

SOME FEATURES OF THE TRANSFORMATION OF MAMMAL FAUNAS OF THE PALEARCTIC AND NEARCTIC IN THE TERMINAL CENOZOIC

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ОБ ОСОБЕННОСТЯХ ТРАНСФОРМАЦИИ ТЕРИОФАУН ПАЛЕАРКТИКИ И НЕАРКТИКИ В КОНЦЕ КАЙНОЗОЯ

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Abstract. Historical changes in the terminal Cenozoic are analyzed in those mammalian species of the Palearctic and Nearctic that, interacting with soil and vegetation, made possible the pasture ecosystems that were distributed from tropical Africa to some Arctic islands. In addition to large herbivores of pasture ecosystems and carnivores feeding on those herbivores, some of the largest rodents are included in the analysis; in the Nearctic, edentates are also discussed: the specifics of their biology made them readily accessible and therefore very desired game for primitive hunters.

Key words: large terrestrial herbivores, carnivores, edentates (armadillos and terrestrial sloths), extinction, extermination, primitive hunters, terminal Pliocene, Pleistocene, Holocene.

For citation: Kalyakin V.N. Some Features of the Transformation of Mammal Faunas of the Palearctic and Nearctic in the Terminal Cenozoic. Russian Journal of Ecosystem Ecology. 2016;1(3). Available from: <https://doi.org/10.21685/2500-0578-2016-3-1>

Аннотация. В статье рассматриваются изменения на территориях Палеарктики и Неарктики в конце кайнозоя в составе тех видов, совокупная жизнедеятельность которых во взаимодействии с почвенно-растительным покровом определяла саму возможность существования экосистем этого типа на пространствах от тропической Африки до ряда арктических островов. Помимо фауны крупных фитофагов пастбищных экосистем и охотящихся на них хищников, в состав рассматриваемых таксонов включен ряд наиболее крупных грызунов, а для территории Неарктики – неполнозубых, биологические особенности которых делали их легкодоступной, а следовательно, и весьма желанной добычей первобытных охотников.

Ключевые слова: наземные крупные фитофаги и крупные хищники, неполнозубые (броненосцы и наземные ленивцы), вымирание и истребление, первобытные охотники, конец плиоцена, плейстоцен, голоцен.

Introduction

The choice of the territories of the Palearctic and Nearctic for this review was determined, above all, by the position of these zoogeographical regions in the extratropical zone of the Northern Hemisphere. Therefore, considerable differences in the dynamics of the faunas of these regions during the same period—from the Late Pliocene to Holocene—cannot be determined by climatic changes, which were absolutely synchronous. The timing of this period is interesting for the following two reasons: on the one hand, the possibility and necessity to analyze the compositions of large herbivore fau-

nas, mainly those of pasture ecosystems, and carnivores feeding on them during the Pleistocene – in the opinion of many authors, a time during which 1–19 surface glaciations took place [1] – and compare them to those of the terminal pre-Pleistocene; and on the other hand, the possibility to compare the mammal faunas of territories that primitive humans started to colonize at considerably different times. This study naturally continues the course of my earlier studies [2–5].

With this purpose, a table has been compiled using data from several main sources [6–10] and many additional ones [11–29].

Faunistic changes

The results given in the table summarize the faunistic changes in the Palearctic and Nearctic during the period in question and give evidence of some similarity between these changes, but at the same time of considerable differences between them. To represent them more vividly, graphs are given (Fig. 1), that take into account the changes made in the timing of the Holocene, Pleistocene, and Pliocene and confirmed by the International Commission on Stratigraphy in 2012. The graphs were based on the last line of the table, in which data on North Africa are excluded from summarized data on the Palearctic, although in most studies the mammal fauna of North Africa is usually

considered as part of the Palearctic mammal fauna. However, this came to be so only quite recently, as a matter of fact only in early historical times, i.e., about 2–2.5 thousand years before present. Until then the mammal fauna of North Africa was a quite natural part of purely Ethiopian mammal fauna, although peripheral and depleted. As for the changes in this fauna (Table 1), as well as the transformation of most of North Africa into the modern deserts, which began at the final stage of the Late Paleolithic and became especially evident after the advent of animal husbandry, these changes are recorded both in countless unique cave paintings [30, 31], first discovered before the Second World War in many areas of Central Sahara, and in corresponding paleontological finds [32, 33].

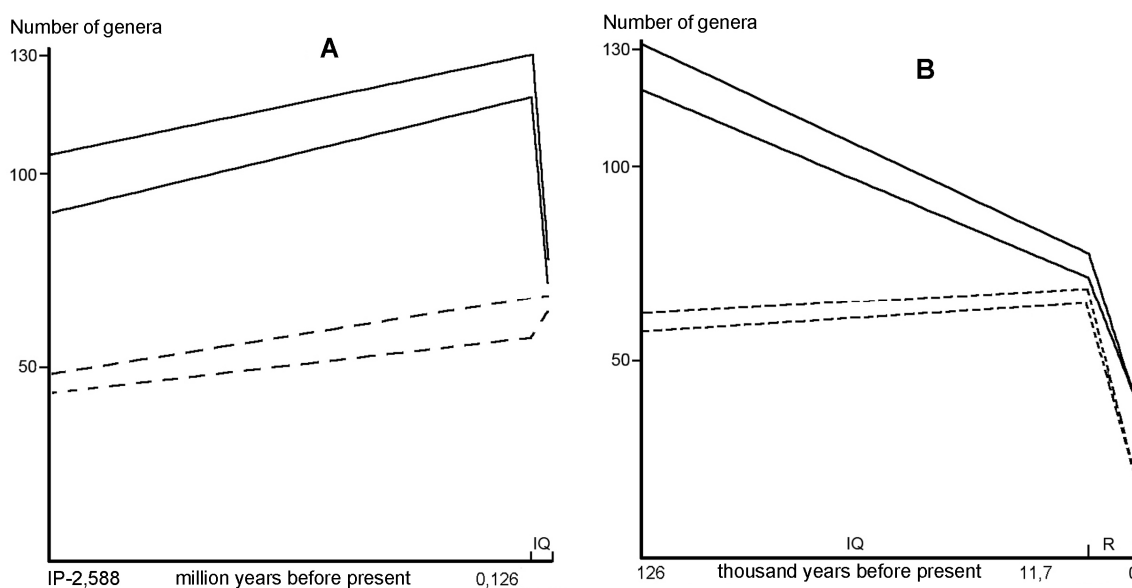


Fig. 1

Table 1

The structure of faunas (mainly at the generic level) of medium- and large-sized terrestrial herbivorous and carnivorous mammals of (over 10 kg) of the Palearctic and Nearctic from the Late Pliocene to present

Taxon (dating, years before present)	Palearctic					Nearctic				
	IP	eQ	IQ	+R	R	IP	eQ	IQ	+R	R
1	2	3	4	5	6	7	8	9	10	11
Cingulata (Dasypodidae)										
<i>Dasypus</i> (CA; ?IP, eQ-R – SA)						+	+	+		+
<i>Dasypus bellus</i> (latest 7200; from Texas 10900 ± 190)								+	+	
<i>Cabassous</i> (mQ-R – SA, CA)										CA
Pampatheriidae										
<i>Pampatherium</i> , including <i>Holmesina</i> (IP-IQ – SA – 9880)						+	+	+	+	
Glyptodontidae										
<i>Pachyarmatherium</i>							?			
<i>Glyptotherium</i> (IQ – CA – 13 970)						+	+	+	?	
<i>Pilosa</i> (Mylodontidae)										

