

Ginnerup Revisited. New Excavations at a Key Neolithic Site on Djursland, Denmark

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Abstract

New excavations of an enclosure-related site at Ginnerup on Djursland, Denmark, in 2020 resulted in the identification of several features containing depositions of marine shells. One of these, A4, is a natural depression with a fill comprised of four consecutively deposited layers, forming an undisturbed stratigraphy, dated by several ^{14}C dates to between ca. 3150 and 2950 cal BC. The oldest layer contained finds from phase MN A Ib of the Funnel Beaker culture, while the remaining three layers yielded finds from the latest Funnel Beaker culture on Djursland (MN A II/III, Ferslev style) with an upwardly increasing content of Pitted Ware culture elements, thereby allowing the emergence of this culture in Denmark to be followed for the first time. Preservation conditions for organic material were excellent due to the presence of marine shells, mainly from oysters and mussels, in all layers. In this preliminary account, a survey of the material culture in the four layers is presented, together with ^{14}C dates, zoological investigations of mammal and fish bones, isotope analyses ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$) and aDNA analyses of mammal bones, and examinations of plant macro-remains. The abundant bones of wild horses also hold a huge potential for zoological and genetic studies, the results of which can qualify the ongoing debate about the re-wilding of horses in present-day Europe.

Introduction

The present contribution deals with a part of the Middle Neolithic in Denmark that saw the transition between the Funnel Beaker and Pitted Ware cultures. Figure 1 shows the subdivision of both cultures into different typological and chronological groups and the abbreviations used in the following. It is important to note that the cultural development in the Early and Middle Neolithic in South Scandinavia in general is characterised by numerous regional developments. Figure 1 reflects the current state of knowledge for Djursland, eastern Jutland and therefore is not necessarily valid in other parts of Denmark.

The Middle Neolithic A traditionally is subdivided into five distinctive phases, which have been named after important settlement finds (Mathiasen 1944; Berg 1951; Becker 1955): MN A Ia (Troldebjerg), MN A Ib (Klintebakke), MN A II (Blandebjerg), MN A III (Bundsø), MN A IV (Lindø) and MN A V (Store Valby). A regional stylistic development of pottery in the northern parts of Jutland (including Djursland) furthermore has been singled out as

DATE CAL BC	CULTURE	TYPOLOGICAL GROUP	CHRONOLOGICAL PHASE	
4000	Ertebølle	Late Ertebølle	Late Mesolithic	
3900	Funnel Beaker (TRB)	Oxie	EN Ia	
3800		Volling	EN Ib	
3700	Classic		Virum	EN II
3600		Troldebjerg	MN A Ia	
3500		Klintebakke	MN A Ib	
3400	Pitted Ware (PWC)	Blandebjerg (Bundsø/Lindø) Ferslev	Ginnerup	MN A II (III–IV)
3300				MN A V
3200	Classic	Kainsbakke	MN B	
3100				
3000	?	?		

Fig. 1. Chronological overview over the Early and Middle Neolithic A on Djursland (Graphics: E. Rasmussen).

Ferslev style, which is subdivided into an early and a late phase corresponding to MN A II and MN A III (Marseen 1960; Ebbesen 1978, 75–77). As apparent from Figure 1, the MN A II–IV ceramic styles on Djursland do not represent chronologically distinct units, as pottery decorated in these styles has been found in the same layers at the Ginnerup site presented here and at the neighbouring Fannerup site (Eriksen 1984).

The Pitted Ware culture (PWC, ca. 3100–2700 BC) was recognised as part of the cultural development of the Neolithic in northeastern parts of Denmark in the 1950s (Becker 1951). This was almost exclusively based on finds of characteristic flint artefacts (tanged arrowheads, bi-polar cylindrical blade cores) collected on the surface, but a few finds from settlements, also comprising pottery, were published shortly thereafter (Marseen 1953; 1962). However, it was not until the discovery of the Kirial Bro site and, in particular, the Kainsbakke locality on Djursland in the early 1980s, with their large assemblages of lithics, pottery and, not least, well-preserved bones (Wincentz Rasmussen/Boas 1982; Wincentz Rasmussen 1984; 1991; Richter 1986a; 1986b; 1989; 1991), that it became possible to describe the Danish branch of the PWC in greater detail. Nevertheless, due to a lack of comparable sites in other parts of Denmark, the PWC remained somewhat of an enigma. Considerable progress in understanding the PWC phenomenon has been made during the past decade. Through the work of R. Iversen (2010; 2013; 2015a; 2015b), it has become clear that different regional expressions of the PWC exist in Denmark. These are characterised by varying degrees of integration of typical PWC elements into Funnel Beaker (TRB) groups. Djursland and northeastern Jutland/the Limfjord region are the only parts of the country where all characteristic elements of PWC material culture (i.e. the lithic types mentioned above, Pitted Ware pottery and several diagnostic ornaments and tools) appear. Other regions (for example Zealand) are characterised by the partial adoption of such elements (lithic types), but

the continued use of TRB pottery. The recent detailed analysis of all available PWC evidence from Djursland (Klassen 2020) has demonstrated that the adoption of PWC elements in the culture's core area in Denmark encompassed ritual aspects (shamanistic bear cult), too. It has also been shown that several aspects (economy, settlement organisation, ritual sites, graves and some parts of the material culture) reflect strong TRB traditions or follow contemporary TRB trends evident in other parts of Denmark. Consequently, even in its 'purest' form, the PWC in Denmark deviates from the culture's expression in its eastern Swedish area of origin (Klassen et al. 2020, 451–466). While a broader picture of the PWC in Denmark has been obtained during the past decade, the culture's genesis still is not well understood. Neither Kainsbakke nor Kirial Bro belong to the culture's earliest phase and the finds (apart from the universally distributed flint axes and clay discs) do not exhibit any obvious links to preceding TRB phases in the area. Nevertheless, as demonstrated by U. Rasmussen (2020, 195–226), a third site in the same part of northeastern Djursland – Ginnerup – does hold the potential to shed light on the TRB-PWC transition, as some of the finds resemble earlier TRB-types (pottery) or can be identified as transitional types (arrowheads combining elements of both transverse [TRB] and tanged [PWC] types). Furthermore, the available ¹⁴C dates indicate that the Ginnerup site is approximately 50–100 years older than Kainsbakke and Kirial Bro, with dates for the final occupation of Ginnerup being ca. 3100–2920 cal BC, as opposed to 3020–2700 cal BC at Kainsbakke and Kirial Bro (Philippson et al. 2020). Unfortunately, previous excavations at Ginnerup (in 2001 and 2003) were largely confined to the removal of topsoil in trial trenches and surface recording of the features thereby uncovered. Consequently, the abundant finds of flint artefacts, pottery and bone recovered from these excavations lack stratigraphical context, thereby limiting their scientific value. Bones are preserved in the acidic soil due to the presence of marine shells deposited in three of the identified features. These shells are continually being ploughed up even today, indicating the ongoing destruction of the site. East Jutland Museum therefore re-initiated excavation of the site in 2020, in collaboration with Moesgaard Museum and the Universities of Aarhus and Copenhagen, with first- and third-year students participating in fieldwork/excavation training.

This preliminary account deals with the results of the 2020 excavation campaign. The excavation has since been continued in 2021 and 2022 and a fourth and final campaign will be carried out in 2023.

