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The Tornio antler story

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This is a story about a 39 000-year-old reindeer antler found in Tornio, southern Finnish Lapland, nearly 60 years ago. It is based on personal experiences and memories that involve Björn Kurtén. It begins with the discovery of the antler and the observations and interpretations made in the 20th century, and is followed by a revision of those interpretations in the light of old and new archaeological and paleoenvironmental data. These suggest that during Lapland's MIS 3 ice-free conditions the antler was shed by a reindeer bull somewhere in the Tornio river valley and was subsequently transported down to its discovery site. Finally, there is a reflection on the effect that the fossil reindeer antler may have had on Kurtén's literary production.

Introduction

In 1972, Professors Joakim Donner and Björn Kurtén asked me to do a microscopic examination of a fossil reindeer antler fragment and search for possible traces of human manipulation. I found none but developed a certain attachment to the antler in the process. This may be why I have always felt that the Tornio antler has not received the attention it deserves. This paper gives me the opportunity to correct the situation, and there is no better way to do it than commemorating the 100th birthday of a friend and mentor. In what follows I tell the story of the Tornio antler and my personal experiences with it. I have entitled it 'The Tornio antler story' after Kurtén's 1976 bestseller on the cave bear.

Tornio 1967

The Tornio antler was found in 1967 in a gravel pit in the North Finnish municipality of Tornio (Fig. 1) as described by its finder, Olavi Vallo, in the letter sent with the find to the Zoological Museum of the University of Oulu on 22 June 1967: "This bone was found in the gravel quarry of Kokkokangas, in Tornio, within a well-consolidated gravel layer at a depth of slightly over 3 m. The bone must have ended up there sometime in antiquity since the layers have not been disturbed in any way by digging" (Ukkonen & Mannermaa 2017: 28).

This places the discovery some 3 km south-southeast of the Tornio city center. However, it is likely that the antler was shed further up in the river valley and subsequently transported to its discovery site by riverine and/or glacial agencies. These processes have reduced the once sizable antler to a fragment of about 30 cm in length (Figs. 2–3).

Oulu 1967–1972

The antler fragment ended up on the desk of Professor Lauri Siivonen, who was first to study and describe it (Siivonen 1975). Since its discovery

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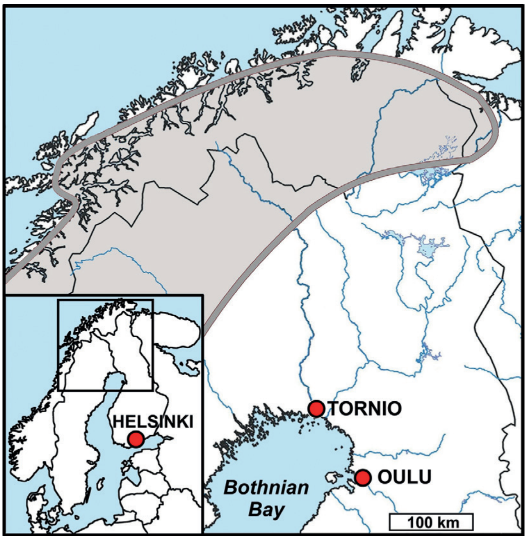

Fig. 1. The site where the Tornio antler was found (65°49´N, 24°11´E) in 1967 lies at the mouth of the Tornio River, which flows from the Scandinavian mountains to the Bothnian Bay and forms the present Finnish–Swedish border. The city of Oulu is where the antler was initially studied by L. Siivonen, and the extant portion of the antler is kept today. The antler was radiocarbon dated and its surface analyzed microscopically in Helsinki in 1972. The gray area corresponds to the approximate extension of the ice sheet during MIS 3 according to Mangerud *et al.* (2023).

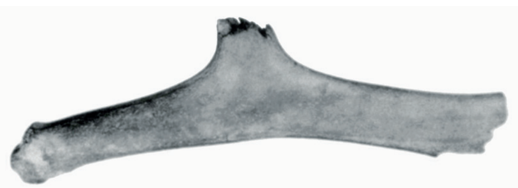

Fig. 3. The Tornio antler in 1972 (*see* Nunez 1991: fig. 1).

