Radiocarbon dating the extinct caribou on Franz Josef Land

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Seven old, shed caribou (*Rangifer tarandus*) antlers from Alexandra Land, in the high arctic Franz Josef Land archipelago where no caribou are found today, were dated to between 3870 ± 70 and 2245 ± 70 radiocarbon years BP. All were found on the ground above the highest shoreline, thus not transported there by sea-ice. That the ages all fall into a relatively narrow time-span suggests that they originate from a population of caribou that really lived on Alexandra Land. We suggest that they migrated there after the culmination of the Holocene climatic optimum (*c.* 6000 to 4500 BP) when the climate again became colder and the sea-ice more persistent. The climate during that period can be compared with that of Nordaustlandet on Svalbard today, where a population of caribou still exists.

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The Geographical Institute of the former Soviet Academy of Sciences and the Swedish Polar Research Secretariat organized an expedition to Alexandra Land in the Franz Josef Land archipelago in the Russian high arctic (Fig. 1), in August 1990 (Glazovskiy *et al.* 1992; Näslund *et al.* 1994).

Fourteen shed caribou (*Rangifer tarandus*) antlers, none of which were pairs, were found on Alexandra Land. They wereall surface samples lying on the ground above the highest shoreline, thus not transported there by sea-ice. The antlers conditions ranged from whole antlers in good condition to partly decomposed pieces. Caribou antlers on Franz Josef Land have been known previously (Hoel 1916; Linnér 1978) but no references to radiocarbon dated specimens are known by us. However, Grosswald *et al.* (1973) found antlers melting out of the Dome Glacier on Hooker Island, indicating that caribou were present there prior to the late Holocene glacier advance around 2500 BP (Govorukha 1988).

We did not find any skulls or other bones, although caribou bones have previously been found on Franz Josef Land (Bruce 1898; Linnér 1978).

The general Russian opinion is that a caribou population lived on these islands during the Holocene climate optimum (Grosswald 1963). However, no wild caribou has even been seen on the islands (Bruce 1898; Bruce & Clark 1899; Horn 1930), and the climate on Franz Josef Land today is harsher than on Eastern Svalbard where caribou are common. This is perhaps illustrated by the fact that the four domestic reindeer brought to Franz Josef Land by the Jackson expedition died, despite being fed with lichens brought from the mainland (Jackson 1899: 105).

Another hypothesis is that the caribou did not live continuously on the islands, but that the antlers were shed by stray animals that came across on the sea-ice (Hoel 1916).

The aim of this paper is to date the antlers on Alexandra Land, and discuss which hypothesis is more likely to be correct. If the first hypothesis is correct, the age of the antlers should suggest a period, or some periods, when the climate was more suitable for caribou than today.

The landscape

Franz Josef Land (Fig. 1) consists of *c.* 190 islands with a total area of about 16 300 km^2. Glaciers cover 85% of the land (Kiteme 1975). The archipelago consists of folded Caledonian basement, Mesozoic sediments and Cretaceous dolerites and basalts, the latter giving most of the islands flat top surfaces, with elevations up to *c.* 550 m (Kiteme 1975).

Alexandra Land is situated at 80°45'N (Fig. 1). Two glacier complexes cover 74% of the island's 1050 km^2. The highest point, 375 m a.s.l., is the summit of the largest ice cap.

The vegetation today is extremely sparse, consisting mainly of lichens and mosses. Fieldwork was conducted in the western half of the main ice-free area of Alexandra Land.

Present-day climate

The present climate is known from meteorological observations conducted at Nagurskaya station (20 m a.s.l.) on Alexandra Land since 1952. The annual mean temperature is −12.9°C, the mean summer temperature (June to August) is −0.15°C and the mean winter temperatures (September to May) is −17.1°C. July is warmest with a mean temperature of +1°C, and March coldest with a mean of −23.7°C (unpublished data covering 1952–1991).