The Ginnerup site

The Ginnerup site is situated in the village of the same name in the north-eastern part of the Djursland peninsula, about 7 km west of Grenaa. At the time the site was occupied, the large Kolindsund Fjord split Djursland in two (Fig. 2). The site is located by the northern shore of this former fjord, to the west of a minor side branch, which extended 500–600 m into the moraine plateau on which the site lies (Fig. 3). The earlier excavations revealed that it was delimited on its southern and eastern sides by steep, 8–11 m high, coastal cliffs towards the fjord, while ravines constituted the northern and western boundaries. These ravines have been partly filled with cultural deposits containing mixed Neolithic finds from the TRB and PWC, some of which exceed 2 m in thickness. Similar but shallower deposits can also be found in minor depressions within the ca. 1 ha occupied area, while all other remains from the occupation of the site have probably been destroyed by ploughing. After topsoil removal, several features were recorded on the surface at the outer limits of the occupied area in 2001/2003. The critical review undertaken by U. Rasmussen (2020, 199–205) of the records from

these investigations has shown that only those extending over ca. 130 m on the eastern side (A3–A8) and a single isolated feature on the northern side (A1) can be identified as probable Neolithic pits or ditch segments, while others date from the Iron Age or are natural phenomena (Fig. 4). A1 comprises a ditch segment with various phases of use identified in section in a machine-cut trench. Features A3 and A4 are characterised by similar fills (as evaluated from the surface), including depositions of marine shells, and were therefore classified as probable ditch segments. The remaining features, pits A5–A8, differ in respect of their fill and probably also their function, although they are aligned in a row together with A3 and A4. Apart from two TRB sherds, all finds have been attributed to the PWC (Rasmussen 2020, 214–222). Statistical modelling of seven ^{14}C dates obtained for non-stratified bones possibly indicated two phases of activity at the site around 3110 and 3070 cal BC, respectively (Philippsen et al. 2020, 258–262).

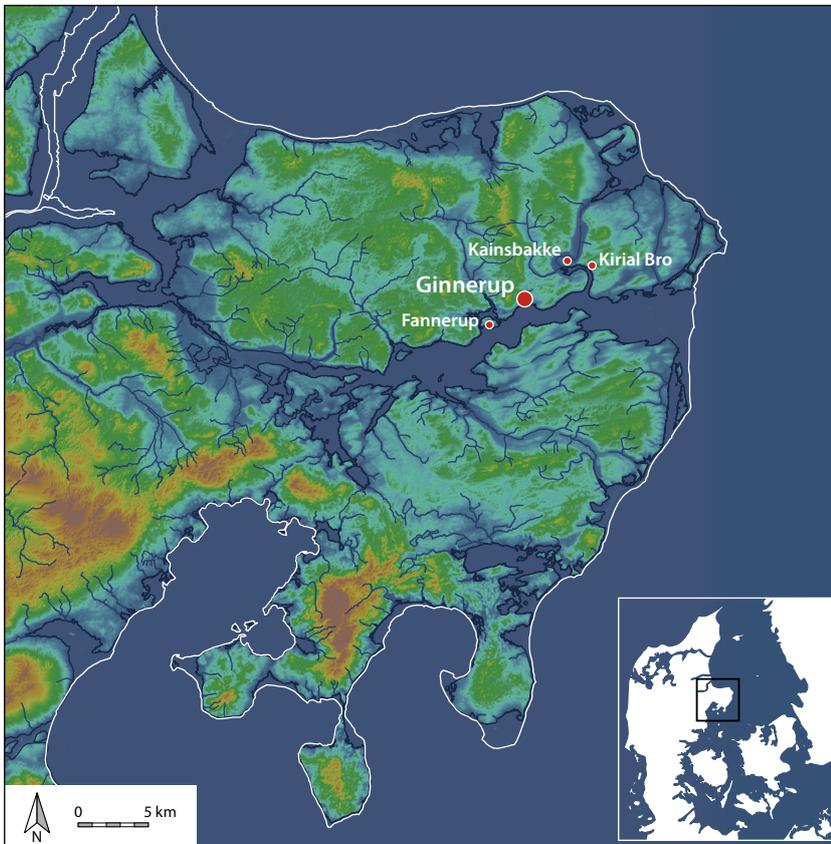


Fig. 2. The location of the Ginnerup site in northeastern Djursland. Coastline reconstructed for the time of occupation around 3000 BC (Klassen 2014, 85–88). The locations of the key Pitted Ware culture sites of Kainsbakke and Kirial Bro, as well as the Funnel Beaker culture settlement complex (MN A II) at Fannerup, are also shown. Modern coastline marked as a white line (Graphics: E. Rasmussen).

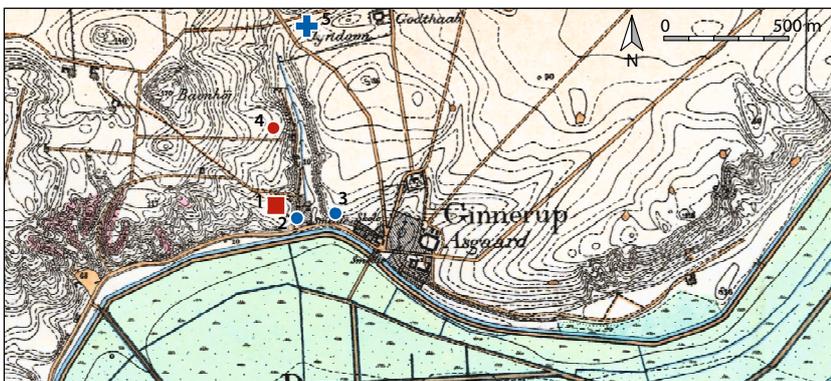
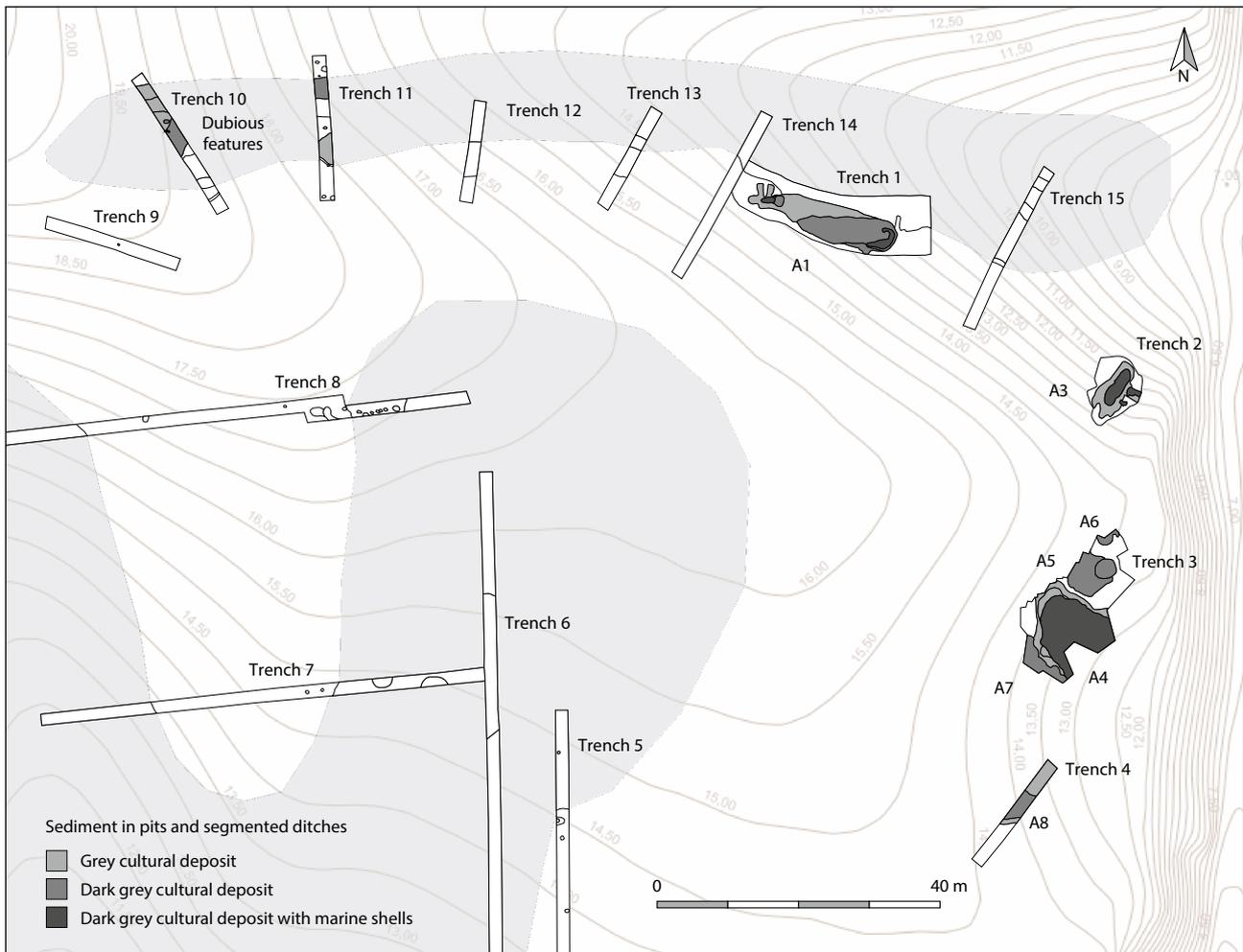