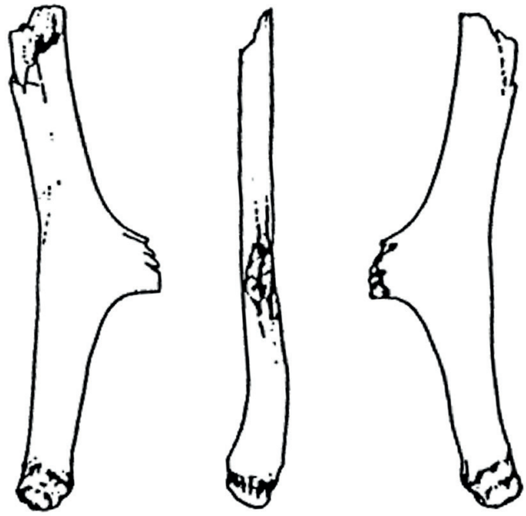

Fig. 2. Frontal and lateral views of the Tornio antler (from Siivonen 1975: fig. 1).

six decades ago, the Tornio antler has been mentioned albeit rather briefly in several publications (e.g. Siivonen 1972, 1974, Donner 1976, 1995, Donner *et al*. 1979, Nieminen & Helle 1980, Aikio 1988, Kurtén 1988, Bahn 1989, 1990, Núñez 1991, 2019, Ukkonen 1993, Ukkonen *et al*. 2003, 2007, Ukkonen & Mannermaa 2017).

When Siivonen spoke about the history and taxonomy of the mountain, forest and domestic reindeer in northern Europe at the First International Reindeer and Caribou Symposium in Fairbanks, Alaska, in August 1972, he estimated an interstadial date for the Tornio antler. This was before he sent the antler to the radiocarbon laboratory, and he may have been urged to do so at the symposium. In any event, the antler arrived at the Helsinki Radiocarbon Dating Laboratory in the fall of 1972, and its age was measured early in 1973. The antler yielded a date of ca. 34 000 BP (ca. 39 000 cal BP) and Siivonen included it in his article in the Fairbanks symposium proceedings (Siivonen 1975). There he concluded that the reindeer bearing the Tornio antler had lived during the recently described Peräpohjola interstadial (Korpela 1969) somewhere in the Scandinavian Mountains and that, after shedding, the antler had been transported down along the Tornio river valley to its finding site. He reasoned that the antiquity of the Tornio antler supported the debated century-old refuge theory favoured by several biologists (e.g. Blytt 1876, Lindroth 1958, Dahl 1961) including himself (Siivonen 1972, 1974), and that it agreed with the present distribution of shrews and tundra voles in Norway: "These species … arrived in Scandinavia most probably from the south during the extensive interstadial and they passed the later stage of the glacial period on the Norwegian coast. The Tornio reindeer is the newest piece of evidence showing that this is obviously what has happened" (Siivonen 1975: 35).

Siivonen included the Tornio antler in his comparative morphological study of recent and ancient reindeer skulls. He found that it bore affinities with some late glacial antler specimens from Denmark, particularly the fact that "the brow tine and the bez tine start from the antler beam at a great distance from each other" (Siivonen 1975: 34). He also pointed out that this feature could be observed in modern forest reindeer and in several late glacial antlers illustrated by Degerbøl and Krog (1959): "The forest reindeer's antlers are characterized, like those of the Tornio reindeer, and in most cases, the prehistoric Danish reindeer, by the fact that the brow tine starts at the burr of the antler and the bez tine considerably higher up" (Siivonen 1975: 36).

This may mislead some to think that Siivonen associated the Tornio antler with forest reindeer but that was not the case, he clearly links it to the mountain reindeer elsewhere: "Paleontological finds confirm that at least mammoths, musk oxen and mountain reindeer (Tornio reindeer) lived in Fennoscandia 34 000–21 000 years ago" (Siivonen 1974: 7).

Helsinki 1972–1973

As mentioned earlier, the antler was submitted to the Helsinki Radiocarbon Dating Laboratory in 1972 (Jungner 1979). One morning in October of that year, when I joined our coffee break at the Geology and Paleontology Department of the University of Helsinki, the staff was discussing the antiquity of a newly arrived sample. They all agreed that it could be interstadial, but some warned that the river could have easily buried it below 3 m of sediments in the Holocene. Being the youngest and lowest in rank, I listened in silence, particularly because I had come too late to learn what the sample was.

A couple of days later, Donner and Kurtén came to my work cubicle. Donner spoke while the smiling Kurtén held an open flat box with the Tornio antler. I immediately identified it as the subject of the coffee break discussion and thought that, since Kurtén had not been present then, bringing the antler to me may have been his idea. Donner explained that the antler fragment looked like some artifacts found at French Upper Paleolithic sites, and like the reindeer antler hammer I had used in my flint-knapping demonstrations. They wanted me to do a thorough microscopic examination of the antler surface to find whether there were any signs of human manipulation. About half of the antler would be needed for radiocarbon dating and they wanted to make sure that any possible evidence of anthropic intervention would not be destroyed in the process. Needless to say I eagerly accepted.