1	2	3	4	5	6	7	8	9	10	11
<i>Glossotherium</i> (IM-IQ – SA; probably since eP; NA; Florida 9880 and 10155 ± 270)						+	+	+	+	
<i>Paramylodon</i> (42500 ± 4400)							?	+		
<i>Myiodon</i> (Kentucky 10600 ± 250; eQ and/or mQ, IQ – SA)								+	+	
Megatheriidae										
<i>Megatherium</i> (IP-Q – SA, in NA from Florida to South Carolina and Ohio)								+	?	
<i>Eremotherium</i> (10 000; ?eQ, IQ – CA; Q – SA)							+	+	+	
<i>Nothrotheriops</i> (Nevada 8527 ± 250)							+	+	+	
Megalonichidae										
<i>Meizonyx</i> (CA)							?			CA
<i>Megalonyx</i> (since IM – NA; IQ – NA to Alaska; ?eQ, IQ – CA; Q – SA; Georgia 9460 ± 85)						+	+	+	+	
<i>Choloepus</i> (R – SA)										CA
Bradipodidae										
<i>Bradipus</i> (R – SA)										CA
Rodentia (Castoridae)										
<i>Trogontherium</i> (eM-mQ – Eu; mM, IP-mQ – As; mM – NA)	+	m								
<i>Eucastor</i> (m-IM – NA; IM-P – As)	?									
<i>Dipoides</i> (since IM – Eu, As, NA)	+					+				
<i>Romanocastor</i>	+									
<i>Zamolxifiber</i>	+									
<i>Procastoroides</i> (since eP – NA)						+				
<i>Castoroides</i> (9550): <i>C. ohioensis</i> (Minnesota 10320 ± 250) <i>C. kansasensis</i> (Kansas 12150 ± 80), from New York to Nebraska						+	+	+	+	
<i>Paradipoides</i>							m			
<i>Castor</i> (since IM)	+	+	+		+	+	+	+		+
Hystriidae										
<i>Hystrix</i> (since ?Olig., eM; IM-R – Af; Q, R – OI)	+	+	+		+					
<i>Erethizon</i>						+	+	+		+
Hydrochoeridae										
<i>Nechoerus</i> (e-IQ – SA; IQ – CA; since eP – NA)						+	+	+		
<i>Hydrochaeris</i> (Q – NA; emQ, IQ-R – SA)							+	+	?	CA
Carnivora (Felidae)										
<i>Dinofelis=Therailurus</i> (IM-IP – As; IM-eQ – Eu; eP-eQ – Af)	+	+				+				
<i>Lynx</i> excluding <i>Caracal</i>	+	+	+		+		+	+		+
<i>Puma</i> (IP – As; ?eQ, mQ-R – SA; IQ-R – CA)	+					+	+	+		+
<i>Panthera</i> (eQ-R – Af; IQ-R – OI)		+	+		+					
<i>Jaguarius</i> (since eP – NA; mQ-R – SA; north of Mexico extinct in basal Holocene: Georgia 10940 ± 210)						+	+	+	+	CA

1	2	3	4	5	6	7	8	9	10	11
<i>Leo</i> (?eQ, Q – As, SA; beside Africa present in India; NA – 10370; Alberta 10930 ± 100; WEu – 10670 ± 160)		m	+	+	Af, SAs (India)			+	+	
<i>Tigris</i>		+	+		+					
<i>Uncia</i>		+	+		+					
<i>Sivapanthera</i> (?eQ – Af)		e								
<i>Acinonyx</i> (eP-eQ, lQ-R – Af; NA: Wyoming 10170 ± 250)	+	+	+		+	+	e	+	+	
<i>Machairodus</i> (lM-eQ – Af; lM – NA)	+									
<i>Homotherium</i> (to lQ – WEu, NAF; lM-lP – Af; eQ/mQ – OI; in NA: Montana 25030 ± 510)	+	+	+			+	+	+		
<i>Ischyrosmilus</i>						+				
<i>Megantereon</i> (lQ – NAF; lP-mQ – Af; e/mQ – OI)	+	+				+				
<i>Smilodon</i> (Tennessee 9410 ± 155; lP-lQ – SA; lP – CA)						+	+	+	+	
Hyaenidae										
<i>Hyaena</i> (mM, eP-R – Af)	+	+	+		+					
<i>Chasmaporthetes</i> (since lM – As, Eu; ?lP/?eQ – Af)	+	e				+	e			
<i>Pachycrocuta</i> , including <i>Parahyaena</i> (?lM, eQ-R – Af; e-mQ – OI)	+	+			Af					
<i>Crocuta</i> (since lP – Af; South China – 11 200 ± 1000; WEu – 22 880 ± 240)	+	+	+	+	Af					
Canidae										
<i>Borophagus</i>						+				
<i>Vulpes</i> = <i>Alopex</i>	+	+	+		+	+	+	+		+
<i>Canis</i> (since lM, eQ-R – Af; e/mQ – OI; R – CA; lQ – Med. (islands Sardinia, Sicily))	+	+	+		+	+	+	+		+
<i>Cuon</i> (e/m, lQ-R – OI)	+	+	+		+		+	+		
Ursidae										
<i>Arctodus</i> (Kansas 9630 ± 60; e-lQ – SA)							+	+	+	
<i>Tremarctos</i> (Georgia 10940 ± 210; R – SA; ?+R – CA(?Panama))							+	+	+	
<i>Spelearctos</i> (eR – Caucasus)		+	+	+						
<i>Ursus</i> (including <i>Thalarctos</i>)	+	+	+		+	+	+	+		+
<i>Ailuropoda</i>		m	+		+					
Mustelidae										
<i>Martes flavigula</i> (R – S, EAs) genus <i>Martes</i> (since eM – Eu)			+		+					
<i>Gulo</i>		m	+		+		e	+		+
Artiodactyla (Suidae)										
<i>Chleustchoerus</i> (lM, P – As, China)	?									
<i>Sus</i> (since ?mM – As; M – NAF; lM – Eu; e,lP/eQ – Med.; eQ-R – OI)	+	+	+		+					
<i>Hippopotamodon</i> (= <i>Dicoryphochoerus</i>) (since lM)	+	+								
<i>Propotamochoerus</i> (since mM As; ?lM Af)	+									