Fig. 3. Ginnerup. Location of the site (red square) on the moraine plateau above the northern shore of the former Kolindsund Fjord. Blue dots denote kitchen middens, the red dot marks a surface collection containing Pitted Ware culture finds and the blue cross the 'Jyndovnen' long barrow/passage grave. Background map: Høje målebordsblade, 1877 (after Rasmussen 2020, 196 fig. 43).



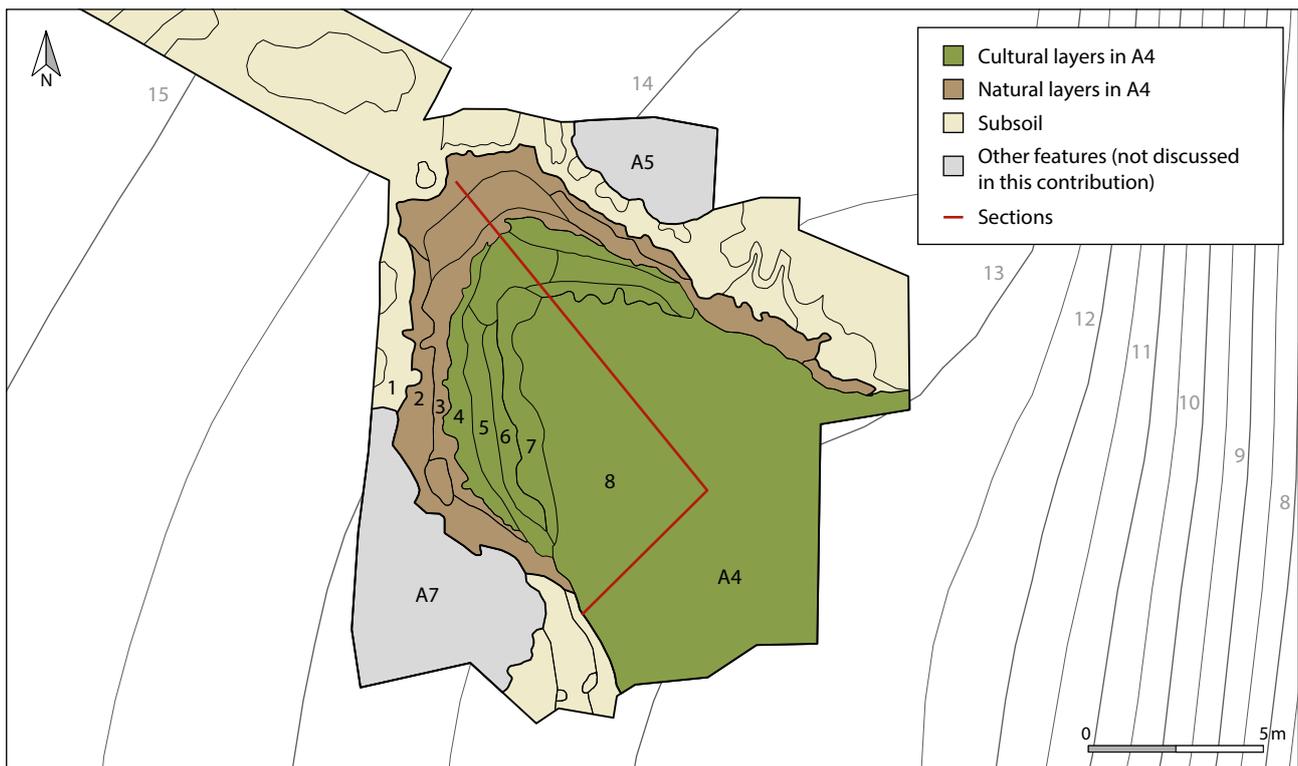
Ditch segment A1, with its traces of recutting and backfilling, is clearly reminiscent of the constructional elements seen in causewayed enclosures (Rasmussen 2020, 205–208). But this, and the other features identified at Ginnerup, do not enclose a specific area or form a consecutive row. The site should therefore be assigned to a group of related structures that, in the absence of a better term, have been dubbed ‘enclosure-related sites’ (Klassen 2014, 31–34). Its closest parallel is the large PWC site of Kainsbakke, only 3 km to the northeast, where an isolated ditch segment (pit A47), aligned with a row of large, round pits, has been found (Wincentz 2020, 40–57). Other common traits of the Ginnerup and Kainsbakke sites include the construction of these specific features on slopes and the deposition of marine shells. Given the extraordinary finds of animal bones preserved in the shell deposits at Kainsbakke (Wincentz 2020, 50 figs. 15–17; Makarewicz/Pleuger 2020; Makarewicz in press; Pleuger/Makarewicz 2020), two of the three proven or suspected ditch segments containing shells at the Ginnerup site – A1 and A4 – were selected for further excavation in 2020. The large ditch segment A1 is characterised by a complex stratigraphy comprising at least three phases of recutting and subsequent backfilling, as well as complex sequences of spatially restricted shell depositions, especially at its eastern end. Further excavations are needed to clarify the precise nature of this structure. The following account therefore concentrates on feature A4, as excavated in 2020.

Fig. 4. Ginnerup. Plan of the site based on the interpretation of the results of trial excavations in 2001 and 2003. The extent of the cultural deposits was established by systematic collection of finds on the surface. Features A1 and A4 were targeted in the 2020 excavation (after Rasmussen 2020, 204 fig. 51).

A4: Excavations in 2020

Feature A4 is situated at the eastern edge of the moraine plateau, just above an 8 m-high coastal cliff. During the first trial excavation in 2001, this finds-rich feature with a shell-mixed fill was only partly uncovered, leading to the conclusion that it was a large pit or ditch segment aligned with five other pits (A3, A5–A8) to form a row along the edge of the cliff (Rasmussen 2020). This conclusion has been revised in course of the new investigations. The 214 m² excavation trench opened in 2020 extended farther towards the cliff than the previous excavation. A4 now revealed itself to be an at least 16 m-long, tongue-shaped, southeast–northwest-oriented feature. The feature's tip points northwest, where it meets the plateau and then broadens out to a width of 10.5 m at the southeastern boundary of the excavation trench. A4 has no clear boundary at this end (Fig. 5). The landscape here falls into a depression towards the cliff, and today this is filled with cultural deposits and accumulated topsoil of progressively increasing thickness. These observations indicate that A4 is not a pit or ditch, but apparently the upper part of a natural ravine partly filled with a stratigraphic sequence of accumulated cultural layers, deposits of dark, finds-rich soil and shell-mixed layers from the Neolithic (Fig. 5). At the bottom of the ravine, sediments probably comprised of alluvial sand rest directly on the moraine, suggesting it originated as a Late Glacial gully.