Why me? Both professors were somewhat familiar with the European Paleolithic (Donner & Kurtén 1958, Kurtén 1961, 1969, 1972, Donner 1973, 1975) and knew that I was even more so. In addition to being an archaeologist, I had worked with Professor François Bordes at Pech de l'Azé Cave and done my master thesis on the Abri Pataud, both Paleolithic sites in Southwest France. Moreover, my experimental flint-knapping antler hammer would be useful for comparison.

The antler examination

When Kurtén handed me the antler it felt much heavier than expected. I attributed it to mineralization and worried that it may not contain enough collagen for radiocarbon dating. Luckily, I was wrong. It appeared to be a shed male antler, possibly from the right side based on the curvature. The cross-section of the beam was elliptical, which tended to be associated with the forest reindeer variety (Jacobi 1931, Banfield 1961, Bouchud 1966). The brow and bez tines as well as the distal portion of the beam had broken off and, interestingly, these three breakage zones seemed to have undergone somewhat different processes.

The proximal end showed substantial attrition. What was left of the burr and its protruding attachment area (medallion) was rounded down and the base of the broken brow tine was virtually obliterated. In contrast, the texture of the bez tine and beam fracture areas showed almost no abrasion. Moreover, based on the fracture patterns, the forces that had caused their breakage differed in both nature and direction. The beam had been broken off by a lateral slow-working pressure, while the bez tine had been ripped off by a kinetic impact oriented roughly longitudinally along the beam in distal to proximal

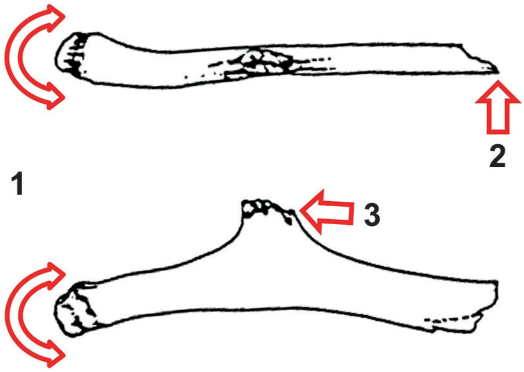

Fig. 4. Zones of abrasion and breakage in the Tornio antler and the estimated direction and chronological order of the forces involved.

direction (Fig. 4). It seemed likely that the distal beam and palmation had broken off first, thus leaving the bez tine exposed to forces working from the distal end of the broken beam. Given the toughness of antler, a significant force would have been needed for breaking the medial beam and, particularly, snapping off the bez tine in the said direction. Furthermore, the scant wear of the fracture zones of the beam and bez tine implied a relatively short interval between their breakage and the final deposition of the antler.

Although it was plausible, from the beginning I had been a bit skeptical about the Tornio antler being an artifact. There were admittedly broad morphological analogies to the artifact types suggested by Donner, the Upper Paleolithic *bâtons percés* (perforated staffs) of Franco-Cantabria (Lartet & Christy 1875, Girod 1906, Breuil 1954, Fernández García de Diego 1962, Daniel 1969) but the Tornio antler lacked the decoration and perforation(s) characteristic of this type of artifacts (Fig. 5A). I had been more partial to the so-called Lyngby axes (Fig. 5B) of Late Paleolithic Denmark and northern Germany (Schwantes 1925, Clark 1938, Degerbøl & Krog 1959, Brøndsted 1966) but crucial diagnostic features were missing. Above all, the Tornio antler showed no signs of the sawing and/or boring generally used to fracture the antler of *bâtons percés* and Lyngby axes in a controlled manner.

Another possibility was that the Tornio antler had been a hammer for making lithic tools (Fig. 5C–E). The Tornio antler resembled two antler segments described by de Ferry (1870) as Paleolithic hammers (*marteaux*) and to Bordes' (1967) and my own modern flint-knapping hammers. But again, it lacked the telltale signs of sawing or boring for controlled breakage. Moreover, the examination under the microscope did not reveal anything supporting a hammer function.

The microscopic examination was carried out at ×10–50 magnifications with the help of a narrow light beam to accentuate relief. The whole antler surface was covered with hundreds of minute shallow scratches, but they did not follow any specific direction, as one would expect from a hammering tool. The differences were obvious when compared with my own antler hammers. There were practically no scratches except at the proximal end, where misses had left long scratches. Moreover, its very end or hammerhead, the medallion, was flattened and bore linear impact scars from hitting sharp flint edges. They were roughly perpendicular to the longitudinal axis of the antler and occurred on the top half of the hammerhead. In contrast, the proximal end of the Tornio antler was not flattened (Figs. 2–3) and lacked impact marks.

