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GEOLOGY

New Data on Large Brown Bear (*Ursus arctos* L., 1758, Ursidae, Carnivora, Mammalia) from the Pleistocene in Yakutia

G. G. Boeskorov[a,b,*], G. F. Baryshnikov[c], A. N. Tikhonov[c], A. V. Protopopov[b], A. I. Klimovsky[b], S. E. Grigoriev[d], M. Yu. Cheprasov[d], G. P. Novgorodov[d], M. V. Shchelchkova[e], and J. van der Plicht[f]

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Abstract—New finds of brown bear (*Ursus arctos* L., 1758) fossil remains from the territory of Yakutia, namely, skulls and mandibular bones, have been investigated. The new finds are exceptionally large: most dimensions of these specimens exceed those of the present-day brown bears of Yakutia and even the maximal parameters of the largest individuals of the present-day Eurasian subspecies *U. a. beringianus* and *U. a. piscator*. Analysis of various data showed that giant brown bears had inhabited northern Yakutia during the Karginian interstadial in the Late Pleistocene.

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The brown bear (*Ursus arctos* L., 1758) is a widespread species that inhabits the forest zone of Yakutia [1]. The association with forest habitats explains why *U. arctos* Pleistocene finds are rare in the northern part of Eastern Siberia, where open tundra–steppe and steppefied landscapes prevailed during the Pleistocene [2–5].

The most ancient Pleistocene *U. arctos* remains found in Yakutia date from the beginning of the Middle Pleistocene [5, 6]. A large bear similar to *U. a. kamiensis* is supposed to have existed in the area at the above-mentioned time, whereas a smaller *U. a. priscus* inhabited the area during the end of the Middle Pleistocene and the beginning of the Late Pleistocene, and the small *U. arctos* ssp. bear of a size similar to that of the modern Yakutian brown bear replaced it at the end of the Pleistocene [5].

A very large *U. arctos* skull (MM 7774; Table 1) was found in 2002 on the shore of Yana Bay [7]. Radiocarbon dating performed at the University of Kiel (Germany) showed that the age of the skull was 42640 + 870/–790 years (KIA-32 836). This was the first evidence of the presence of a large brown bear form on the territory of Yakutia in the Karginian time of the Late Pleistocene.

New fossil remains of several exceptionally large brown bear individuals discovered in 2015–2016 in northern Yakutia are described in this article. The abbreviations used are as follows: IDPMG, Institute of Diamond and Precious Metals Geology, Siberian Branch, Russian Academy of Sciences; AS, Academy of Sciences of the Republic of Sakha (Yakutia); MM, Mammoth Museum of the Research Institute for Applied Ecology of the North, Ammosov Northeastern Federal University (all in Yakutsk, Russia); MB, Betenkyos settlement museum (Yakutia); SM, Closed Joint-Stock Company Severnyi Mir (Moscow, Russia). The material consisted of *U. arctos* skulls and mandibular branches (Figs. 1, 2).

All finds described were derived from adult individuals, probably males. They are only slightly mineralized, as is characteristic for bone remains from the Yakutian permafrost of the Karginian–Sartanian

[a] *Institute of Diamond and Precious Metals Geology, Siberian Branch, Russian Academy of Sciences, Yakutsk, 677007 Russia*
[b] *Academy of Sciences of the Republic of Sakha (Yakutia), Yakutsk, 677007 Russia*
[c] *Institute of Zoology, Russian Academy of Sciences, St. Petersburg, 199034 Russia*
[d] *Research Institute for Applied Ecology of the North, Ammosov Northeastern Federal University, Yakutsk, 677013 Russia*
[e] *Institute of Natural Sciences, Ammosov Northeastern Federal University, Yakutsk, Russia*
[f] *Centre for Isotope Research, University of Groningen, Groningen, NL-9747 the Netherlands*
**e-mail: gboeskorov@mail.ru*