Fig. 5. Ginnerup, feature A4. The excavation trench located just above the coastal cliff. The stratigraphic sequence (layers 1–8) depicted in the horizontal plane on the surface of A4. See text for description of the layers (Graphics: C. Skaaning Andersen/Moesgaard IT/ E. Rasmussen).



The 2020 excavation focused on the western half of A4, with the aim of excavating the upper part of the shell deposits, currently suffering destruction from ploughing, while establishing a longitudinal section along the central axis (not yet completed) and a shorter transverse section in the southern part (Fig. 6). The approach was to carefully excavate the stratigraphical sequence by individual context. Significant finds of pottery, bones and flint tools were recorded separately, and all soil was wet-sieved through a 2 mm mesh, by 1 m²-square and stratigraphical unit. This meticulous excavation



Fig. 6. Ginnerup, feature A4. The excavation of its western part seen from the west. The upper accumulated soil layer 8 has been removed, exposing the sequence of the primary archaeological layers 4–7 on the surface between the scale bar and the sections (Photo: U. Rasmussen).

method yielded abundant, diverse finds and a preliminary understanding of the stratigraphy and chronology of A4. A trial trench was subsequently added at the northwestern corner of the main trench, extending into the upper plateau, aimed at detecting potential settlement layers above A4. No such layers were found preserved here.

The following account is the result of a first, preliminary study of the material.

Stratigraphy and nature of deposits

After the first thorough cleaning of the surface of the excavation trench, a stratigraphical sequence of geological and archaeological deposits in the ravine appeared clearly in the horizontal erosion plane arising from modern ploughing (Figs. 5–7). The subsoil beneath and surrounding the ravine is reddish-brown to light grey chalk-rich moraine with a high content of dark grey Danien flint (layer 1). Sediments comprised of alluvial sands (layer 2) mixed with dark humus uppermost (layer 3) have accumulated at the base and up the sides of the ravine. The oldest and lowest archaeological deposits (layer 4) rest directly on this sand and consist of dark grey sooty and humus-rich silt, mixed with marine shells and artefacts. These are followed by two similar shell-mixed deposits, characterised by rather crushed shells (layer 5) or more complete and compacted shells (layer 6). The shell deposits vary in thickness from 5 to 15 cm. A finds-rich primary archaeological context then follows in the form of a ca. 5 cm-thick, dark, greasy, sooty and humus-rich silt without shells (layer 7). Finally, an up to 1 m-thick layer of accumulated, mixed cultural deposits fills the upper part of the ravine (layer 8). The genesis of layer 8 remains rather unclear but appears to be related to later prehistoric erosion of the Neolithic layers on top of the plateau. Its voluminous character is remarkable, though commonly found in all the depressions running down the sides of the plateau (Rasmussen 2020, 201).

The stratigraphy revealed in transverse section in the southern part of the trench largely corresponds to that outlined above, but the section's position may be slightly peripheral relative to the extension of the lower shell deposits.

The molluscs represented in the shell deposits (layers 4–6) are as follows: Mussels (*Mytilus edulis*) and oysters (*Ostrea edulis*) feature prominently. The age and size of individuals of both species varies from small and young to rather large and old. Cockles (*Cerastoderma edule*) and common periwinkle (*Littorina littorea*) are moderately abundant, while several other species (*Tritia reticulata* and others) occur occasionally. Broadly speaking, the shell

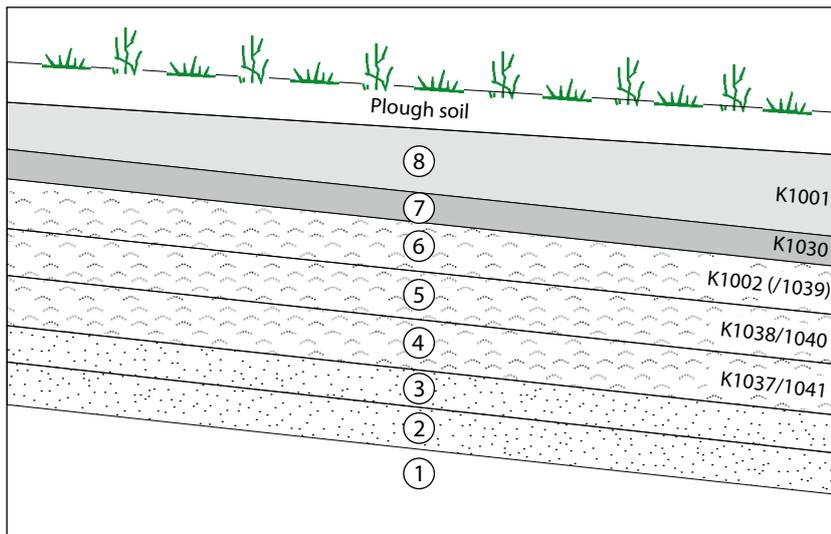


Fig. 7. Ginnerup, feature A4. Simplified and schematic illustration of the vertical stratigraphy based on the horizontal sequence and the southern section. See text for description of the layers, some of which include several contexts (= K-numbers) (Graphics: U. Rasmussen).

assemblages correspond to the typical species mix seen in Danish kitchen middens from the Mesolithic and Neolithic (Andersen, S. H. 2000, 370), but the relatively great abundance of mussels is remarkable. Their number can easily be underestimated due to their often very fragmented state in archaeological contexts. Another remarkable observation is that some of the shells may have been collected from dead individuals, as they are water-rolled and perforated by a boring sponge (Clionidae). This may suggest that the shell depositions represent something more than discarded waste from meals (see below), but this observation requires further analyses for confirmation.

The nature of the accumulation of the primary archaeological deposits has not yet been fully clarified. A straightforward interpretation of the deposits would be that they represent refuse dumps resulting from activities on top of the plateau. However, several observations indicate more complex activities in the ravine. The crushed nature of the shells seems to suggest traffic and activity on the sediments. The character of flint scatters on top of the shell deposits along the western side indicates *in situ* flintknapping. A concentration of bone splinters and heat-affected stones probably reflects food-processing on the spot. Finally, some faunal remains appear to have been consciously deposited. This is possibly true for mandibles of wild horse (*Equus ferus*), that were visually conspicuous on the surface of layer 5 (Fig. 8). A pair of pig (*Sus cf. domesticus*) scapulae and a scapula of roe deer (*Capreolus capreolus*), found under a stone at the northwestern end of A4, appeared to have been intentionally arranged (Fig. 9). The sides of the ravine slope ca. 15° transversely and c. 5–10° longitudinally. This moderate slope does not exclude activities taking place in the ravine.

A high accumulation rate of the cultural deposits (see section on absolute chronology below) has led to constant covering or sealing of the individual layers. In this way, they were (with minor exceptions) protected from later disturbance by natural erosion and subsequent human activity.

Artefacts and relative chronology

Pottery

Analysis of the sparse remains of pottery recovered during the trial excavations in 2001 and 2003 indicated two phases of use of the site in general: a TRB phase (EN II/MN A I and MN A II) followed by a potentially early PWC phase



Fig. 8. Ginnerup, feature A4. Mandible of wild horse *in situ* on the transition between layers 5 and 6 (Photo: U. Rasmussen).



Fig. 9. Ginnerup, feature A4. A pair of pig scapulae *in situ* at the northwestern end of the feature. They are potentially from the same individual (Photo: U. Rasmussen).