My verdict was thus negative. There were no indications of human intervention on the Tornio antler. It was obvious but I felt nonetheless bad about failing to detect manipulation traces and letting my mentors down. It was with heavy heart that I told Donner about my conclusions. I was relieved to hear that neither he nor Kurtén thought it was an artifact, but they wanted a second opinion. I replied that just in case we could still have one more opinion. I suggested we take a good photo of the antler (Fig. 3) and save its proximal end so it could be examined by Professor Bordes during his visit to Helsinki in spring 1973. Donner agreed and left before I could show him my notes.

Over half of the antler beam was used for dating — a painful price one had to pay for old conventional radiocarbon dating. Bordes examined the intact proximal end and quickly dismissed the idea of human manipulation. What was left of the antler was eventually sent back to Oulu, and I thought that was the last I would see or hear about the Tornio antler. I was wrong.

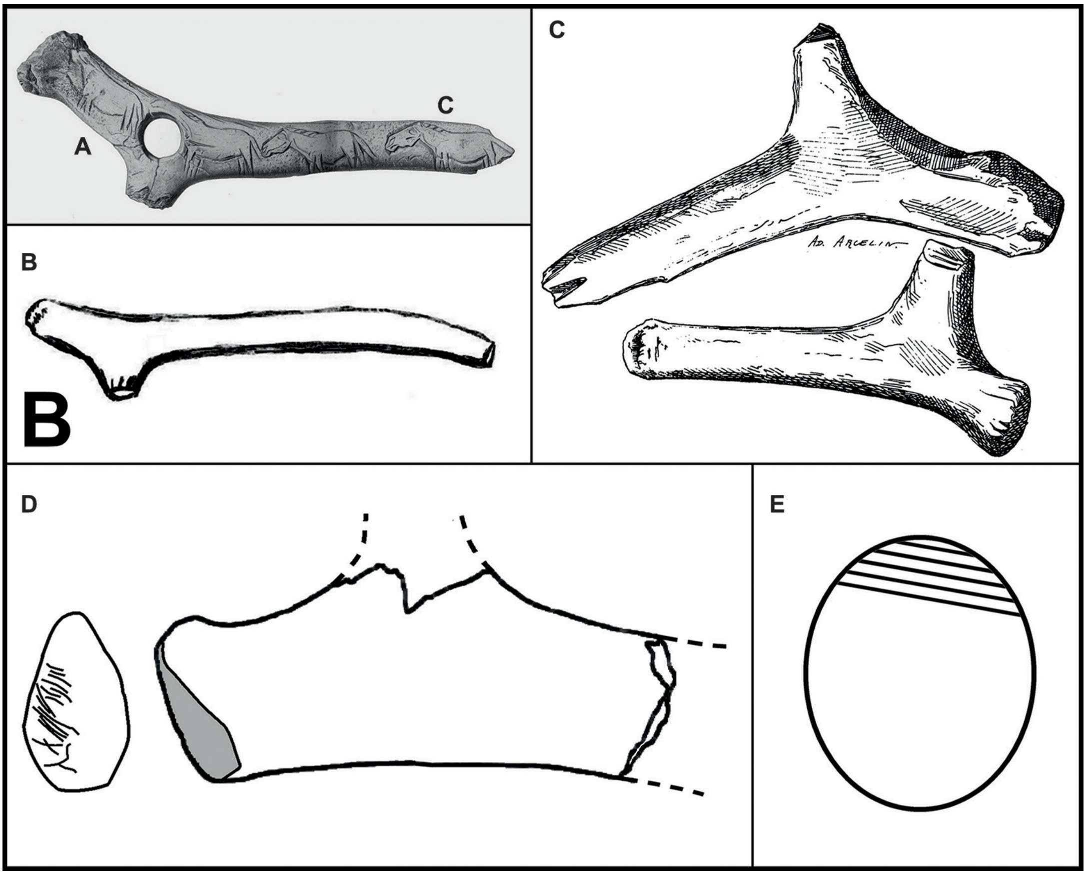

Fig. 5. Paleolithic antler artefacts and impact marks on hammer medallions. — **A**: *Bâton percé*, Dordogne (Lartet & Christy 1875: Plate 30). — **B**: Lyngby axe, Denmark (after Clark 1936). — **C**: Hammer, Saône-et-Loire (de Ferry 1870: Plate 28; *see* also Estévez 1978: Plate I, Rigaud *et al*. 2013: fig. 1). — **D**: Hammer and impact marks in its medallion, Dordogne (after Bordes 1974). — **E**: Sketch of the impact marks observed in the medallion of my flint-knapping hammer in 1972. They resemble those illustrated in **D** and by other authors (e.g. Estévez 1978: plate 2, Averbouh & Bodu 2003: fig. 11–12, Rigaud *et al*. 2013: fig. 2, Baumann & Maury 2022: fig. 6).