Table 1. Skull sizes in the fossil and modern *Ursus arctos*

Measurements, mm	Yakutia					Amur area	Kamchatka
	Late Pleistocene					Adult males of the present time [5]	
	Yana River	Yana Bay shore	Indigirka River basin			*U. a.* ssp.	*U. a. beringianus*	*U. a. piscator*
	Yunyugen Creek	Ulakhan Orto-Stan River [7]	Uyandina River, SM		Oguruokha River	$n = 66$	$n = 8$	$n = 9$
	MM no. 1845	MM no. 7774	No. 1	No. 2	AS no. 8004	$\frac{limit}{X \pm m}$	$\frac{limit}{X \pm m}$	$\frac{limit}{X \pm m}$
Condylobasal length	374	398	433	360	421	285–356 320.05 ± 2.15	331.5–400.2 368.53 ± 8.53	329–384 369.82 ± 6.00
Length of the upper dentition ($C–M^2$)	138.3	142.2 (alv.)	149	136.5	149.4	120–144 131.04 ± 0.95	125–150 134.90 ± 2.01	124–149 136.22 ± 2.46
Cheek tooth length ($P^4–M^2$)	83.6	80.8 (alv.)	85	82.5	80.6	63–82.7 71.87 ± 0.47	73–83.5 78.24 ± 1.33	67.2–84.2 75.97 ± 1.83
Zygomatic width	–	252	283	–	288	185–231 209.05 ± 1.43	206–246.6 228.71 ± 6.17	226–265 245.44 ± 5.90
M^2 length	42.8	36 (alv.)	37.1	40.6	37.3	29–41 34.62 ± 0.28	36.2–43 39.35 ± 0.94	33.4–43 37.40 ± 0.91

time. The bone surface color varies from yellowish light brown to dark brown. The MM 1661 mandibular branch is mineralized to a higher degree, and its color is dark brown to almost black, this being characteristic of more ancient bones, which date to the Middle Pleistocene and the beginning of the Late Pleistocene. Bear remains from the Uyandina, Oguruokha, and Yunyugen rivers originate from Upper Pleistocene sediments and occur together with the remains of typical mammals of the mammoth fauna, the mammoth *Mammuthus primigenius* (Blum.), the steppe bison *Bison priscus* (Boj.), and the cave lion *Panthera spelaea* (Goldfuss) [8–11]. The age of the largest bear skull from the Uyandina River (SM 1/1) was >45 000 years, as shown by the results of analysis performed at the University of Groningen (Netherlands) (GrA-65241). The degree of preservation of this skull and other remains of brown bears (3–4 individuals in total) found in the area, along with the composition of accompanying fauna remains, allow for the conclusion that the taphocenosis in question was formed during the Karginian interstadial (25–60 (65) thousand years ago), when special conditions for the death and burial of mammoth fauna mammals were formed [4, 5, 12].

The AS 8004 skull (Fig. 1c; Table 1) was found in 2015 in the same outcrop where a skull of sable (*Martes zibellina* (L.), radiocarbon age >45 000 years, specimen GrA-62462), apparently from the Karginian time, was found a year earlier. The sable and brown bear, which are forest species, apparently migrated far north during the Karginian thermochrone, as the areas with tree vegetation expanded [9].

The MM 1845 skull (Fig. 1d) also seems to date from the Karginian time, since radiocarbon dating of mammalian bones from the Yunyugen location yielded a series of values in the range of 36 300–47 600 years ago ($n = 5$), this being indicative of bone accumulation during this interstadial [10].

The MM 1661 mandibular bone (Fig. 2c) from the Irelyakh Siene River is apparently of a more ancient age, as is evident from strong mineralization of the specimen and the presence of remains of several Early and Middle Pleistocene species (Olerian fauna) at the same location [10, 11].

The diagnostic features of the finds enable confident attribution to *U. arctos* [6].

Many sizes of fossil brown bear remains exceed the corresponding sizes of the modern *U. arctos* from Yakutia. The total jaw length and the c1–m3 dentition length in MB 145 noticeably exceeded those of the dental bones of modern Yakutian males and were close to those of the Kamchatka bears (Table 2).