(Rasmussen 2020, 214–224). Modelling of seven ^{14}C dates for non-stratified bones permitted two possible interpretations: either two temporally discrete occupational events, in the TRB and PWC, respectively, or a continuous development from the TRB to the PWC (Philippesen et al. 2020, 258–261). The finds from 2020 provide a much better basis for chronological studies. Although the results of these generally confirm earlier observations, some important additions and corrections can now be made. A survey of the TRB chronology used in the following can be found in M. S. Midgley (1992). The evidence for Early TRB activities in EN II/MN A I has been corroborated by a few sherds of funnel beakers, decorated with simple incised vertical lines on the body (Fig. 10,1). Several sherds found in the northwestern part of A4 are from a funnel beaker decorated with two horizontal lines below the rim, an unclear composition of vertical lines on the neck and groups of vertical lines on the body. All the lines have been executed with impressions of whipped cord (Fig. 10,2). Based solely on the typological arguments, this material cannot be dated more precisely within the period given above due to the chronologically broad occurrence of incised vertical lines and a lack of precisely dated parallels to decoration produced with impressions of whipped cord. However, the ^{14}C evidence for the layer 4 that yielded these finds (see below) indicates that they belong to late MN A I (= MN A Ib).



Fig. 10. Ginnerup, feature A4. Potsherds of the phase MN A I: 1 Sherd with incised lines; 2 funnel beaker with decoration in whipped cord forming two horizontal rows below the rim and vertical lines made with impressions of whipped cord on the belly (Photo: Mark C. Dyer/East Jutland Museum).

The greatest proportion of the pottery relates to TRB MN A II, with a variety of ornamental details that are, for example, known from the nearby localities of Fannerup and Ørum Å (Eriksen 1984). Identification of the vessel shapes is difficult due to the degree of fragmentation, but ledged and shouldered vessels of different sizes are represented. Large storage vessels are decorated with characteristic undulating moulding (Fig. 11,1) and various stabs below the rim, for example simple, round pits. The finer vessels and beakers are frequently decorated with chevrons below the rim (Fig. 11,2–3), in one case on the inside (Fig. 11,4). On the latter vessel, the outside is decorated with a horizontal band delimited by two opposing chevrons with fine cross-hatching in between. The ledges can be decorated with short, vertical lines or fine cuts and chevrons like the more special appearance shown on Figure 11,5, produced with a *Cardium* shell. Fragments of two clay spoons, decorated with a *Cardium* shell and perhaps notch stamps, can be added to the MN A II inventory.



Fig. 11. Ginnerup, feature A4. Potsherds of the phase MN A II (Photo: M. C. Dyer/East Jutland Museum).

Some of the late MN A II pottery, and probable examples executed in MN A III style, stands out by having a darker ware and pronounced use of notch stamps in the form of vertical and horizontal chevrons, rhombuses and more complex compositions (Fig. 12). The decoration relates directly to the Ferslev style prominent in northern Jutland. Comparable decorations are known from Fannerup (Eriksen 1984, 57–58).

Few sherds can be securely assigned to the PWC. Vessel shapes are difficult to reconstruct due to the very fragmented nature of the material, but all the sherds appear to represent storage vessels. The ware is generally thicker and coarser than that of the TRB vessels. Decoration is limited to horizontal rows of simple pits or short vertical stamps below the rim. In a few cases,



Fig. 12. Ginnerup, feature A4. Potsherds of the Ferslev style. A dark ware and pronounced use of notch stamps in different compositions. Sherd no. 2 has preserved remnants of white incrustation (Photo: M. C. Dyer/East Jutland Museum).

a combination with additional stamps of circles on the neck can be demonstrated (Fig. 13).

It is difficult to ascribe sherds to the (early) PWC phase with certainty because some of the decorative elements used on rims, like simple pits, short vertical stamps and even horizontal chevrons, were employed in both TRB MN A II and the (early) PWC. This observation may indicate a direct transitional link between the two, a possibility further underlined in the material from A4 by the fact that the certain PWC sherds have a slightly finer ware (and are therefore closer to the TRB ware) than those found at the Kainsbakke site nearby (cf. Rasmussen 2020, 224).

Sherds from several clay discs are present, but no ornaments or holes have yet been identified and their cultural affiliation has not been established.

The stratigraphical distribution of a sub-sample of ornamented and well-dated sherds that have been investigated in more detail shows a distinct tendency towards a chronological sequence (Table 1). The MN A I sherds are clearly related to the lowest shell context (layer 4), MN A II pottery has been found in layers 5–7, while sherds decorated in Ferslev style derive from layers 5 and 7. PWC sherds are present in layers 5–7, increasing in number upwards, thereby indicating a gradually increasing degree of inclusion of PWC material culture into the latest TRB at the site. A few, isolated PWC sherds from layer 4 can presently be interpreted as the result of secondary displacement due to erosional processes.



Fig. 13. Ginnerup, feature A4. Potsherds of the PWC phase (Photo: M. C. Dyer/East Jutland Museum).

Table 1. Stratigraphical distribution of a sub-sample of ornamented and well-dated sherds. F in brackets identifies the occurrence of sherds decorated in Ferslev-style.

	MN A I	MN A II	MN A III	PWC
Layer 7		16 (F)	1 (F)	7
Layer 6		3		6
Layer 5		9 (F)		4
Layer 4	6			2

Flint

There is a great abundance of waste flint and discarded tools in all the archaeological layers. The raw material comprises partly the local dark, matt, coarse, grey Danien flint, characterised by a thick, hard chalk cortex, and partly flint of a finer quality that must have been collected elsewhere. The tool inventory is diverse and appears to reflect a broad range of typical settlement activities. A more detailed analysis of the flint material may reveal patterns of specialisation or specialised production in the local flint. The following account focusses on the chronologically significant types.

The flint axes (Fig. 14) are very fragmented and represented by eight severely broken or fire-cracked pieces and a quantity of simple flakes showing traces of polishing. Secure identification of the axe types (typology and chronology according to Nielsen 1979, 17 ff.) is difficult due to the fragmented state of the finds and the lack of complete butt fragments. All the axes

are quadrifacial and have extensive polishing on their broad sides, while no examples of polish on the narrow sides have been detected. While a few fragments may represent the thin-butted Blandebjerg type (MN A II), three can best be assigned to the early thick-butted axes of Bundsø type (MN A III). There is therefore good chronological agreement between the axe types and the pottery, although axes belonging to the MN A I horizon are apparently absent. No fragments of thick-butted Lindø (MN A IV) or Valby (MN A V) types are present. These latter types characterise the PWC inventories at Kirial Bro and Kainsbakke (Wincentz 2020, 88–89; 126–127). It is therefore possible that the Bundsø axes constitute part of the potential early PWC phase at Ginnerup, but this cannot yet be adequately demonstrated by stratigraphical analysis due to the small number of finds.



Fig. 14. Ginnerup, feature A4. Butt fragment of a polished flint axe of Bundsø type (Photo: M. C. Dyer/East Jutland Museum).



Fig. 15. Ginnerup, feature A4. Different types of transverse arrowheads from layer 7 (Photo: M. C. Dyer/East Jutland Museum).

Arrowheads are represented by 17 examples – 16 transverse and one tanged. The transverse arrowheads are generally small and show a great variety of shapes. Types with concave, straight and convex sides are all represented and have been found within the same stratigraphical units (Fig. 15). The tanged arrowhead is of type A1 (Fig. 16,1) which, according to C.J. Becker's chronology, relates to the early PWC (Becker 1951, 188–195). While this relative dating is consistent with the assumption of an early PWC phase at Ginnerup, Becker's chronology has recently been challenged by R. Iversen (2010; 2016), who suggests that all the A-, B- and C-type arrowheads occur coevally. The single arrowhead from Ginnerup obviously does not permit further analysis of this question. No tanged arrowheads were found during the earlier trial excavations. It is therefore possible that the use of tanged arrowheads in the early PWC was very limited and to a major degree combined with that of transverse types. The production of tanged arrowheads at Ginnerup is probably indicated by the finding of a cylindrical blade core (Fig. 16,2) and several blades from bipolar cores. The straight bipolar blades could also have served as raw material for other tools, for example blade sickles or knives, such as the example from the upper shell context, layer 6 (Fig. 16,3). The tanged arrowhead and the cylindrical core are from layer 7 and layer 8, respectively.