1	2	3	4	5	6	7	8	9	10	11
<i>Potamochoerus</i> (since mM – As; since eP – Af; IQ – Naf; R – Madagascar)	+	e,m	?	+	Af					
<i>Hippohyus</i> (since IM)	+	e								
<i>Phacochoerus</i> (since IP – Af; IQ – Naf)		m	+	+	Af					
<i>Metridiochoerus</i> (IP-mQ – Af)		m								
Tayassuidae										
<i>Platygonus</i> (Ohio – 4370 ± 150; IP-IQ – SA)						+	+	+	+	
<i>Mylohyus</i> (Georgia 10940 ± 210)						+	+	+	+	
<i>Tayassu</i> (?IP, Q, R – SA; IQ-R – CA)						+	+	+		+
Hippopotamidae										
<i>Hexaprotodon</i> (since IM – Af; IP-IQ – OI)	+	+	+	?	Af					
<i>Hippopotamus</i> (since IP – Af; Q – Med.; +R – Naf, SWAs, Madagascar)		+	+	+	Af					
Camelidae										
<i>Hemiauchenia</i> (since mM; e-IQ – SA; Kansas 13410 ± 300)						+	+	+	?	
<i>Pliauchenia</i> (since IM; 11690)								+	+	
<i>Blancocamelus</i>						+				
<i>Camelops</i> (California 8550 ± 100; IQ – CA)						+	+	+	+	
<i>Palaeolama</i> (9880; Florida 12350 ± 50; IP-IQ – SA)							+	+	+	
<i>Lama</i> (Nevada 12060 ± 450; IP-R – SA)								?	+	SA
<i>Camelus</i> (since IM; probably extinct in wild state)	+	+	+	?	?					
<i>Titanotylops</i> (since ?P – As, Eu; since eP – NA)	?					+	e			
Tragulidae										
<i>Dorcatherium</i> (e-IM, P – As; e-mM – Af; m/IM – Med., Crete)	?									
<i>Dorcabune</i> (since mM)		e								
Moschidae										
<i>Blastomeryx</i> (e-IM, P)						?				
<i>Longirostrimeryx</i> (since mM)						+				
<i>Moschus</i> (since IM)	?	?	+		+					
Antilocapridae										
<i>Capromeryx</i> (since P; New Mexico, 11 040 ± 500)						?	+	+	+	
<i>Tetrameryx</i>						+	+	+		
<i>Stockoceros</i> (11 500)							m	+	+	
<i>Antilocapra</i>								+		+
Cervidae										
<i>Hydropotes</i> (EAs)					+					
<i>Platycemas</i> (P – As) "?" deleted"	?									
<i>Paracervulus</i> (since IM)	+	e								
<i>Muntiacus</i> (since IM, R – OI)	+	+	+		+					
<i>Eostyloceros</i> (since IM)	+	e								
<i>Metacervulus</i> (since IM)	+	e	+							
<i>Elaphodus</i>		m			+					
<i>Tamanalces</i> (P – EEU)	+	?e								

1	2	3	4	5	6	7	8	9	10	11
<i>Pseudalces</i> (P – WAs; P – EEU)	?									
<i>Torontoceros</i>								+		
<i>Cervavitus</i> (since ?m, IM)	+	e								
<i>Pliocervus</i> (since IM)	?									
<i>Arvernoceros</i> (Eu)	+									
<i>Orchonoceros</i> (EAs)	+									
<i>Sinomegaceros</i> (EAs)	+	+	+							
<i>Psekupsoceros</i> (EEU)		e								
<i>Praemegaceros</i> (Eu, As)		+								
<i>Candiacervus</i> (Crete, Kasos, Karpathos)		?m	+							
<i>Megaloceros</i> (As, Eu; Middle Urals 6 816 ± 35)		m	+	+						
<i>Allocaenelaphus</i> (EEU)		m								
<i>Megaceroides</i> (EEU; IQ – Naf)		e	+	+						
<i>Nesoleipoceros</i> (Corsica, Sicily)			+							
<i>Cervus</i> (mQ-R – Malta, Sicily; R – Af, Ol)	+	+	+		+		+	+		+
<i>Axis</i> (since ?IM – As; Q-R – Ol)	+	+			Ol					
<i>Eucladoceros</i> (Eu)	+	+								
<i>Croizetoceros</i> (Eu)	+	e								
<i>Elaphurus</i> (EAs, extinct in wild state)		e	+	+						
<i>Dama</i> (?Q Naf; m/IQ – Sicily)		+	+		+					
<i>Sangamon</i> (9 440; West Virginia 17 060 ± 220)								+	+	
<i>Procapreolus</i> (since IM)	+	e								
<i>Capreolus</i>	+	+	+		+					
<i>Cervalces</i> (Michigan 10020 ± 80)	?	+	+			+	+	+	+	
<i>Alces</i>		?m	+		+			+		+
<i>Bretzia</i> (IQ/R)								?	?	
<i>Odocoileus</i> (Q – CA, SA)						+	+	+		+
<i>Blastocerus</i> (eQ, m/IQ – SA)								+		
<i>Mazama</i> (Q, R SA; R CA; R – Mexico)								?		+
<i>Navahoceros</i> (11 500; New Mexico 12 000 ± 400)								+	+	
<i>Rangifer</i>		+	+		+		+	+		+
Giraffidae										
<i>Palaeotragus</i> (since ?e, mM; e-IM – Af)	+									
<i>Sogdianotherium</i> (As)	+									
<i>Macedonitherium</i> (Eu)	+	e								
<i>Giraffa</i> (IM, Q – As; eP-R – Af; +R – Naf)	+	+	+	+	Af					
? <i>Honanotherium</i> (IM/P – As)	?									
<i>Mitilanotherium</i> (EEU)		E								
<i>Sivatherium</i> (eP-IQ – Af; Q – EEU, since eP – WAs)	+	?	?	+						
Bovidae										
<i>Pontoceros</i> (EEU)	+	+								
<i>Parabubalis</i> (As)			+	+						
<i>Gazella</i> (including <i>Procapra</i> ; since eM; eM-R – Af)	+	+	+		+					
<i>Antilope</i> (since IM; IP – Af)	+	+	+		+					
<i>Antilospira</i> (EAs)	+									
<i>Sinoreas</i> (since eP – EAs)		?e								
<i>Parastrepsiceros</i> (WAs)	+									
<i>Spirocerus</i> (E.As; since IM CAs)	+	+	+							