Archaeologists discover the Tornio antler, 1988–1991

In the spring of 1990, I was surprised by an intriguing reference to the Tornio antler in the *Current Anthropology* journal. But it is best to first explain the historical background and context where it was mentioned. The archaeology discipline had undergone a major paradigm shift in the 1960s. There was an increased interest in long-term cultural processes, like the interaction of humans with plants and animals. Some archaeologists had proposed that the domestication of plants and animals was the result of long gradual processes of symbiotic relationships between humans and certain plants or animals and, moreover, that close interaction events could have occurred already during the Paleolithic (Higgs & Jarman 1969). This was a plausible scenario. Kurtén himself was of the same opinion. In his first novel on the Paleolithic, set incidentally in southern Sweden during the same interstadial the Tornio antler was shed, the woman Svarta Molnet (Black Cloud) exchanges body fluids with a reindeer cow: human urine for reindeer milk (Kurtén 1978: 139, 1981: 152). Although I had no problems with the Higgs-Jarman hypothesis, I was not comfortable with what some of its advocators claimed as evidence for it.

Feeling the same way, Randall White (1989) had written a paper debunking much of the so-called evidence for Upper Paleolithic animal husbandry in SW France. I will only deal with what prompted the mention of the Tornio antler. White had criticized Paul Bahn (1978) for accepting Étienne Patte's (1958) suggestion that an allegedly castrated reindeer antler hinted at Paleolithic husbandry: "A single castrated male reindeer antler from Bois-du-Roc in Charente is entered as evidence for human intervention. This is difficult to accept" (White 1989: 612).

As customary in the *Current Anthropology* journal, the article was followed by comments of researchers savvy on the subject. Among them was of course Bahn, who defended himself by stating that he had not meant it as evidence and that he had pointed out elsewhere (Bahn 1984) that one castrate does not make a herd. Nevertheless, this explanation was immediately followed by a seemingly contradictory sentence: "It is interesting that an antler found in Finland in the 1970s and dated to 34,000 years ago has been identified by a Saami reindeer herder as belonging to a castrated male and thus ascribed to a reindeer herding system" (Bahn 1989: 618).

In his final address to the researchers' comments, White accepted that Bahn may not have been inferring Paleolithic herding from Patte's castrate reindeer, but at the same time he reacted to Bahn's additional comment about the Tornio antler: "Curiously, after disclaiming advocacy of the relevance of a castrate antler, he seems immediately to contradict this in citing a Saami reindeer herder" (White 1989: 627).

The last word of the White–Bahn debate on this subject appeared in a second note by Bahn in the following volume of *Current Anthropology*: "There is no contradiction in my reiteration of scepticism about these [castrate antlers] and my mention of the opinion of a Saami reindeer herder. It is always useful to look at both sides of the evidence coupled with the view of an expert" (Bahn 1990: 74).

Were they discussing the Tornio reindeer antler? Bahn had not mentioned Tornio, but the antler was 34 000 years old and from Finland. There could hardly be any other. I felt like writing a comment to *Current Anthropology* but had to get hold of the original article cited by Bahn first. It took months. There was no Amazon.com in 1990 and the book had to be ordered through the local bookstore. Living on Åland did not make things easier.

Judging by the surname Aikio, the author could be a reindeer herder, and in that case, he should know what he was saying. But the idea of the Tornio antler being from a castrated reindeer did not make much sense. The method generally used by archaeologists for deducing castration in prehistoric antlers went back to Patte's work, who had borrowed it from a treatise on reindeer by two Soviet researchers cited by him as Bol and Nikolaievsky (Patte 1958). The proximal end of castrate shed antlers was supposed to be concave whereas that of intact male antlers was convex. In addition, castrate antlers were said to be noticeably porous and spongy (Patte 1958, Bouchud 1966, Sturdy 1975). Neither criterion quite fitted the Tornio antler. The original shape of its proximal end was distorted due to abrasion damage, but did not seem to have been concave, on the contrary. More importantly, the osseous matrix of the Tornio antler was very dense and not at all porous.

While waiting for the book, I learned that Pekka Aikio was indeed a Sámi reindeer herder and that he had a master's in biology. His opinion was to be taken seriously. But when the book finally arrived in December 1990, it became clear that things were not quite the way I had imagined.