Fig. 16. Ginnerup, feature A4. Flint artefacts of the PWC: 1 Tanged arrowhead of type A1; 2 bipolar, cylindrical blade core; 3 backed knife made of a blade from a bipolar core (Photo: M. C. Dyer/East Jutland Museum).

Bone and antler

Finds of bone and antler tools and ornaments are relatively numerous due to the excellent conditions for preservation in the shell contexts and systematic wet sieving of the excavated soil. Most of the 20–25 examples comprise small fragments of needles or pins made from cortical bone of mammals and bird bones. In addition, there are fragments of other types of bone objects, such as an antler harpoon of Kainsbakke-type (Fig. 17; see Wincentz 2020, 108 fig.58,4 for comparison), a pendant/bead made from a fish vertebra (Fig. 18) and a worked scapula from aurochs/domesticated cattle (Fig. 19). The latter was probably used for production of bone discs/rings and was found in the oldest cultural deposit (layer 4). It has been dated directly by ^{14}C to 3200–3100 cal BC (see below). It resembles worked aurochs scapulae recovered from Mesolithic (Ertebølle) sites, for example Brabrand (Thomsen/Jessen 1906, 37 fig. 11) and Ringkloster (Andersen, S. H. 1975, 70 fig. 62a; 1998). The perforated fish vertebra is of special interest, too. The vertebra is from a pike (*Esox lucius*) and is one of only two freshwater fish bones from feature A4 (the other being a cyprinid). It may have had an inland origin, although both pike and some cyprinids tolerate brackish water to some degree and could, therefore, potentially have come from a branch of the fjord. Objects of this type are extremely rare in southern Scandinavia, with only about a handful known in total (unpublished). Two of these are from the immediate vicinity of Ginnerup (Fannerup and 'Kolindsund'). This concentration of finds probably indicates local production, but it is also possible that the Ginnerup example represents an imported object, as perforated pike vertebrae have been used in other parts of Europe in much greater numbers (Makowiecki et al. 2021). The function of these artefacts is still debated, and it seems likely that this changed through time and from region to region.

^{14}C dating

Eleven new radiocarbon dates have been obtained for samples from feature A4 (Table 2). In contrast to the earlier samples mentioned above (Philippson et al. 2020, 258 ff.), the stratigraphical contexts of these samples are well-known: The samples derive from six contexts in four layers (layers 4–7; Fig. 7). There are one to three samples per context and a total of one to five samples per layer. The dates were all obtained for bones of terrestrial herbivores.

One sample was dated at the A. E. Lalonde AMS Lab, Ottawa, Canada (UOC-code), the others at the University of Arizona AMS Laboratory, USA (AA-code). Collagen was extracted by a modified Longin method including gelatinisation and ultrafiltration with a cut-off at 30kDa (Longin 1971; Brock et al. 2010; Crann et al. 2017).

Collagen yields of over 2% and C/N ratios of 3.2–3.3 indicate excellent collagen quality (see Table 4 below). The radiocarbon dates all lie in the range 4550–4300 uncal BP. The oldest dates are generally from the lowermost layer (layer 4), although the relationship is not monotonic (Fig. 20).

The straightforward stratigraphy of this feature was translated into a simple age model using OxCal v4.4.4 (Bronk Ramsey 2009) and IntCal20 (Reimer et al. 2020). Firstly, average ages for each context were calculated using OxCal's 'Combine' function, as all samples from the same context pass the Ward and Wilson (1978) test. Afterwards, the dates were arranged in a sequence, with each layer being a phase in the sequence. With an agreement index of 111.3 for the model, the dates concur well with the hypothesis that the sampled material was deposited in chronological order, although the uncalibrated radiocarbon ages do not lie in strict stratigraphical order (Fig. 20). Depositions in feature A4 appear to have taken place during a ca. 200-year period, from around 3150 cal BC to around 2950 cal BC.



Fig. 17. Ginnerup, feature A4. Fragment of harpoon of Kainsbakke type made of antler (Photo: M. C. Dyer/East Jutland Museum).



Fig. 18. Ginnerup, feature A4. Pendant/bead made from a perforated pike (*Esox lucius*) vertebra (Photo: M. C. Dyer/East Jutland Museum).



Fig. 19. Ginnerup, feature A4. Fragment of a scapula (*Bos* sp.) with circular cut-out. Probably left over from the production of bone discs/rings (Photo: M. C. Dyer/East Jutland Museum).

Table 2. Ginnerup site, feature A4. New radiocarbon dates for animal bones with unmodelled and modelled (cf. Fig. 21) ages (calibration with OxCal v4.4.4 [Bronk Ramsey 2009] and IntCal20 [Reimer et al. 2020]).

ID (x-no.)	Layer	Context	Species	¹⁴ C lab no.	¹⁴ C date BP	Unmodelled cal. age BC (95.4%)	Modelled cal. age BC (95.4%)
x1532	7	K1030	<i>O. aries/C. hircus</i>	AA115432	4396 ± 25	3093–2921	2997–2923
x1541	7	K1030	<i>Equus ferus</i>	AA115440	4386 ± 25	3092–2915	2997–2923
x1411	6	K1002	<i>Equus ferus</i>	AA115442	4352 ± 26	3075–2902	3015–2963
x1662	6	K1002	<i>O. aries/C. hircus</i>	AA115441	4336 ± 26	3018–2897	3015–2963
x1231	6	K1002	<i>Bos</i> sp.	AA115434	4325 ± 25	3011–2893	3015–2963
x1251	6	K1039	<i>Bos</i> cf. <i>primigenius</i>	AA115435	4333 ± 26	3016–2896	3018–2957
x1260	6	K1039	<i>Equus ferus</i>	AA115436	4353 ± 25	3073–2903	3018–2957
x1679	5	K1038	<i>Equus ferus</i>	UOC-16832	4409 ± 32	3316–2915	3101–3001
x1607	4	K1037	<i>O. aries/C. hircus</i>	AA115437	4539 ± 25	3366–3103	3230–3101
x1649	4	K1037	<i>Bos</i> sp.	AA115438	4507 ± 25	3352–3099	3230–3101
x1877	4	K1041	<i>Bos</i> sp.	AA115439	4515 ± 25	3356–3101	3246–3091

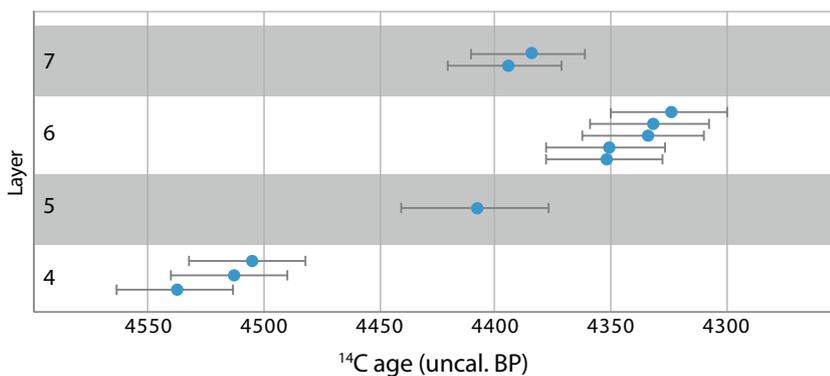


Fig. 20. Ginnerup, feature A4. Radiocarbon dates by layer. The error bars denote the 1 σ uncertainty of the radiocarbon ages (± 25 to ± 32 yr uncal. BP).