1	2	3	4	5	6	7	8	9	10	11
<i>Gazellospira</i> (Eu, WAs)	+	m								
<i>Tragospira</i> (Eu)		+								
<i>Pantholops</i> (Q As)		?	+		+					
<i>Saiga</i> (Eu, As; Alaska, Canadian Arctic: 12220 ± 130)		m	+		+		m	+	?	
<i>Ourebia</i> (?e, mQ-R – Af; IQ – R – Naf)			+	?	Af					
<i>Myotragus</i> (Med: Balearic Islands)	+	+	+	+						
<i>Capraoryx</i> (EEu)		e								
<i>Protoryx</i> (since ?m, IM – As, EEu)	+	e								
<i>Sinocapra</i> (China)	+									
<i>Capra</i> (since IM – As, Eu; IP, R – Naf; IQ – England)		m	+		+					
<i>Procamptoceras</i> (Eu)	+	e								
<i>Ovis</i> (IQ – England, Af; R – Med.)	+	+	+		+		m	+		+
<i>Ammotragus</i> (eQ – WEu; IQ-R – Naf)		+	+		Naf					
<i>Hemitragus</i> (Eu; R – SAs)	+	+	+		+					
<i>Numidocapra</i> (Naf)		e								
<i>Rupicapra</i> (Eu; R and WAs)		m	+		+					
<i>Oreamnos harringtoni</i> (Arizona 10 870 ± 200; <i>O. americanus</i> is extant)								+	+	+
<i>Pseudois</i> (As)		+	+		+					
<i>Megalovis</i> (Eu, As)	+	e								
<i>Budorcas</i> (Q,R – As)	+	+	+		+					
<i>Praeovibos</i> (As, Eu; ?e, mQ – NA)		+					+			
<i>Bootherium</i> (Alaska 6410 ± 120)							m	+	+	
<i>Ovibos</i> (Eu, As, NA)		m	+	+			m	+		+
<i>Symbos</i> (Utah 7325 ± 160)							m	+	+	
<i>Soergelia</i> (Eu, NEAs)		m					m			
<i>Boopsis</i> (As)		m								
<i>Euceratherium</i> (California 8250 ± 330)							m	+	+	
<i>Gallogoral</i> (Eu)	+	e								
<i>Nesogoral</i> (Sardinia)		e								
<i>Naemorhedus</i> (Q, R – As; IQ – Eu)		+	+		+					
<i>Capricornis</i> (Q, R – As; R – OI (Sumatra))		?	?		+					
? <i>Plioportax</i> (P – EEu)	?									
<i>Proboselaphus</i> (eP-IQ – China; Q – OI)	+	+	+							
<i>Boselaphus</i> (+R to 18 in – Naf; R – SAs)			+	+	SAs					
<i>Leptobos</i> (IM-mQ – Eu, since P – As; ?IM, ?Q – Naf)	+	+	?	?						
<i>Parabos</i> (since IM – Eu)	+	?e								
<i>Syncerus</i> (IP-R – Af; IQ – Naf)			+	+	Af					
<i>Yakopsis</i> (Eu)	+									
<i>Hemibos</i> (As; ?IP – Eaf)	?	e	+							
<i>Bos</i> , including <i>Bibos</i> , <i>Poephagus</i> (As, Eu; since IP/eQ – R – Naf; +R – Eu; IQ – Sicily; R – Java, Borneo; Q – Alaska; Washington State 610 ± 40)		e	+		+		?	+	+	

1	2	3	4	5	6	7	8	9	10	11
<i>Bubalus</i> (IP-R – SAs, OI; IP-mQ – WEu, China)	+	m	+		SAs OI					
<i>Agjiderebos</i> (As)	+									
<i>Bison</i> (+R – As, R – Eu)		+	+		+		m	+		+
<i>Platycerabos</i> (Q; 12 950)							?	+	?	
<i>Tragelaphus</i> (IM-R – Af; lQ, +R – Naf)	+	+	+	+	Af					
<i>Taurotragus</i> (IP-R – Af; lQ, +R – Naf)	+	+	+	+	Af					
<i>Redunca</i> (?IM, IP-R – Af; ?IM – As, N-W Iran; lQ, +R – Naf)			+	+	Af					
<i>Kobus</i> (eP-R – Af; lQ, +R – Naf)			+	+	Af					
<i>Hippotragus</i> (eQ – As; IP-R – Af; ?+R – Naf)	+	e	+	+	Af					
<i>Addax</i> (lQ, ?+R – Naf; R – Af)			+	+	Af					
<i>Oryx</i> (IP-R – Af; +R – Naf, WAs)	?	e	+	+	Af					
<i>Alcelaphus</i> (lQ – +R – SWAs, Naf; since IP – Af)			+	+	Af					
<i>Damalops</i> (Middle, SAs; ?IP – Af)	+	e								
<i>Connochaetes</i> (IP-R – Af; lQ, ?+R – Naf)			+	+	Af					
<i>Damaliscus</i> (IP-R – Af; lQ, ?+R – Naf)		+	+		Af					
<i>Perissodactyla</i> (Equidae)										
<i>Nannipus</i> (since mM)						+				
<i>Hipparion</i> (since mM; IM-mQ – Af; IM – Crete; IM – CA)	+	E								
<i>Proboscideipparion</i> (As)	+	E								
<i>Cormohipparion</i> (since mM NA; since IM Eu, As, CA)						+				
<i>Hippidion</i> (since IM, IP/eQ – NA; since IP – SA, where it became extinct about 8 thousand years before present)						?	?e			
<i>Onohippidium</i> (eP – NA; since IP – SA)						?	?	?		
<i>Equus</i> , including <i>Amerhippus</i> , <i>Asinus</i> , <i>Hemionus</i> , <i>Onager</i> (since eP – NA, where it survives or almost survives to European colonization; Washington 595 ± 50, Ontario 895 ± 110; since IP – As, Eu, Af; m-lQ – SA, lQ – CA); *subgenus <i>Equus</i> in probably extinct in Eurasia in wild state	+	+	+	+	+, Af	+	+	+	+	
Rhinocerotidae										
<i>Itanzatherium</i> (As)	?	?								
<i>Aceratherium</i> (lOlig-M – As, Eu, ?eP, ?Q – As; e-lM – Af; ?mM – Crete)		?	?							
<i>Elasmotherium</i> (As, Eu)	+	+	+							
<i>Dicerorhinus</i> (l. Olig. – lQ Eu; eM-lQ – Af; ?+R – Naf; mM-R – SEAs; R – OI)	+	+	+	?	SAs OI					
<i>Coelodonta</i> (since IP – As, since mQ – Eu; +R – As, ?– Eu; Middle Urals 9510 ± 260)	+	+	+	+						

1	2	3	4	5	6	7	8	9	10	11
<i>Rhinoceros</i> (IM-IQ; ?IM, Q – Af; eP-R– SAs; R – OI)	+	e	+		SAs OI					
<i>Ceratotherium</i> (since IM – Af, Eu, WAs; ?+R – Naf, WAs; ?IM – Sicily)			+	?	Af					
<i>Diceros</i> (mM-Q; eP-R – Af; IQ, ?+R – Naf)	+	+	+	+	Af					
Tapiridae										
<i>Tapirus</i> (Florida 10155 ± 270; IM – Q Eu; IM – R – SAs; ?e, IP-R – SA; Q,R – CA)	+	?	?		OI	+	+	+	+	CA
? <i>Megatapirus</i> (SAs, ?South China)		m	+	+						
Uranotheria (Mammutidae)										
<i>Mammut</i> (New Jersey 5220 ± 120; IM-P – As; to eQ – Eu; to ?eQ – Af; since eP – NA; Q – CA)	+	e				+	+	+	+	
Gomphotheriidae										
<i>Sinomastodon</i> (E. As)	+	m								
<i>Rhynchotherium</i> (since mM; IM CA)						?				
<i>Stegomastodon</i> (since eP)						+	m			
<i>Haplomastodon</i> (Q CA; P/eQ-IQ SA)						?	?	?		
? <i>Notiomastodon</i> (SA; not recorded in NA so far)						?	e SA			
<i>Cuvieronius</i> (IM-IQ – NA; IQ – CA; ?IP,Q – SA; SA – 11380)						+	+	+	?	
Elephantidae										
<i>Tetralophodon</i> (since mM; m-IM, ?eP – Af; eP-mQ – NA)		e				+	m			
<i>Anancus</i> (since IM; m-IM – NA; IM-eQ – Af)	+	e								
<i>Stegolophodon</i> (since eM – As, Japan; ?P – Eu)	+	?e								
<i>Stegodon</i> (since IM – As, Japan, Taiwan, northeastern China; IP, Q – OI)	+	+	+	+						
<i>Mammuthus</i> , <i>Archidiscodon</i> (eP-mQ – Af; IP – CA; Wrangel Island 3685 ± 60; Zhaoyuan (China) – 3584 ± 104; Oklahoma (United States) – 2050 ± 580; Vologda Oblast 9760 ± 40)	+	+	+	+			e	+	+	
<i>Elephas</i> , <i>Palaeoloxodon</i> (As, Japan, Taiwan, Tilos, Rhodes in Holocene; to Holocene? – Naf; R – SAs)	+	+	+	+	SAs OI					
Total number of genera	90–105	120–131	84–90	33–39	42–43	43–48	58–63	64–68	32–40	20
Total number of genera, excluding North Africa from the Palearctic	90–105	120–131	72–78	19–23	41–42	43–48	58–63	64–68	32–40	20