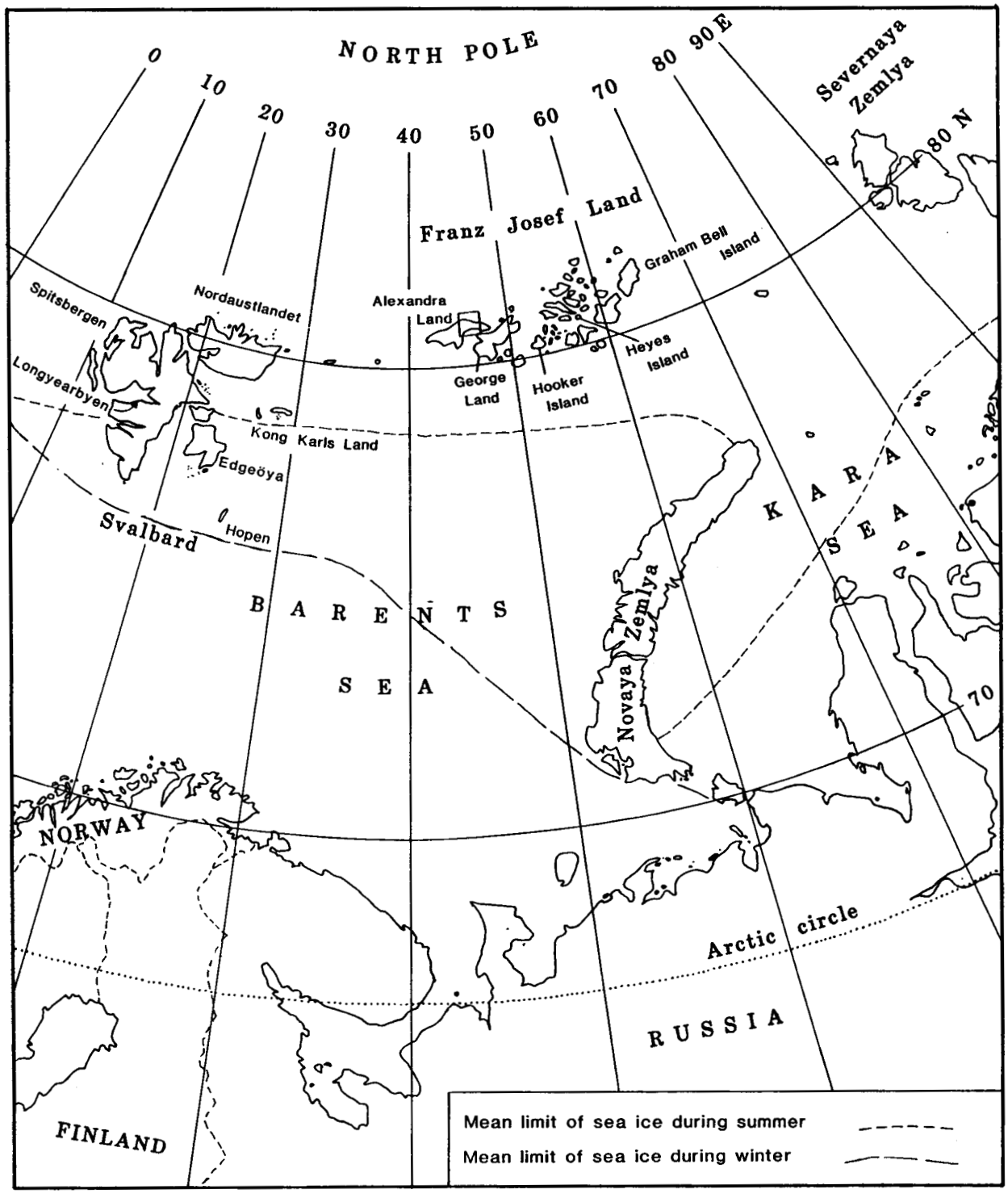

Fig. 1. Franz Josef Land in its arctic setting. Fieldwork area is marked. Present day summer and winter sea-ice limits are indicated (Gow & Tucker 1990).