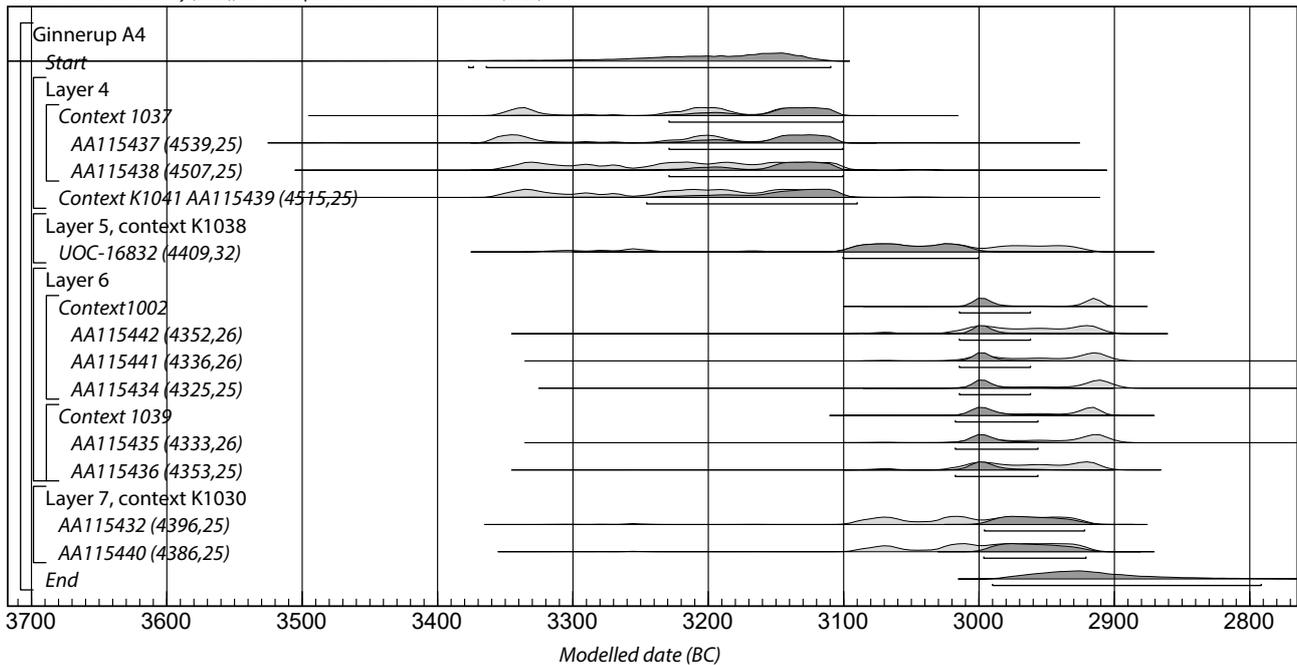
The model helps to improve the precision of many calibrated ages, as can be seen when comparing the unmodelled (light grey) with the modelled (dark grey) probability distributions (Fig. 21). Layer 6, which is dated to ca. 3020–2960 cal BC (95.4%), clearly shows this. For a Stone Age context, this can be regarded as a high-precision date.

There is a relatively sharp decline in the radiocarbon calibration curve at 3100 cal BC, compared to the plateaus and wiggles evident before and after this date. This lets us conclude that layer 4 was deposited before 3100 cal. BC, and the subsequent layers after this date.

Layer 4 was most probably deposited in 3200–3100 cal BC, with the highest probability in the second half of that century. The single date from layer 5 spans the entire next century, 3100–3000 cal BC, as it hits a wiggle on the calibration curve. After the aforementioned layer 6 of shorter duration (3020–2960 cal BC), layer 7 is slightly less well-constrained and is dated to ca. 3000–2920 cal BC.

Previously obtained dates from Ginnerup also generally fall into the interval between 3300 and 2900 cal BC (Philippson et al. 2020). As these samples did not derive from stratified contexts, their dating could not be specified further. They did, however, concur with the hypothesis of two separate occupations at the site, based on archaeological observations from the earlier excavations (Rasmussen 2020). The earlier phase identified in the previous study had been dated to approximately the same time interval as layer 4

OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020)



in A4, while the later phase is contemporaneous with layers 5 to 7 in A4 (Philippesen et al. 2020, 261 fig. 5).

Elemental and stable isotope analyses have been performed at the Simon Fraser University, Canada, and are discussed in detail below. All samples have $\delta^{13}\text{C}$ values that are typical for herbivores with a terrestrial diet. We can therefore exclude the risk of the reservoir effects that could possibly arise from seaweed fodder or similar.

Fig. 21. Ginnerup, feature A4. Age model for the stratified samples, with start and end boundaries.

Zooarchaeological analyses

Thousands of animal bones and bone fragments were collected during the excavation of feature A4 in 2020.

Only mammal and fish bones have been analysed so far (Table 3). The mammal bones are generally well-preserved due to the favourable local geology (boulder clay mixed with a high content of pre-Quaternary chalk) and a significant quantity of mollusc shells in the archaeological deposits. The bones are, however, heavily fragmented, and apart from the teeth, only a few – almost exclusively from the feet (carpals, tarsals and phalanges) – are intact. The large number of fragments partly results from the extensive use of sieving and subsequent sorting of the sieve residues. This has yielded a huge number of small bone splinters that cannot be readily identified with respect to either element or species. The large number of small bone fragments may, however, also indicate traffic (trampling) and other activity on the sediments, as suggested above. Consequently, the number of mammal bones and bone fragments identified to family, genus or species (NISP: 862) is modest (8%). Fish bones (NISP: 1 692) are generally in a better condition with, for example, most of the vertebrae largely complete. Unlike the mammal assemblage, non-diagnostic fish bone fragments have not been quantified. Bird bones are rare (Table 3).

Cutmarks have been identified on 41 bone fragments from a variety of mammal species. Only two bones show characteristic carnivore gnawing marks, which concurs well with the apparent absence of dog bones in the material (Table 3). Evidence of burning was seen on 21 of the fish bones and 433 of the (predominantly unidentified) mammal bones.

Table 3. Ginnerup, feature A4. Number of identified specimens (NISP) per animal species.

