coracoideum) and "limb" elements (humerus, ulna, radius, carpometacarpus, femur, tibiotarsus, tarsometatarsus) found in Bazhukovo III, on the background of their proportions in pellets and uneaten food remains of various species of owls and diurnal birds of prey. N – total number of core and limb elements

Elements	Present data (Bazhukovo III)	Eagle Owl[1]	Tawny Owl[1]	Long-eared Owl[2]	Gyrfalcon[3]	Imperial Eagle[4]		White-tailed Eagle[5]	Golden Eagle		
									Uneaten food remains		
		Pellets	Pellets	Pellets	Pellets	Pellets	Uneaten	Uneaten	Contemporary remains[6]	Tjenberg's data[7]	Subfosil data[7]
	N=1837 (%)	N=2138 (%)	N=4646 (%)	N=2217 (%)	N=252 (%)	N=393 (%)	N=458 (%)	N=1039 (%)	N=1817 (%)	N=671 (%)	N=267 (%)
Core	28	26	29	26	21	29	36	47	55	63	78
Limb	72	74	71	74	79	71	64	53	45	37	22

1 – BOCHEŃSKI et al. 1993; 2 – BOCHEŃSKI & TOMEK 1994; 3 – BOCHEŃSKI et al. 1998; 4 – BOCHEŃSKI et al. 1997; 5 – MLIKOVSKY 1996; 6 – BOCHEŃSKI et al. 1999; 7 – BRAMWELL et al. 1987.

(sub)fossil materials the bones already altered by digestion are most strongly affected by soil corrosion and weathering – especially in acid soil like that in Bazhukovo III, which certainly decreases the share of digestion traces recognized (ANDREWS 1990a). Thus, we may expect that digestion affected originally more bones than we were able to distinguish. However, it is also very unlikely that the traces of digestion were produced by a diurnal bird of prey such as the Gyrfalcon because the type and extent of damage must have been larger in that case (ANDREWS 1990a; BOCHEŃSKI et al. 1998; MAYHEW 1977). Taking all the aspects into account it seems safe to conclude that surface damage on the material is most similar to that of owls.

Final conclusion

Various accuracy of the analyses employed may well be due to modifications before and after burial (e.g. scavenging, trampling, weathering, soil corrosion) on the one hand and to relative robusticity and strength of particular skeletal elements on the other hand (ANDREWS 1990a; BJORDAL 1988; WORTHY & HOLDAWAY 1994, 1996). Therefore taphonomic studies of fossil assemblages should be based on many various analyses.

Although particular analyses of the present study lead to various conclusions regarding the origin of the material from Bazhukovo III, it is possible to make the following, more general remarks.

The prey species in the assemblage are likely to have been captured only by either eagle owls or gyrfalcons. The low frequency of skull elements also accords well with element survival patterns in bone assemblages from these two taxa. However, the survival of other skeletal elements (a moderate prevalence of wing elements over leg elements, and more proximal than distal elements) is more similar to that of the eagle owl. Also, diurnal birds of prey such as the gyrfalcon cause more fragmented bone assemblages in which remains exhibit heavy digestion features not seen on the Bazhukovo III fauna. Moreover, gyrfalcons usually nest or roost in sites substantially different to the fossil site, but eagle owls use such sites.

Thus, it is highly probable that the sediments come from pellets of a large owl, and probably the Eagle Owl.

V. REFERENCES

ANDREWS P. 1990a. Owls, caves and fossils. Predation, preservation and accumulation of small mammal bones in caves, with an analysis of the Pleistocene cave faunas from Westbury-sub-Mendib, Somerset, UK. Natural History Museum Publications, London, 231 pp.

ANDREWS P. 1990b. Small mammal taphonomy. [In:] E. H. LINDSAY et al. (eds) – European Neogene mammal chronology. Plenum Press: 487-494.

BJORDAL H. 1988. Metrical and mechanical properties of some skeletal bones from the House Sparrow, *Passer domesticus*, a contribution to the understanding of zooarchaeological problems. *Ossa*, **13**: 49-59.

BOCHEŃSKI Z. M. 1997. Preliminary taphonomic studies on damage to bird bones by Snowy Owls *Nyctea scandiaca*, with comments on the survival of bones in palaeontological sites. *Acta zoologica cracoviensia*, **40**(2): 279-292.

BOCHEŃSKI Z. M., BOEV Z., MITEV I., TOMEK T. 1993. Patterns of bird bone fragmentation in pellets of the Tawny Owl (*Strix aluco*) and the Eagle Owl (*Bubo bubo*) and their taphonomic implications. *Acta zoologica cracoviensia*, **36**(2): 313-328.