Note: Olig. – Oligocene, M – Miocene, P – Pliocene, Q – Pleistocene (for every period: l – Late, e – Early, m – Middle), "?" in eQ column – early or middle Q, but in other columns "?" indicates doubts of source author about precision of following dating, but not further dating, if they are given; + (in eQ column) – both Early and Middle; +R – extinct in Holocene or at boundary between Late Pleistocene and Holocene; R – recent; As – Asia, Eu – Europe, Af – Africa (N – northern, S – southern, W – western, E – eastern, C – central), OI – Ost-India. NA – North America; CA – Central America; SA – South America, Med – Mediterranean islands.

So, what follows from the given graphs, in both of which the upper curve represents the Palearctic fauna and the lower curve represents the Nearctic fauna?

First, let us note the similarities. Both in the Palearctic and in the Nearctic, the faunas of the studied groups proved more depleted in the Late Pliocene than in the Early and Middle Pleistocene, but the recent faunas are even more depleted. However, neither fact can be linked to changes of the climate.

Second, let us discuss the differences. The greater richness of the Palearctic fauna compared to the Nearctic fauna is quite logical in the light of the much larger area of the Palearctic and its broader connections in both space and time with the faunas of the adjacent zoogeographical regions (Ethiopian and Indomalaysia). The direct contact of the Nearctic with the adjacent Neotropical region was most probably re-established only in the Late Pliocene, i.e. about 3 million years before present or somewhat earlier, following a period of isolation that lasted during the entire preceding part of the Cenozoic or even since the Late Cretaceous, over 60 million years before present [34, 35]. Therefore, this difference is quite natural. The differences between the Late Pleistocene histories of the Palearctic and Neotropic mammal faunas are much more considerable. Having reached a maximum of generic diversity in the Late and Middle Pleistocene (121–132 genera), the Palearctic fauna then dramatically becomes depleted: the number of genera decreases to 73–79 in the Late Pleistocene. During the same period, the corresponding fauna of the Nearctic grows from 59–64 to 65–69 genera. However, during the last 55 thousand years, the depletion of the Nearctic fauna was more intense than that of the Palearctic. Furthermore, during the very last few millennia of the Pleistocene, 6–12 taxa, including one species, became extinct in the Nearctic, and already in the Holocene the fauna of the Nearctic included only 32–40 genera. A total of 32–40 genera of 65–69 became extinct in the Nearctic, and the ranges of eight genera are confined in the north within the boundaries of Central America. It should be noted that radiocarbon dates of the latest known records are available for 42 genera and two species that disappeared from the Nearctic fauna over the last 55 thousand years (i.e., since the earliest occurrence of humans in North America according to the available data). It is very revealing that the latest records are at most 10 thousand years old in 23 of these genera, at most 11 thousand years old in six of them, less than 12 thousand years old in four, and less than 14 thousand years old in two; i.e., at least 34 taxa became extinct during the Holocene (32 genera and 2 species). The latest records of two more gen-

era are dated to earlier times: 42 500 years before present (*Paramilodon*) and 25 030 years before present (*Homotherium*). The latest date of the latest known record among Nearctic carnivores is that of *Smilodon* (9410 years before present), whereas in the Palearctic only *Homotherium* survived until the Late Pleistocene – a genus once distributed from Alaska to Java. It would seem that the easily accessible armadillos and terrestrial sloths could have become extinct, precisely as a result of hunting by primitive humans, earlier than the other mammals. Indeed, almost all of them became extinct by the terminal Pleistocene or in the very basal Holocene. However, one representative of each of these two groups managed to survive longer in the Nearctic: the latest record of a 2 m long terrestrial sloth *Nothrotheriops* from Nevada is dated to 8527 years before present, and the latest record of the armadillo *Dasybus bellus* from Texas, a species twice as large as the recent *Dasybus novemcinctus*, is dated to as late as 7200 years before present. It should be noted that while terrestrial sloths and giant armadillos became completely extinct both in the Nearctic and in the Neotropic, a total of 21 species of smaller armadillos, which represent eight or nine genera, remain extant in South and Central America and some coastal islands of the Caribbean Sea. The above-mentioned *Dasybus novemcinctus* has colonized also the southern areas of the Nearctic, which happened most probably rather recently; in any case, even in the 20th century its range is known to have expanded northward. Only one of the 20 or 21 extant armadillo species, *Priodontes giganteus*, which lives in central and eastern areas of Brazil, reaches a rather great size: a length of 1 m and a weight of 55 kg, whereas glyptodonts and *Glyptotherium* were 2–2.5 m long and could weigh up to 1 t or more. Woolly mammoths, the largest terrestrial herbivores, disappeared in the Nearctic much later than in the Palearctic. The latest dates of mammoth fossils are as follows: in Oklahoma 2050 years before present, in Michigan 3310 years before present, in Arizona 3320 years before present, in Alaska 3500 years before present, in Calgary, southwestern Canada, 4080 years before present, in Idaho 4300 years before present, in Ontario 4370 years before present. These dates give evidence that this species was widespread even relatively recently. In absolutely most of the Palearctic, the woolly mammoth disappeared much earlier; the latest dates of fossil records during the early Holocene are known from Estonia, Vologda Oblast, Taimyr Peninsula, and New Siberian Islands [36, 37]. The woolly mammoth remained extant much longer on Wrangel Island (3685 years before present), on which the latest mammoths were nearly half as large as the original form (inevitable consequence of long life on rather small arc-