The annual mean temperature of Franz Josef Land decreased as much as 4.5°C in ten years (10-year running mean) during the 1950s and the first half of the 1960s (Rodewald 1972). The mean temperatures of the coldest months were more than 10°C lower during the 1960s than during the previous 30 years (Lamb 1977). However, it is not clear whether this was really related to a climatic change, or if is is an

artifact of the inclusion of new data from other meteorological stations established on Franz Josef Land in the 1950s.

About 45% of the summer is foggy and the remaining period is dominated by overcast conditions. This increases the relative humidity to more than 90%. The dominant south-southeasterly, moisture-carrying winds, given the Cape Nagurskiy area of Alexandra Land an annual precipitation of 230 mm, 85% of which falls as snow (Grosswald *et al.* 1973).

The Holocene climate

The Holocene climatic history of Franz Josef Land began with a cool period, the Rubini stage, starting around 10 500 BP, or possibly 12 000 BP. It ended not later than 8500 BP. This was followed by a warm period from 8700 to 2500 BP (Grosswald *et al.* 1973). Lake sediment studies on Heyes Island, indicated a culmination of the Holocene climatic optimum between 6000 and 4500 BP (Govorukha 1988). There is also evidence for a glacier advance around 4500 BP. Two late Holocene cooling events, the Sedov stage 2500– > 1000 BP, and the Victoria stage from the 14th to the 19th century, have also been proposed (Grosswald *et al.* 1973; Govorukha 1988).

Forman *et al.* (1992) dated the deglaciation of Franz Josef Land to 10 400 BP, and reported that the glaciers were at or behind their present limits by *c.* 8340 BP.

Alexandra Land was, at least partly, deglaciated by *c.* 8800 BP (Näslund *et al.* 1994). A glacial readvance occurred some time after 7800 but well before 6800 BP, when the Lunar Ice Cap was smaller than at present. It has now grown again and is close to its mid- to late-Holocene maximum. A huge beach ridge, best developed on the northern shores, indicates conditions with less sea-ice than today, and thus a warmer climate, around 5000 to 4500 BP. At around 2000 BP climate deteriorated as indicated by the formation of a snow/ice dammed lake (Glasovsky *et al.* 1992).

A glacial advance began prior to 1165 BP, had its maximum *c.* 1100 BP and receded prior to 775 BP (Miller *et al.* 1992).

Arctic caribou

Three races of small caribou live or have recently lived in the Arctic; *Rangifer tarandus pearyi* (Allen), *R. t. eogroenlandicus* (Degerböl) and *R. t. platyrhyncus* (Vrolik).

The areas occupied by these are as follows (Skjenneberg & Slagsvold 1968): *pearyi* is found on the Canadian Arctic island, and in a small, now probably extinct, population in the Thule District (Roby *et al.* 1984; Meldgaard 1986); *eogroenlandicus* existed in East Greenland but became extinct about 1900 AD after a couple of especially harsh winters. The *platyrhyncus* is found in all ice-free areas of Svalbard, even in the northern part of Nordaustlandet. The populations of both *peraryi* and *plathyryncus* are sensitive to climatic changes (Miller *et al.* 1975).

The Euroasiatic caribou, *Rangifer tarandus tarandus* (Linné), is found along most of Siberia's northern coast, on Bolshevik island (Severnaya Zemlya), and on Novaya Zemlya (Fig. 1) (Skjenneberg & Slagsvold 1968; Petrovskii 1984).

The migration history of the arctic caribou, their interrelationships and their possible refuges during the Weichselian glacial period have been intensively discussed (cf. Hoel 1916; Macpherson 1965; Skjenneberg & Slagsvold 1968; Miller *et al.* 1975; Linnér 1978; Roby *et al.* 1984; Meldgaard 1986; Stewart & England 1986). Recent work shows a genetic similarity between *pearyi* and *platyryncus*, suggesting a common origin from an isolated High Arctic population during the Weichsel glaciation (Røed 1985; Røed *et al.* 1986; Røed & Thomas 1990; Røed 1992).

