



## Direct dating of arctic fox remains from Hässleberga in Scania

The arctic fox (*Vulpes lagopus*) is regarded as a typical faunal element of the Pleistocene. Numerous subfossil remains of arctic foxes dated to the latest glacial period have been reported from throughout continental Europe (Sommer & Benecke 2005). A lack of records for the warmer Allerød interstadial is followed by the apparent reappearance of the species in the succeeding cold period Younger Dryas. On this basis Robert Sommer and Norbert Benecke propose that the European distribution during warm periods was restricted to regions in the north, influenced by sub-arctic or arctic climate. They thereby depict the arctic fox as a model example for a rapid reaction of animal distribution to climatic fluctuations during the Glacial.

Favourable conditions for the arctic fox to migrate into the Scandinavian Peninsula are believed to have existed. Modern arctic foxes are known to follow polar bears on the pack ice in order to scavenge remains of kills (Audet et al. 2002). Late glacial remains of polar bears have been found along the west coast of Sweden, and so an early route of immigration from the south would be plausible here. A sub-fossil find of arctic fox from a natural deposit dated to about 13 500 cal BC from the Norwegian cave Skjonghelleren demonstrates that the species had immigrated by this time (Frafjord & Hufthammer 1994).

The formation of a land bridge connecting southern Sweden to Denmark and continental Europe about 11 000 cal BC enabled the immigration of several members of the glacial fauna, including reindeer, wild horse and mountain hare (Rosengren 2014). They are believed to have been accompanied by carnivores like the arctic fox.

However, when mitochondrial DNA sequences retrieved from Late Pleistocene arctic foxes in middle-latitude Europe were compared with those from both extant and historical samples from Scandinavia they revealed no post-glacial habitat tracking in the arctic fox (Dalén et al. 2007). Instead, a high genetic similarity between the extant populations in Scandinavia and Siberia suggested an eastern origin for the Scandinavian

population at the end of the last glaciation. The results showed that the arctic fox in middle-latitude Europe most probably went extinct at the end of the Pleistocene.

### *Material and results*

During the 1990s, many animal bones and antlers were collected at Hässleberga in Scania by an amateur archaeologist (Magnell et al. 1999; Larsson 2012). These skeletal remains originated from a number of kettle holes which had been emptied and turned into crayfish ponds. The sediments had been spread out on the surrounding ground where the bones were later collected. Consequently, the dating of the bones cannot be based on stratigraphy. Instead, antlers and bones identified as belonging to species typical of the period, such as reindeer, were interpreted as Late Glacial. Furthermore, bones with a colour and surface texture typical of bones from the Late Glacial gyttja layers of the kettle holes were also considered to be Late Glacial. Finally, eighteen bone and antler fragments were radiocarbon dated. Fragments identified as reindeer and wild horse confirmed the presumed Late Glacial age and rendered site the most important for studies of the mammalian fauna from this period (Magnell et al. 1999).

Remarkably, the material also includes a tibia and a mandible identified by Kim Aaris-Sørensen of the Zoological Museum at the University of Copenhagen as belonging to arctic fox (fig. 1–2; Magnell et al. 1999). Based on the criteria above, these remains were interpreted as the first Late Glacial finds of the species in southern Scandinavia. Since no fossils of arctic fox have so far been found in Denmark, the Hässleberga find was interpreted by Aaris-Sørensen (2009) as representative of the Danish Late Glacial fauna. It also formed the basis for a description of the immigration history of the arctic fox into Scania (Rosengren 2014).

With the intention to investigate any lost genetic variation and contribute to the resolution of the fate of the Pleistocene arctic fox popu-



Fig. 1. Arctic fox tibia from Hässleberga (Lzzz/5002).



Fig. 2. Arctic fox mandible from Hässleberga (Lzzz/5001).

lation from middle-latitude Europe, we have sampled the finds from Hässleberga for DNA extraction. However, there have been reports of migrations of arctic foxes from the Scandinavian Mountains into Scania in the 1800s (Nilsson 1847). Therefore we also submitted material to the Oxford Radiocarbon Accelerator Unit for dating. The resulting radiocarbon measurement gave a modern, post-1950 date ( $1.25671 \pm 0.00408$   $\delta^{13}\text{C}$  -18.76; OxA-34179). This shows that the colour and texture of the bone surface are not reliable traits for identifying ancient material from Hässleberga.

The late date in combination with the site being outside the known normal distribution of the wild arctic foxes points to the Hässleberga find being an escaped farm fox. The first Scandinavian arctic fox farm was established in Norway in 1913, with breeding animals imported from Alaska and Greenland. A previous study based on the mitochondrial control region has shown that

these animals were genetically distinct from wild Scandinavian arctic foxes (Norén et al. 2005). A future study, using the method described by Norén et al. can potentially serve to resolve the origin of the arctic fox from Hässleberga as an escaped farm fox or a migrant wild arctic fox.

#### *Conclusion*

The present study has shown that the remains of arctic fox from Hässleberga found in the 1990s are recent. Since this find is the only record of arctic fox from southern Scandinavia, the date presented here demands a reinterpretation of the local history of the species. It also shows that remains of varying age can accumulate in kettle holes over long time spans, and that colouring and surface texture are unreliable characteristics for distinguishing ancient bones. Instead, the use of direct dating is essential. In the future, a genetic study might resolve the origin of the arctic fox remains from Hässleberga.

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