tic islands in many larger animals) and in northwestern China (3584 years before present). A dwarf form of the Asian elephant survived on some islands of the Eastern Mediterranean until the times of the pharaohs, 1445 BC [38]; it is assigned by some authors to the forest elephant genus *Palaeoloxodon*. *Stegodon* survived in Yunnan, China, until the Neolithic, up to 4100 years before present [39]. The American mastodon *Mammuth americanum* survived in the Nearctic at least until the Middle Holocene (the latest record, from New Jersey, is dated to 5220 years before present), although in the Palearctic this genus disappeared as early as the Early Pleistocene. Wild horses and yaks lived in the Nearctic much longer than was believed only recently. The latest records of the horse (595 years before present in the state of Washington and 895 years before present in Ontario) show that it survived almost until the European colonization, or even later, which cannot be excluded. An even later record, 410 ± 100 years before present from Michigan, without knowledge of any details, cannot be reliably assigned to the wild horse, rather than to the horse introduced by the colonists. The latest record of the yak, 610 ± 40 years before present in the state of Washington, gives evidence that this species managed to disperse over the Rocky Mountains far south. It is quite obvious that the latest radiocarbon dates given in the table are actually not the latest dates and only roughly give some evidence of the timing of extinction for different taxa, which in reality in the vast majority of cases became extinct only somewhat later. Therefore, all genera recorded during the last millennia of the Pleistocene are provided with a question mark in column +R (i.e., those that became extinct in the Holocene). The above-given examples raise several questions. The first and foremost is how to explain such a strong difference in the timing of rather dramatic depletion between the Palearctic and Nearctic faunas discussed here. In the Palearctic extinction takes place in two stages: during the first, long stage, from the Early–Middle to Late Pleistocene, the fauna becomes depleted to nearly half of its initial size; during the second stage, from the Late Pleistocene to present, the total depletion is only one-fifth to one-sixth of the earlier depletion, but the intensity of extinction is considerably higher, possibly even by a factor of magnitude, considering the much greater duration of the first stage (by a factor of 20–30 or even more). By contrast, in the Nearctic, during the first stage of similar length, the fauna does not become depleted at all: it even becomes somewhat richer, but during the second stage it becomes depleted mainly during a period only one or two millennia longer than the entire Holocene; i.e., the "effectiveness" of extinction in the Nearctic during the last 13 or 14 millen-

nia is similar to that "achieved" in the Palearctic during many tens (or even hundreds) of millennia. As a result, the fauna of the taxa in question in the Palearctic currently makes up 31.1–34.7 % of the maximum size of this fauna of the Early–Middle Pleistocene (i.e., also during the entire period of about 3 million years treated in this study), and the corresponding fauna in the Nearctic is 30.4–32.3 % its maximum size of the Late Pleistocene, terminal Cenozoic. It has already been mentioned above that this sharply pronounced difference can by no means be linked to climate: it is quite obvious that the Palearctic and Nearctic are situated in the same climate zones, and the extinctions themselves, although much more rapid in the Nearctic than in the Palearctic, are nevertheless stretched over 13–14 millennia. Therefore, the most likely cause of these differences, as well as the most likely cause of the extinctions themselves, is human activity. The dispersal of *Homo erectus*, the direct ancestor of modern humans, from Africa to the Palearctic and Southeast Asia, took place over 1 million years before present and was not at all the only such event [40]. The age of the Peking men, which had mongoloid features, is estimated to at least 370 thousand years [41]. It was most probably by the later Peking men that the wolf was first domesticated [3], thus becoming a companion also of modern humans that dispersed from Africa [42] on their way from South–Southeast Asia to Australia. At least 200 thousand years before present, the Palearctic was inhabited by Neanderthal men, their genes (up to 4.5 %) are present in the genotypes of modern humans, that replaced one of its ancestors, the Neanderthal man, during the period from 45 to 27 thousand years before present [43]. Many data give evidence that during the late Le Moustier Neanderthal men already successfully hunted woolly mammoths [44, 45], and most probably had an indispensable helper in the domesticated wolf, as directly confirmed by the data obtained by Ovodov et al. [46] in the Altai. Thus, in the Palearctic humans in possession of fire affected the environment for hundreds of millennia. It is very unlikely that the earliest humans penetrated into North America earlier than 55 thousand years ago. In the opinion of most experts, successful colonization of the New World by modern humans via Alaska and their subsequent dispersal south took place about 15 thousand years before present or somewhat later [43], which is indirectly confirmed also by rather numerous data given in the table and results of radiocarbon dating from sites of primitive humans known in North America. Subsequently the growth of the number of later radiocarbon dates accelerates: 18 from 55 to 45 thousand years before present, 65 from 25 to 15 thousand years before present, and then 14 during the 14th millennium,

16 during the 13th millennium, 56 during the 12th millennium, 121 during the 11th millennium, 217 during the 10th millennium, then growing exponentially [10]. Thus, professional woolly mammoth hunters that colonized America accompanied by the wolf (dog) began to disperse rapidly and grow in numbers more and more, beginning with 13–12 thousand years before present. It is very revealing that in the first one-third of the Holocene the number of recorded stone spearheads and darts used for hunting large carnivores that lived in the Great Plains, where they were especially abundant, is greater by several orders of magnitude than the number of the same tools recorded in other areas of the United States [47]. As a result, almost all main game of the primitive hunters (whose mode of life remained unchanged in northern parts of the continent for some time even after the start of the European colonization of America) became totally extinct already in the Holocene [48]. By that time, only the bison, pronghorn, and reindeer remained extant of the truly abundant larger herbivore species. The balance required by that essentially closed system was established between the abundance of those herbivores and the population size of the primitive hunters that existed mostly on this game. In the Palearctic (and to a smaller extent in the Neotropic), the Mesolithic crisis, largely caused by the dramatic decrease in abundance of the principal game species on which the primitive hunters mainly lived, eventually led to the Neolithic revolution, the advent of crop farming and animal husbandry, initially narrowly regional, but rather soon spreading wider and wider [49]. It was this revolution that postponed the moment of final extinction or the critically low abundance for several most important game species. At the same time, in the Palearctic degradation of initial pasture ecosystems started much earlier and went much farther, very strongly increasing the risk of extinction in some species or resulting in dramatically shrinking ranges in others. These ecosystems are now completely replaced with continuous forests over huge areas with the most humid climate. Most lately, during less than three centuries, the forests have been barbarously cut in places and affected by other anthropogenic factors. It is typical that over the last few millennia not a single large herbivore of the typical edificator assemblage of pasture ecosystems has preserved in the Palearctic a range close to initial and similar to the current range of the American bison, which stretches from Alaska to the Gulf of Mexico and northeastern Mexico. The range of the North American arboreal porcupine *Erethizon dorsatum*, the only species of the genus *Erethizon* (Erethizontidae), is even more stunning. This species evolved in South America