BOCHEŃSKI Z. M., HUHTALA K., JUSSILA P., PULLIAINEN E., TORNBERG R., TUNKKARI P. S. 1998. Damage to bird bones in pellets of Gyrfalcon *Falco rusticolus*. *Journal of Archaeological Science*, **25**: 425-433.

BOCHEŃSKI Z. M., HUHTALA K., SULKAVA S., TORNBERG R. 1999. Fragmentation and preservation of bird bones in food remains of the Golden Eagle *Aquila chrysaetos*. *Archaeofauna*, **8**: 31-39.

BOCHEŃSKI Z. M., KOROVIN V. A., NEKRASOV A. E., TOMEK T. 1997. Fragmentation of bird bones in food remains of Imperial Eagles *Aquila heliaca*. *International Journal of Osteoarchaeology*, **7**(2): 165-171.

BOCHEŃSKI Z. M., TOMEK T. 1994. Pattern of bird bone fragmentation in pellets of the Long-eared Owl *Asio otus* and its taphonomic implications. *Acta zoologica cracoviensia*, **37**(1): 177-190.

BOCHEŃSKI Z. M., TOMEK T. 1997. Preservation of Bird Bones: Erosion Versus Digestion by Owls. *International Journal of Osteoarchaeology*, **7**(4): 372-387.

BRAMWELL D., YALDEN W., YALDEN P. E. 1987. Black grouse as the prey of the golden eagle at an archaeological site. *Journal of Archaeological Science*, **14**: 195-200.

CRAMP S. 1985. The birds of the Western Palearctic, Vol. IV. Oxford University Press, Oxford, New York, 960 pp.

CRAMP S., SIMMONS K. E. L. 1980. The birds of the Western Palearctic, Vol. II. Oxford University Press, Oxford, London, New York, 695 pp.

CRUZ-URIBE K., KLEIN R. G. 1998. Hyrax and hare bones from modern South African Eagle roosts and the detection of eagle involvement in fossil bone assemblages. *Journal of Archaeological Science*, **25**: 135-147.

ERICSON P. G. P. (1987). Interpretations of archaeological bird remains: A taphonomic approach. *Journal of Archaeological Science*, **14**: 65-75.

FERNANDEZ-JALVO Y., ANDREWS P. 1992. Small mammal taphonomy of Gran Dolina, Atapuerca (Burgos), Spain. *Journal of Archaeological Science*, **19**: 407-428.

GLUTZ VON BLOTZHEIM U. N., BAUERK. M. (eds) 1980. Handbuch der Vögel Mitteleuropas. Vol. IX. Akademische Verlagsgesellschaft, Wiesbaden, 1148 pp.

LIVINGSTON, S. D. 1989. The taphonomic interpretation of avian skeletal part frequencies. *Journal of Archaeological Science*, **16**: 537-547.

MAYHEW D. F. 1977. Avian predators as accumulators of fossil mammal material. *Boreas*, **6**: 25-31.

MLIKOVSKY J. 1996. New data on the food of the White-tailed Sea Eagle (*Haliaetus albicilla*) in the Svjatoj Nos wetlands, Lake Baikal. *Buteo*, **8**: 115-118.

NEKRASOV A. E. 1996. [Birds of Holocene cave deposits of the western slopes of the Middle Ural Mountains (Serga River Valley)]. Sbornik Nauchnykh Trudov: Materialy i issledovaniya po istorii sovremennoy fauny Urala. Ekaterinburg. Pp: 119-135. (In Russian).

SMIRNOV N. G. 1993. [Late Pleistocene and Holocene small mammals of the Middle Ural Mountains]. Nauka, Ekaterinburg, 61 pp. (In Russian).

WORTHY T. H., HOLDAWAY R. N. 1994. Scraps from an owl's table – predator activity as a significant taphonomic process newly recognized from New Zealand Quaternary deposits. *Alcheringa*, **18**: 229-245.

WORTHY T. H., HOLDAWAY R. N. 1995. Quaternary fossil faunas from caves on Mt Cookson, North Canterbury, South Island, New Zealand. *Journal of The Royal Society of New Zealand*, **25**(3): 333-370.

WORTHY T. H., HOLDAWAY R. N. 1996. Taphonomy of two Holocene microvertebrate deposits, Takaka Hill, Nelson, New Zealand, and identification of the avian predator responsible. *Historical Biology*, **12**: 1-24.