SM 1 and AS 8004 are particularly notable among the new finds, since the sizes of these specimens are exceptionally large, with most measurements far exceeding those of the modern brown bears from

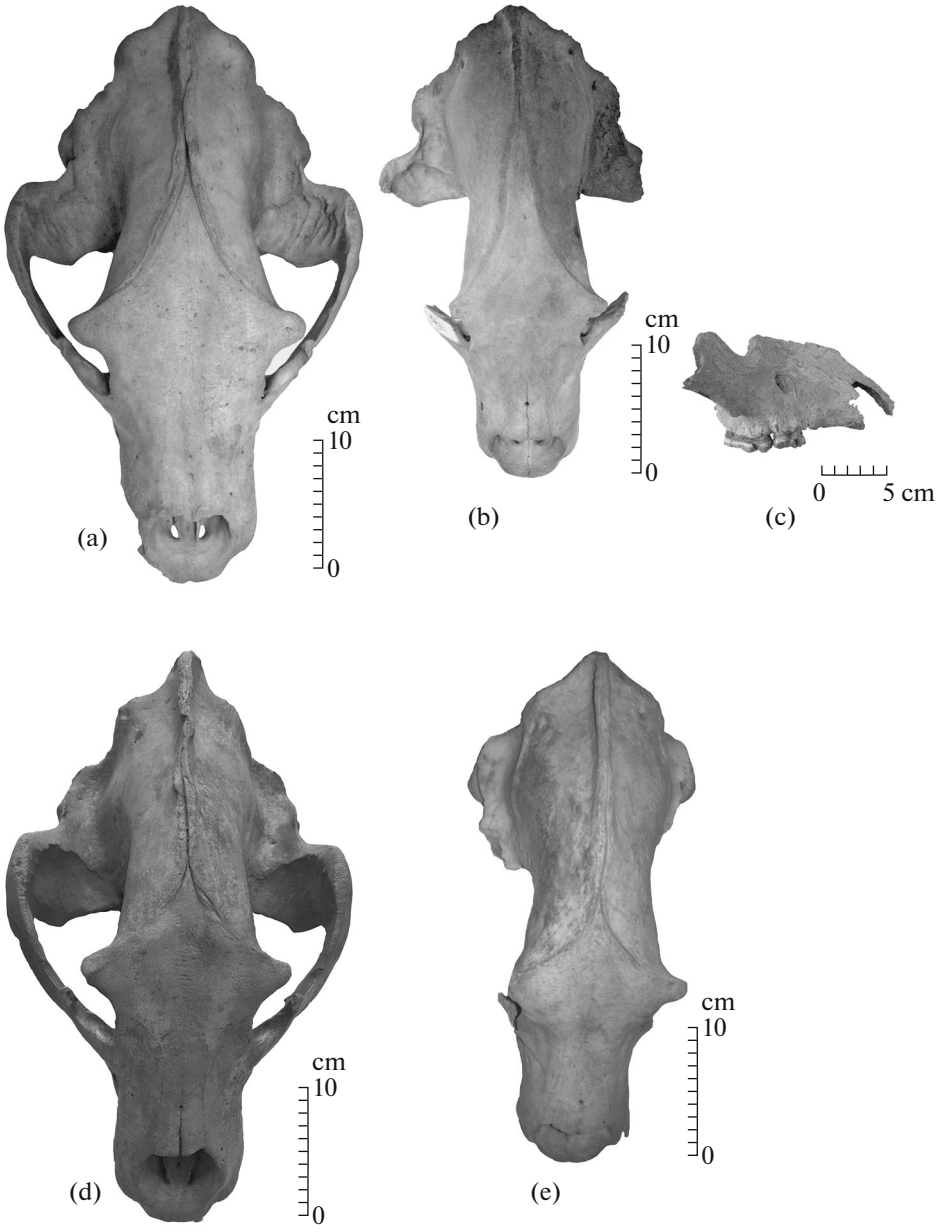

Fig. 1. Skulls of fossil brown bears from Yakutia: a, SM no. 1/1; b, SM no. 2; c, AS no. 8003, all from the Uyandina River, the left tributary of the Indigirka River; d, AS no. 8004, the Oguruokha River in the Indigirka River basin; e, MM no. 1845, Yunyugen Creek, a tributary of the Yana River.