since the Oligocene and penetrated into North America only in the Late Pliocene, when the "splendid isolation" [34] of the Neotropic and Neartic regions ended. As for the remaining 12 species, one of them is distributed only in Central America (from Central Mexico to Panama), the range of another one encompasses the tropical forests of South and Central America, one lived on the Greater Antilles but became extinct during historical times, and all others are distributed within the limits of South America [28]. In this connection, the generic composition of the fauna of Alaska, the northernmost continental area of North America, during the coldest time of the Pleistocene (17 to 26 years ago) and comparison of this composition with the current composition of this fauna are of special interest. Such a comparison became possible following the review of 2654 radiocarbon dates of terrestrial mammal fossils of North America published by Levi et al. [8–10]. During the coldest time of the Late Pleistocene, in addition to recent genera that currently live in Alaska, the fauna of this peninsula included the following genera and species, currently either extinct (in North America or everywhere) or confined to more southern ranges: *Megalonyx*, *Arctodus*, *Camelops*, *Saiga*, *Bootherium*, *Equus*, *Mammut*, and *Mammuthus* comprise the former group, and *Taxidea taxus*, *Puma concolor*, and *Cervus elaphus* comprise the latter group. Of the last three species, the North American badger *Taxidea taxus* displays the most considerable shrinking of range. But the ranges of two related species of steppe polecats, *Mustela eversmanni*, distributed in Eurasia, and *M. nigripes*, distributed in North America, have shrunk even more dramatically; the latter species is a subspecies of the former (Fig. 2, 3; [13]). The records of these species have earlier dates in Alaska: $33\,550 \pm 350$ years ago for *M. eversmanni*, and $30\,370 \pm 560$ years ago for *M. nigripes*. The shrinking of the range of the Eurasian steppe polecat to date is quite comparable in scale to the retreat of *Saiga* and the horse (subgenus *Equus*) to Eurasia and subsequent shrinking of their ranges, although it is possible that the horse has already become extinct in the wild in Eurasia. It is also very revealing that the ranges of such mammals as the tapir and jaguar, currently distributed in the north within the boundaries of Central America, stretched much farther northward during the coldest period. The tapir was distributed to the modern Pennsylvania, and the jaguar was distributed to Tennessee, where their ranges overlapped with the range of reindeer. At the same time, the arctic lemming, currently indigenous to the Arctic and Subarctic, was distributed in the south to Iowa.



Fig. 2

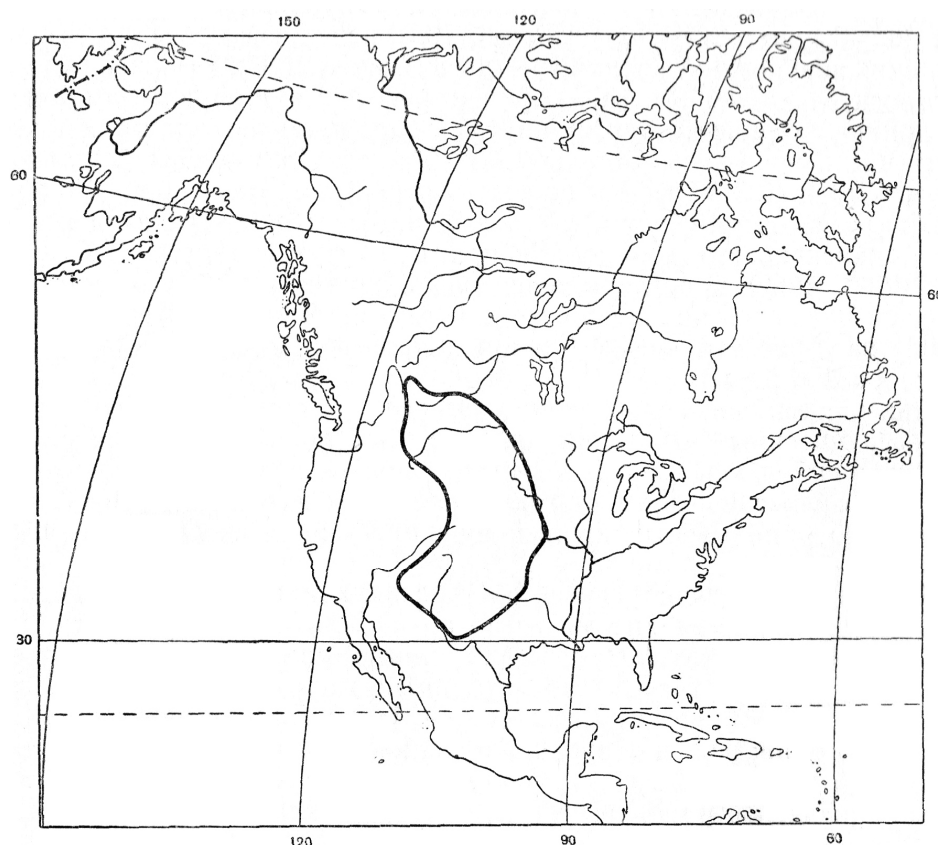


Fig. 3

Rather many other similar examples on both the Nearctic and Eurasia can be given. Since the Late Pleistocene fauna of the New Siberian Islands has already been discussed in my previous contribution, let us limit the discussion to the examples of the British Isles and Scandinavia, which, according to very many authors, during the coldest period were covered with glaciers that crawled further south over the plains of Europe. The following radiocarbon dates are available for woolly mammoth fossils from Finland: 13 133, 13 134, 13 180, 15 761, 16 120, 16 121, 16 122, 24 450, and 43 000 years before present; $15\,500 \pm 65$, $22\,420 \pm 315$, $23\,340 \pm 350$, $24\,450 \pm 390$, $25\,200 \pm 500$, $28\,740 \pm 670$, $31\,970 \pm 950$, and $34\,300 \pm 2\,000/1450$ years before present [9]. From the coldest period of the Pleistocene in the British Isles, dates are available for the wolf, red fox, brown bear, wolverine, moose, red deer, giant deer, reindeer, bison, muskox, woolly rhinoceros, woolly mammoth, and – revealingly – cave hyena *Crocota crocuta spelaea* (not reaching far northward anywhere in Eurasia during the Pleistocene), as well as the mole *Talpa*, which, like the other above-listed species, cannot live not only on glaciers or under glaciers but also in any areas with deeply freezing soil. The latest available dates for records of some mammal species in the British Isles are as follows: terminal Pleistocene for the woolly mammoth ($12\,320 \pm 120$ years before present) and saiga ($12\,100 \pm 140$); Holocene for the moose ($11\,190 \pm 100$), northern mole vole *Ellobius talpinus* ($10\,370 \pm 90$), currently absent west of southern Ukraine, steppe pika *Ochotona pusilla* ($10\,180 \pm 90$), currently absent west of the Volga, arctic lemming *Dicrostonyx torquatus* ($10\,000 \pm 80$), which "retreated" eastward beyond the White Sea, lynx (8875 ± 70), giant deer (6816 ± 35), brown bear (6410 ± 110), wild pig (4730 ± 80), aurochs (4040 ± 60), bison (3870 ± 60), horse (3050 ± 80 , later dates are also available), and beaver (2900 ± 60). The following species that accompanied the woolly mammoth during the coldest period of the Pleistocene are currently extant in the British Isles: the European mole, red fox, and red deer, and reindeer, which is currently rather rare and confined to Scotland [50]. It is also worth noting that not only the British Isles but also Scandinavia (including extreme southern areas) are inhabited by some amphibians and reptiles (five amphibian and six reptilian species and nine amphibian and six reptilian species, respectively [51]). This fauna could have dispersed into the two regions only "by dry land", i.e., during a period of sufficiently pronounced regression, which either coincided with the coldest period of Pleistocene or took place much earlier, but according to the latter scenario the presence of those species should not

(could not) have been disrupted by glaciation. In any case, either of the two scenarios contradicts the glacier hypothesis, also contradicted by the presence of endemic plants distributed northward to Greenland.