Radiocarbon dating the antlers

Seven of the caribou antlers from Alexandra Land have been radiocarbon dated by the Isotope Laboratory at the Natural History Museum in Stockholm (conventional technique), and by the Svedberg-Laboratory in Uppsala (AMS technique).

The dated antlers got ages between 2245 ± 95 and 3870 ± 70 BP (Table 1). Care has been taken to ensure that a representative selection of the 14 specimens were dated: both large and small, both well and poorly perserved ones. There is no indication that the oldest antlers are the poorest preserved, or that the size is related to the age of the antler.

Discussion

That the ages of the antlers fall within a *c.* 1600 year interval indicates that they do not originate from stray animals, but from a population living on Alexandra Land. This is also in line with the fact that all the antlers were shed, indicating that the animals were alive in February, the shedding period on Svalbard today (Linnér 1978).

Caribou can only reach Franz Josef Land across sea-ice. That the antlers are younger than the culmination of the climatic optimum between 6000 and 4500 BP (Govorukha 1988), and the period with comparatively little sea-ice between *c.* 5000 and 4500 BP (Glazovskiy *et al.* 1992), is thus logical.

Häggblom (1982 and pers. comm.) found indications on Hopen, Svalbard, of a high percentage of open water between 6000–4200 BP, rather severe ice

Table 1. Radiocarbon ages of caribou antlers from Alexandra Land, Franz Josef Land. Samples have been dated with AMS technique by the The Svedberg-Laboratory at Uppsala University (Ua-prefix) and with conventional technique by the Laboratory for Isotope geology at the National History Museum, Stockholm (St-prefix). All samples have been corrected for isotope fractionation, although six of the seven $\Delta^{13}C$ values have been estimated (est.). Error $\pm$ 1 SD. T1/2 = 5568 years.

Lab. number	Age	$\Delta^{13}C$ ‰	Remarks (L = length, D = maximum diameter in cm)
Ua-3107	2245 ± 95	−21 (est.)	Part of large, medium well preserved antler (L = 40, D = 5)
St-12667	2285 ± 70	−25 (est.)	Complete, large, well preserved antler (L = 70, D = 50)
Ua-3104	3140 ± 95	−21 (est.)	Complete, large, poorly preserved antler (L = 90, D = 5)
Ua-3103	3295 ± 95	−21 (est.)	Complete, large, well preserved (except for the tips) antler (L = 70, D = 5)
Ua-3105	3605 ± 105	−21 (est.)	Complete, small, well preserved antler (L = 35, D = 3)
Ua-3106	3770 ± 70	−21 (est.)	Complete, large, well preserved antler (L = 75, D = 5)
St-13090	3870 ± 70	−19.97	Complete, small, well preserved antler (L = 50, D = 3)

conditions between 4200–3800 BP, a high percentage of open water between 3800–3000 BP and then severe ice conditions between 3000–2400 BP. To get to Alexandra Land, the caribou were dependent on a climate cold enough to form persistent sea-ice, but mild enough to support them on arrival. This climate evidently existed only at the end of the climatic optimum.

The youngest antlers are 2245 ± 95 and 2285 ± 70 BP. This indicates that the caribou became extinct when the climate deteriorated during the late Holocene. As mentioned, Grosswald *et al.* (1973) found evidence of a cooling event, the Sedov stage, on these islands *c.* 2500– > 1000 BP, and Glazovskiy *et al.* (1992) reported a climatic deterioration around 2000 BP on Alexandra Land.

Conclusion

A population of caribou lived continuously on Alexandra Land between *c.* 3900 and 2250 radiocarbon years BP. They migrated there after the culmination of the Holocene climatic optimum, when the climate started to cool and sea-ice became more persistent, but when the terrestrial conditions, i.e. the vegetation, could still support them. They became extinct when the climate deteriorated further.

The Franz Josef Land climate during this period may have been similar to that of Nordaustlandet today, which supports a limited caribou population.

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