The book was *The Walking Larder*, edited by Juliet Clutton-Brock, with over 30 archaeological and/or ethnographical articles on human-animal relationships. Among them was Aikio's (1988) "The changing role of reindeer in the life of the Sami". It began with a touching description of the lifeways of Sámi reindeer-herding families before the introduction of snowmobiles in the 1960s, and ended with a nostalgic lament about the failure of modern society to understand the true significance of traditional herding practices. The Tornio reindeer antler and its date were mentioned briefly together with Siivonen's 1975 illustration halfway into the essay (Aikio 1988: 176–177) but the reference to its possible castrate nature did not appear until the last page.

"There are no written documents on the piece of antler which was found near the city of Tornio and which is 34,000 years old. However, a

Sámi reindeer-herder who saw a drawing of this antler concluded that it had belonged to a castrated reindeer. If this is true, then, this reindeer belonged to a reindeer-herding system and was not wild" (Aikio 1988: 183).

From this it was clear that Aikio was not the one who deemed the castrate nature of the antler. It had been done by another reindeer herder on the basis of a drawing. Although Aikio did not specify which drawing, it was most likely the one published by Siivonen in 1975 and reproduced in Aikio's 1988 article. Regardless of expertise, it is difficult to think that an accurate identification could be made from such a drawing (Fig. 2). Moreover, Aikio himself does not sound very convinced when he uses the expression "if this is true".

In January 1991, I contacted *Current Anthropology* about submitting a comment about the Tornio antler. The answer was positive but gave me a limit of two pages and four weeks to do it since the original article had appeared over a year earlier. I complied, unfortunately leaving out much of what I would have liked to write (Nunez 1991). Bahn did not reply to the journal but wrote me a cordial letter, which was answered in the same manner. That was the end of the Tornio antler's archaeological episode.

Oulu 2009–2012

When I was called to the University of Oulu in 1994, I knew that the Tornio antler was somewhere in the Biology Department but was too busy to inquire. Fifteen years later, in connection with our joint Archaeology-Biology Finnish Academy project "Human-animal relationship among Finland's Sámi 1000–1800 AD — DNA and stable isotope analyses of bones from offering sites" (2009–2012), the Tornio antler was sampled for AMS dating and stable isotope and aDNA analyses. The new AMS date corroborated the old conventional age from 1973 (Table 1).

Unfortunately, the sample got stuck with the DNA researchers and has yet to be analyzed for stable isotopes. It would have been interesting to compare its isotopic values with those of the reindeer bones analyzed by our project. In any event, for all it is worth, $\delta^{13}C$ of –19.4‰ VPDB measured by the Uppsala Ångström Laboratory does not differ significantly from the $\delta^{13}C$ means of –19.4‰ ± 0.6‰ of 12 fossil reindeer (45 000–33 000 cal BP) from Doggerland or –19.3‰ ± 0.9‰ of 7 medieval reindeer (1150–1450 cal AD) from Finnish Lapland (Núñez *et al*. 2020, van der Plicht & Kuitems 2022).

The aDNA analysis of the Tornio antler is still ongoing and the results will be published by the DNA researchers in due course. At this point we can assume that the Tornio antler is genetically representative of the reindeer population living in Finland some 39 000 years ago. However, the maternal lineage of the Tornio antler seems to have become extinct since then (Matti Heino, personal communication). No matches have been found so far in later reindeer individuals.

Summing up

The Tornio reindeer antler has played Cinderella to other fossil mammal remains from Finland, which may have to do with mammoths being extinct against thousands of reindeer roaming in Lapland. The only researcher that has described the Tornio antler is Lauri Siivonen (1975), who correctly placed it within the Peräpohjola interstadial before its antiquity had been determined by radiocarbon. The confirmation of his taxonomic classification of modern mountain, forest and domestic reindeer varieties and their possible relationship to the reindeer of interstadial Finland will have to wait for DNA research

Table 1. The ages yielded by the Tornio antler: conventional (Hel-254) in 1973 and AMS (Ua-43133) in 2012.

	Radiocarbon years BP	cal BP (1σ)	cal BP (2σ)
Hel-254	34300 + 2000/– 1450	41011–37514	42171–36147
Ua-43133	34545 ± 1022	40828–38368	41407–36953

results, which so far suggest that the issue is quite complex (e.g. Røed *et al*. 2014, 2018, 2022, Heino *et al*. 2019, 2021, Salmi & Heino 2019, Heino 2021, Weldenegodguad *et al*. 2020, Pokharel *et al*. 2023).