Finally, let us discuss yet another peculiar feature of the vivid and rapid faunistic transformations that took place in the Nearctic. It would have seemed natural if the first extinctions of the many taxa that disappeared in the Nearctic around the Pleistocene–Holocene boundary were those of edentates (the largest armadillos and terrestrial sloths), splendidly protected from any predators but defenseless in the face of primitive hunters, like giant tortoises. In reality, however, the first extinctions were those of the larger carnivores specialized at preying either on the largest herbivores typical of pasture ecosystems (the saber-toothed *Homotherium* and *Smilodon* and the lion) or on relatively small but the most abundant herbivores typical of pasture ecosystems (the cheetah). It would have seemed that the relatively low abundance of the larger carnivores, similar to that of edentates (especially compared to those of the most abundant ungulate species and extremely valuable proboscideans, also hunted at a limited scale), and the extremely high danger of hunting them could have safely protected them from early extinction. However, these factors failed to protect them. So, why did they prove the most vulnerable and why did they become extinct in the Nearctic millennia earlier than some herbivores, including the woolly mammoth and mastodon, while bison remained abundant until the 19th century, and reindeer remains rather abundant over large areas of North America to this day? The larger carnivores "strategically" lose to the larger herbivores not only because of their narrower specialization and position at the very top of the food pyramid. It is no less important that their offspring, in contrast to those of ungulates, proboscideans, and edentates, is born quite helpless. It takes rather long for the young of these carnivores to reach even partial independence (the ability to accompany their mother or pride). By contrast, a reindeer calf can successfully outrun a single wolf as early as several hours after birth [52]. Therefore, the very capacity of the larger carnivores to reproduce normally became more and more restricted as a result of various activities of primitive hunters, even if they did not aim at directly exterminating their main competitors.

Conclusions

It can be concluded with some certainty from the facts given here and in my earlier study [3] that

the hypothetical giant surface glaciations covering areas of millions of square kilometers actually never happened, and climates similar to that of the Antarctic, required for the emergence of such glaciations and their existence over millennia, did not exist in the Northern Hemisphere. This statement by no means denies any changes of the climate whatsoever, but implies that such changes took place at much more moderate and "reasonable" scales. The causes of the emergence and establishment of the glacier hypothesis were splendidly outlined by Zagorskaya [53], who argued that the lithological image of the moraine has long been lost, and lost for good. As for the catastrophic climatic perturbations that caused worldwide mass extinctions of many groups, they were most probably associated with the "landing" of giant asteroids at the Permian–Triassic boundary and at the Cretaceous–Paleogene boundary [54]. But this problem should be discussed in more detail separately, in another study.

The clear and quite considerable differences in the timing, direction, and scale of changes in the composition of mammal faunas, especially those of large mammals of pasture ecosystems, within the Palearctic and Nearctic (as well as outside them in the vast majority of cases) were initially determined by profound differences in the timing, duration, and some other peculiar features of the colonization of these areas by humans. However, the extinction of particular taxa should not be reduced to mere consequence of direct extermination. The scenario was much more complex. Ecosystems of Eurasia were first colonized by our ancestor *Homo erectus* earlier than 1 million years before present and therefore affected by humans for immeasurably longer than those of North America, where the events in question started to unfold in earnest only 14 to 5 thousand years before present, but where the "professional" level of the primitive hunter colonists "allied" with the domesticated wolf (dog) was from the very beginning as high or almost as high as ever. Moreover, this "economic lifestyle", initial for the pioneers of America, remained essentially unchanged in the Nearctic until the European colonization, and Native Americans remained hunter-gatherers in most of extratropical North America.

It must be taken into account that in the much larger Palearctic region humans, which colonized it since the Early Pleistocene, possessed fire for hundreds of millennia and used it for such a long time with inevitable ecological consequences.

In my previous study [3] I discussed the causes of the special vulnerability of woolly mammoths, as well as modern elephants, and their first-rate value for primitive hunters. The considerable de-

crease of their abundance, followed by decrease in the abundance of other principal edicator species of pasture ecosystems, inevitably led to the following consequences of utmost importance. (1) Degradation of this type of ecosystems over larger and larger areas increased, especially in regions with the most humid climates. As a result, the giant pasture ecosystem zone of the Palearctic is in effect "cut" through these regions by the more and more strongly developed forest zone into two parts, so that at present the zone of forest-tundra to polar deserts is distributed north of the forest zone and a zone of forest-steppes to deserts is distributed south of the forest zone. This resulted in extinction in some taxa and cardinal range changes in others. (2) The economic structure of primitive hunters underwent a growing crisis: this crisis quite clearly peaked in the Palearctic as early as the Mesolithic, at the Late Pleistocene – Holocene boundary, whereas in most of the Nearctic clear manifestations of this crisis did not become evident until the European colonization.

The geographical differences between the main continents of the Old World and New World most probably quite strongly determined the subsequent (post-Mesolithic) course of events within the Palearctic and Nearctic. In the Palearctic, the extremely long zone of inevitable contacts between foci of the "Neolithic revolution" and more northern areas determined the very broad and rapid spread of crop farming and especially animal husbandry, up to the two essentially different reindeer husbandry lifestyles [55]. It should be noted that in some areas of the Palearctic the primitive hunter-fisher-gatherer lifestyle did not disappear [49]. The less pronounced Neolithic foci (comparatively tiny) of South and Central America, additionally rather isolated, had almost no principal effects on the fate of the Native American population over most of the Nearctic until the European colonization.

The domestication of the horse and invention (originally by Scythians) of the saddle – still unknown, for instance, to Alexander the Great – were of colossal importance in many areas of the Palearctic and subsequently in most other areas. The later fate of mammal faunas and the whole biosphere was more and more determined by the technological development of the human civilization, although the term "civilization" sometimes appears inappropriate even in the 21st century.

It can be concluded from all above-said, including my earlier study, that the known changes in the compositions of mammal faunas in the Palearctic and Nearctic, which followed essentially different "scenarios" during the terminal Cenozoic, including the Holocene, and the considerable changes of ranges in the extant species and genera (many of

which have not been discussed above) cannot be linked to climate changes, which were simultaneous in extratropical latitudes of the Northern Hemisphere. Human activity was the initial cause of these changes, gradually resulting in decreasing abundance (population density) and eventually extinction of the main edificator species of pasture ecosystems, inevitably causing the growing (especially in the Palearctic) degradation and profound transformation of pasture ecosystems, and thus causing another series of inevitable consequences, which should be discussed in a separate broad review. It was the growing degradation of pasture ecosystems and their disappearance over huge areas

as that were later conducive not only to the extinction of some taxa and principal changes in the ranges of many others but also to profound transformation of vegetation over colossal areas, an event that inevitably had to affect the climate.

Acknowledgments

I am deeply grateful to A. K. Agadzhanian, N. N. Kalandadze, M. V. Kalyakin, T. V. Kuznetsova, A. P. Rasnitsyn, and O. V. Smirnova, who kindly provided me with some extremely valuable publications and information.

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