Yakutia and even the maximal parameters of *U. a. beringianus* and *U. a. piscator*, the largest Eurasian subspecies (Tables 1, 2).

U. arctos can reach extremely large sizes if a rich forage base is available [13]. The modern Yakutian bears live in an area with a severe climate and have a rather poor diet. The Yakutian bears eat less food of animal origin, and low-calorie plant food predominates in their diet. A small bear ecomorph has formed under conditions unfavorable for the existence of the species; prolonged winter hibernation of 6.5 to 7.5 months is a distinctive adaptive feature of this ecomorph [1, 5].

Thus, the majority of finds described date from the time of the Karginian thermochrone, when the expansion of forest vegetation, apparently accompanied by the resettlement of forest species to the north, occurred in northern Siberia. This is apparently evidenced by the accumulation of fossil *U. arctos* remains at the Uyandina River (located to the north of the modern polar circle). The reasons for giantism in the fossil brown bear of northern Yakutia remain difficult

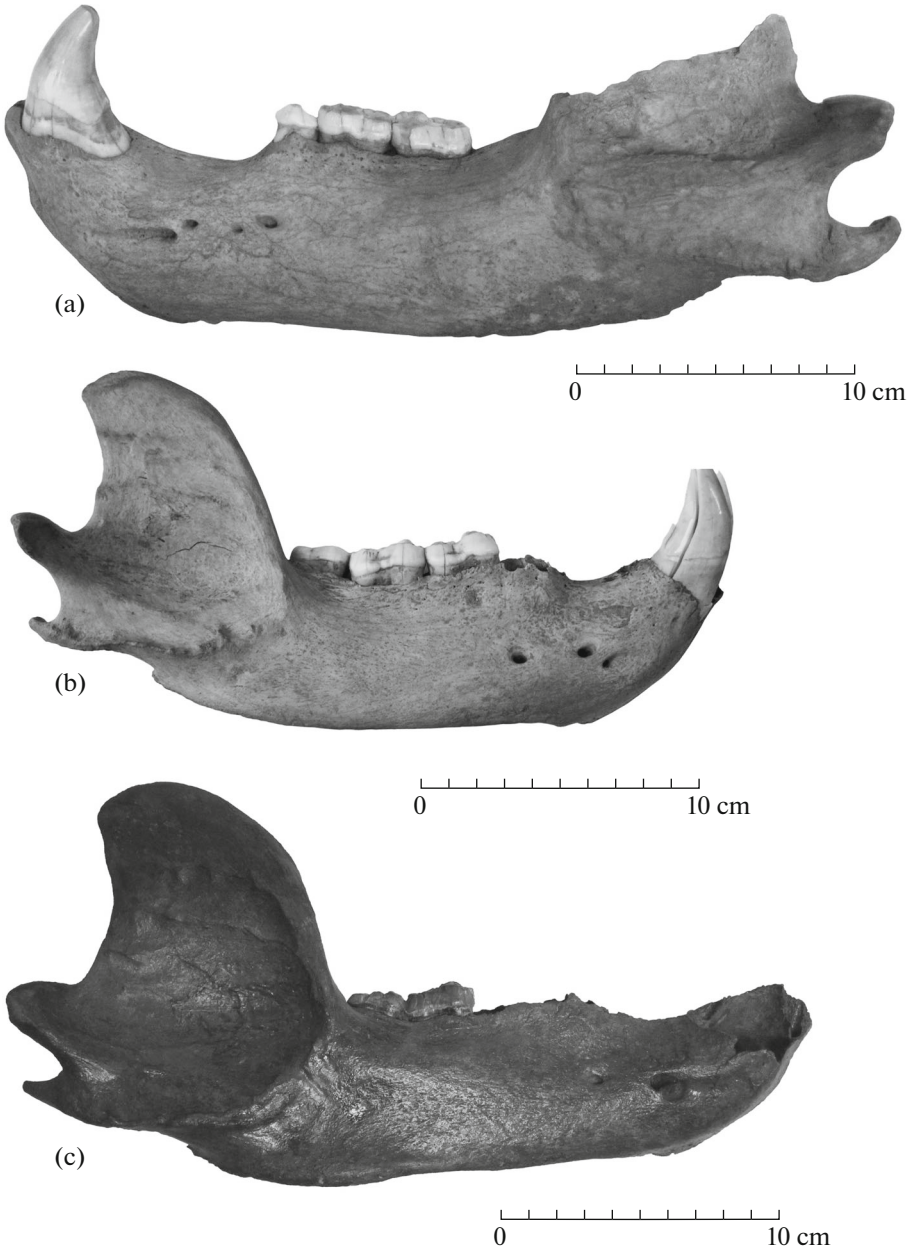

Fig. 2. The mandibular bones of fossil brown bears from Yakutia: a, SM no. 1/2, b, AS no. 8002, all from the Uyandina River; c, MM no. 1661, Irelyakh Siene River, a tributary of the Kolyma River.

to explain. The distinctive features of the Karginian warming, with an increase in the diversity of vegetation, including that of edible plants, apparently facilitated the size increase. Moreover, deaths of the largest animals, primarily mammoths and woolly rhinoceroses, due to soil defrostation were frequent at that time [4, 5, 12]. The bears could have fed on the cadavers of mammoths, rhinoceroses, and other large herbivores, and preyed on the young of these species [5]. The