The same applies to the debated theory of reindeer surviving in Norwegian ice-free refugia during the Last Glacial Maximum (LGM). There are indications of reindeer in coastal Norway and central Sweden around the time the Tornio antler was shed (Lundqvist 1967, Valen *et al*. 1996, Hufthammer 2001, Mangerud *et al*. 2003, 2010, Johnsen 2010) but it is not clear if they survived the LGM. The idea is not so far-fetched given the resilience of reindeer and the fact that most of Andøya Island was ice free during the LGM (Alsos *et al*. 2020, Dussex *et al*. 2023) but interpretation is complicated by the early influx of reindeer from Denmark and/or Doggerland at the end of the LGM. The genetic signature of a small island population could be obscured by that of more numerous southern newcomers. There is evidence of reindeer reaching south-western Norway by 12 500 cal BP, northernmost Norway by 11 000 cal BP, and northernmost Finland by 10 000 cal BP (Ukkonen *et al*. 2006, Rankama & Kankaanpää 2008, Bang-Andersen 2012, Kleppe 2014).

The Tornio antler together with a few mammoth remains and numerous OSL dates from sediments indicate that most of Finland was ice free (Fig. 1) during much of Marine Isotope Stage (MIS) 3 (Ukkonen *et al*. 2003: Mäkinen 2005, Helmens & Engels 2010, Johansson *et al*. 2011, Helmens 2014, Sarala *et al*. 2016, 2022, Kleman *et al*. 2021, Eskola & Lunkka 2022, Mangerud *et al*. 2023). The ice-free period in northern Fennoscandia, including the Tornio river valley, was recently shown to fall roughly between 55 000 and 35 000 cal BP (Kleman *et al*. 2020, 2021, Eskola 2021, Eskola & Lunkka 2022, Mangerud *et al*. 2023).

It is worth mentioning that reindeer was not restricted to Fennoscandia during MIS 3. Their dated remains have been reported from much of western Europe: Britain, Doggerland, the Netherlands, Germany and France (e.g. Murray *et al*. 1993, Fontana 2000, Zilhão & d'Errico 2003, Glimmerveen *et al*. 2006, Conard 2009, Higham *et al*. 2011, van Kolfschoten *et al.* 2011, White & Pettit 2011, Morin 2012, Talamo *et al*. 2020, van der Plicht & Kuitems 2022, Britton *et al*. 2023). Reindeer remains dominate in all the 14 culture layers of Abri Pataud (Bouchud 1975) including the early Aurignacian levels with 24 dates within 42 000–35 000 cal BP (Higham *et al*. 2011, Lenoble & Agsous 2012). These reindeer had been in SW France since the MIS 4 stadial (Bouchud 1966, Morin 2012, Rendu *et al*. 2023).

Based on geologist Heikki Paarma's comment about the source of the gravel associated with the Tornio antler, Siivonen (1975: 34) suggested that it had been "transported along the Tornionjoki River Valley from as far as the slopes of the Kölen [Scandinavian] Mountain Range". However, this would mean a distance of 300–350 km, which may be too long. It takes 150–250 km of fluvial transport to wear quartz pebbles down to spherical shape (Kelly 1983), and the proximal end of the antler is not fully rounded even if antler is at least ten times softer (6 *versus* 7 on the Mohs scale).

Although it is difficult to estimate how long a trajectory was needed to round off the proximal end of the antler and obliterate the base of the broken brow tine, the nearly unworn state of the fractures of the beam and bez tine point to a short transport distance after their breakage. The beam and the bez tine fractures should have broken off shortly before the antler reached its final deposition place. I am inclined to think the Tornio antler was shed much closer to its discovery site than the Scandinavian mountains.

The non-artifact status of the Tornio reindeer antler remains unchanged. In addition to the earlier stated reasons, recent research has shown that the *bâtons percés* are incompatible due to their geographical distribution and the Lyngby axes due to their much later date (Rigaud 2001, Fischer *et al*. 2013, Geiling *et al*. 2015, Girininkas *et al*. 2016, Soldatova 2016, Lucas *et al*. 2019, Zagorska *et al*. 2019).

Paleolithic antler hammer finds were rare in 1972, and I was forced to compare the Tornio antler with my own flint-knapping hammers. During a study visit to Bordeaux in the fall of 1973, Bordes showed me one such Paleolithic specimen he was studying (Bordes 1974). The shape and marks of the hammerhead were much like those on my flint-knapping hammer

(Fig. 5D and E). Later, the same features were reported from dozens of subsequently found Paleolithic antler hammers (e.g. Estévez 1978, Averbouh & Bodu 2002, Rigaud *et al*. 2013, Baumann & Peschaux 2014, Baumann & Maury 2022). Those features are conspicuously absent from the Tornio antler.

Yet, the similarity of the Tornio antler and Paleolithic artefacts that intrigued Donner and Kurtén is not coincidental. We must bear in mind that the preserved segment of the Tornio antler corresponds to the hardiest portion of reindeer antlers. This is why it survived the geological transport processes and, for the same reason, that specific portion of antlers was preferentially used by prehistoric humans for their tools (cf. Wild *et al*. 2020).

The identification of the Tornio antler as being from a castrated reindeer is puzzling. A likely explanation is that, as mentioned by Aikio (1988), it was based on a drawing. The reindeer herder may have misinterpreted an innocent detail as a castrate feature. But instead of speculating, it is best to focus on those characteristics of the antler that clearly indicate otherwise. Castration leads to recognizable morphological changes in the reindeer skeleton, including the antlers (Soppela *et al*. 2022, van den Berg *et al*. 2023). According to 24 reindeer herders interviewed by Soppela *et al*. (2022) during 2019–2020, there are noticeable differences between the antlers of castrated and intact male reindeer (Table 2).

The characteristics are essentially the same as those previously mentioned by some archaeologists on the basis of ethnographic literature (e.g. Patte 1958, Bouchud 1966, Sturdy 1975), but these stem from direct contact and field observations. The diagnostic differences in the shape of the burrs are clearly seen in a photograph published by Soppela *et al*. (2022: 84). Although abraded, the extant portion of the proximal end of the Tornio antler is closer to that of the intact male antler than to that of the castrate in the said photograph. Moreover, the bony matrix of the Tornio antler is very dense, which is characteristic of intact male antlers. Otherwise, it probably would not have survived the rough geological transport.

Kurtén and the Tornio antler

As an epilogue I would like to comment on something that I have often wondered for four decades. Did the Tornio antler have any influence in Kurtén's literary production? I am referring to his Paleolithic novels *Den svarta tigern* from 1978 (*Dance of the tiger*, 1981) and *Mammutens rådare* from 1984 (*Singletusk*, 1986).

One year after the dating of the Tornio antler, sometime in 1974, I sat chatting with Björn Kurtén in a London pub. We were there on a weekend excursion with a dozen Helsinki Geology students to visit the British Museum (Natural History) (now Natural History Museum, London). After Kurtén's mind-blowing museum tour, the students had wandered off while I stayed with him. At some point he complained that he had finished writing a book and was stuck trying to choose what to write about next. Should he write about our fossils? The dialog that ensued went something like this:

MN: Orthoceratites and trilobites or reindeer and mammoths?
BK: Mammals, mammals.
MN: Excellent. Perhaps, you should do as Bordes, who alternates between writing scientific papers and science fiction novels whenever he gets stuck.
BK: François Bordes writes science-fiction?
MN: Yes and no. He uses the pen name of Francis with the surname Carsac, the Dordogne village where he is from and lives when not in Bordeaux.

Table 2. Main differences between the antlers of intact and castrated male reindeer (data from Soppela *et al.* 2022).

	Intact males	Castrates
Density	Very dense, solid, heavy, strong	Less dense, softer, porous
Attachment	Strongly attached	Loosely attached
Burr shape	Protruding	Concave

BK: Are his novels about the Paleolithic?
MN: No, they are all set in the distant future.

Kurtén said that his would be in the past and joked that he could write as Bjorne Vasa. And he did, but with his real name.

In 1978 I went to do postgraduate research in Canada and then in 1981, while browsing in a bookstore, I could not believe my eyes. Among the new paperback arrivals, there was the sign "A story of our dawn age" and below it a book entitled *Dance of the tiger* by Björn Kurtén. I bought it and, after devouring its content, read in the afterword:

"There was a warmer spell, between about 40,000 and 25,000 years ago, when the ice retreated to the north, leaving much of Scandinavia uncovered; and the story takes place in this interval. … We know that mammoth and reindeer lived in Scandinavia at the time, so I feel justified in populating the landscape of Nordic forests and skerries with an Ice Age fauna" (Kurtén 1981: 257).

My thoughts went back to our London conversation seven years earlier. I thought of asking Kurtén about it but never got the chance. When I returned to Finland in 1982, I went directly to work on Åland and was seldom in Helsinki. I met him briefly only two or three times before his death.

But the question remains: Did the Tornio antler inspire Kurtén to write his Paleolithic novels? It cannot be answered, but I would like to think so.

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