tendency for predation and carrion feeding in the modern *U. arctos* is intensified during periods of plant food deficit [13]. The corpses of adult mammoths that weighed at least 4000–5000 kg could have provided the brown bears with protein-rich food for a long time, since the modern bear can feed off a moose carcass (weighing 400–500 kg) for 7–10 days, with almost the entire carcass being consumed [14]. Data of isotope analysis of the eastern Beringia samples point to the consumption of mammoth meat by brown bears [15]. Larger amounts of food being available apparently promoted the increase in the size of the Karginian brown bear from Yakutia.

Table 2. Mandibular bone sizes in *Ursus arctos*

Measurements, mm	Pleistocene							Holocene				
	Yakutia											Kamchatka
	Indigirka River basin, Uyandina River		Kolyma River, Irelyakh Siene, MM no. 1661	Lena River, Yunkyur site, Upper Paleolithic [5]	Adycha River [5]		Aldan River, Mamontova Gora [5]	Vilyui River, Syul'dyukar site, Neolithic [5]		Present-day males $n = 11$ [5]		
					Kyra-Sullar, IDPMG no. 4969	Ulakhan Sullar, MB				$n = 11$	$n = 3, 53$	
	SM no. 1/2	AS no. 8002				no.145	no. 146		No. 69	No. 285	limit (X)	n	limit (X)
Total jaw length	321	258	290	>190	241	268	–	>194	243	237	228–259 (242.10)	53	238.7–289 (265.6)
Alveolar length C_1–M_3	177	152	167	133	–	150	147	–	144	141	123–145 (136.40)	53	142.3–167.5 (155.6)
Alveolar length P_4–M_3	91.9	92.2	90.3	81	84	90.7	82	77	75.6	82	77.6–88.0 (80.70)	53	77.2–94.3 (85.44)
Symphysis length	104	>77	81.4	>50	ca. 71	74	71	–	64	62	61–72 (66.37)	3	82–88 (85.67)
Height at the coronoid process	–	118.6	127	–	123	127	–	–	118	>110	109–132 (120.64)	53	100–127.6 (115.56)
Height under P_4	67.3	56.8	58.8	37	47	52	–	–	46	46.2	41–48 (44.10)	3	53–54 (53.33)

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