	Total	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
Greater weever (<i>Trachinus draco</i>)	1224	1	7	134	1082	–
Righteye flounders (Pleuronectidae)	246	1	7	78	160	–
European eel (<i>Anguilla anguilla</i>)	183	5	9	43	126	–
Trout/salmon (<i>Salmo</i> sp.)	20	–	–	10	10	–
Short-horn sculpin (<i>Myoxocephalus scorpius</i>)	8	–	–	2	6	–
Atlantic herring (<i>Clupea harengus</i>)	5	–	–	–	5	–
Codfish (Gadidae)	2	–	–	–	2	–
Atlantic mackerel (<i>Scomber scombrus</i>)	2	–	–	1	1	–
Carps and minnows (Cyprinidae)	1	–	–	1	–	–
European sea bass (<i>Dicentrarchus labrax</i>)	1	–	1	–	–	–
unidentified birds (Aves)	22	6	5	4	6	1
European mole (<i>Talpa europaea</i>)	1	–	–	–	1	–
European hare (<i>Lepus europaeus</i>)	2	–	–	1	1	–
European red squirrel (<i>Sciurus vulgaris</i>)	2	–	–	1	1	–
European water vole (<i>Arvicola terrestris</i>)	10	–	–	–	10	–
unspec. rodent (Rodentia)	1	–	–	1	–	–
European wildcat (<i>Felis silvestris</i>)	3	–	–	–	3	–
European wildcat? (cf. <i>Felis silvestris</i>)	1	–	–	–	1	–
Pine marten (<i>Martes martes</i>)	1	–	–	1	–	–
European badger? (cf. <i>Meles meles</i>)	1	–	–	–	1?	–
Harp seal (<i>Pagophilus groenlandicus</i>)	1	–	–	1	–	–
unspec. seals (Phocidae)	8	2	2	2	2	–
Brown bear (<i>Ursus arctos</i>)	2	–	–	2	–	–
unspec. carnivore (Carnivora)	1	–	–	–	–	–
Wild horse (<i>Equus ferus</i>)	131	1	3	56	55	12
Roe deer (<i>Capreolus capreolus</i>)	29	1	2	9	15	1
Elk (<i>Alces alces</i>)	6	–	–	4	1	1
Red deer (<i>Cervus elaphus</i>)	29	–	–	11	15	3
Elk/red deer (<i>A. Alces/C. elaphus</i>)	7	–	–	3	4	–
Aurochs (<i>Bos</i> cf. <i>primigenius</i>)	17	1	–	4	9	3
Domestic cattle (<i>Bos</i> cf. <i>taurus</i>)	17	2	1	3	10	1
Aurochs/cattle (<i>Bos</i> sp.)	126	19	15	42	40	8
Bovids/cervids (<i>Bos</i> sp./Cervidae)	34	1	2	16	14	1
Sheep (<i>Ovis aries</i>)	2	1	–	1	–	–
Sheep/goat (<i>O. aries/Capra hircus</i>)	141	11	15	48	63	3
small ruminants (roe deer/sheep/goat)	47	5	1	9	30	2
Wild boar (<i>Sus</i> cf. <i>scrofa</i>)	9	1	–	1	7	–
Domestic pig (<i>Sus</i> cf. <i>domesticus</i>)	10	–	2	3	5	–
unspec. pig (<i>Sus</i> sp.)	223	16	29	55	119	4
Unidentified (Mammalia)	9934	509	594	2262	6170	373
Unclassified bones	13	1	–	–	11	1
Total	12523	584	695	2809	7985	414

The identified bones represent a minimum of 18 mammalian species – 15 wild and three domesticated, and at least ten species of fish (Table 3). Overall, wild mammals are well-represented, including numerous small game and carnivorous species. However, larger herbivorous game animals, such as red deer (*Cervus elaphus*), roe deer and, in particular, horses (*Equus ferus*), dominate alongside domesticated animals (Table 3). A large proportion of the wild mammal species – brown bear (*Ursus arctos*), pine marten (*Martes martes*), badger (*Meles meles*), wildcat (*Felis silvestris*), squirrel (*Sciurus vulgaris*), wild boar (*Sus cf. scrofa*) and elk (*Alces alces*), prefer wooded habitats that provide dense cover. Some of the identified animals – for example red deer, roe deer and aurochs (*Bos cf. primigenius*), however, feed in open areas too, indicating a mixed ecological environment. The presence of open or semi-open land is further indicated by a significant number of bones of wild horse and by the presence of a few bones of European brown hare (*Lepus europaeus*). To these can be added remains of domesticated animals such as sheep (*Ovis aries*) and domesticated cattle (*Bos cf. taurus*). Furthermore, the close vicinity of the sea is evident from the presence of marine mammals, such as harp seal (*Pagophilus groenlandicus*) and marine fish, such as greater weever (*Trachinus draco*), righteye flounders (Pleuronectidae), herring (*Clupea harengus*), codfish (Gadidae), short-horn sculpin (*Myoxocephalus scorpius*), mackerel (*Scomber scombrus*) and sea bass (*Dicentrarchus labrax*). The dominance of greater weever in the fish remains is notable but not unprecedented in Neolithic assemblages from the area (Pleuger/Makarewicz 2020). All in all, the preliminary zooarchaeological analyses suggest the presence of different or mixed ecological habitats with access to both woodland and grasslands, the fjord and possibly the open sea.

There is an apparent trend towards increasing numbers of wild mammal bones from the earliest well-defined cultural layers (layers 4 and 5) to the later, uppermost layers (layers 6 and 7). In the two oldest layers, bones of wild mammal species constitute respectively 30 and 31 % of the bones that can be assigned to either wild or domesticated species, while wild mammals make up more than 60% of the total in the overlying layers 6 and 7 (Fig. 22). In addition, there appears to be a marked increase in the number of fish bones in layers 6 and 7, compared to layers 4 and 5, although with the caveat that more material has been excavated in the upper layers and this picture may change (Table 3). Furthermore, bones of wild animals constitute as much 83 % of the total in the uppermost layer 8. Although of mixed chronological origin (see above), and few in number, the faunal remains from layer 8 therefore underline the apparent increase in the proportion of wild mammals remains relative to those of domesticates through time. As the analyses have so far been restricted to a single feature, and there are a relatively small number of identified bones from each layer (especially layers 4 and 5), we can presently not rule out the possibility that the observed pattern is coincidental. Nevertheless, the increasing numbers of bones of wild relative to domesticated mammals may potentially reflect important chronological dietary and socioeconomic changes during the period under consideration here and should be investigated further in the future.

The importance of marine resources to Neolithic people in Denmark is still a subject of debate, not least because of the scarcity of faunal assemblages containing fish remains. Whether this situation reflects limited exploitation of fish or results from taphonomic and research biases is an open question. The Ginnerup material, with its abundant fish remains, provides a rare opportunity to examine fishing in the Danish Neolithic. Moreover, the remains provide a glimpse into the faunal history of Denmark during the 4th millennium BC.

The numerous fragments of horse bones are of special interest. Although horse bones have been found on other Neolithic sites in Jutland (Enghoff 2011; Kveiborg 2017; Makarewicz/Pleuger 2020; Richter 1991;

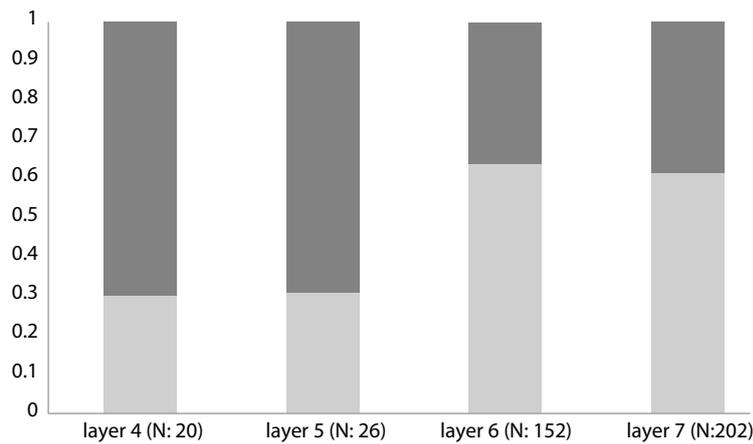


Fig. 22. Ginnerup, feature A4. The relative abundance of bones of wild (light grey) and domesticated (dark grey) mammals per layer. Bones that cannot be assigned to either wild or domesticated species or subspecies have been omitted (Graphics: J. Kveiborg).

Rowley-Conwy 1984), both their number and their relative abundance at Ginnerup are unprecedented. As with the remains of wild mammals in general, the relative abundance of horse bones increases from the oldest layers 4 and 5 to the stratigraphically later layers 6 and 7. Horses make up 2 and 4% of the identified mammal bones in layers 4 and 5, while they constitute 20 and 14%, respectively, in layers 6 and 7.

There is nothing so far to indicate the presence of domesticated horses in Neolithic northern Europe, although the subject has been controversial (Bendrey 2012; Davidsen 1978; Kveiborg 2017, 37–58; Nyegaard 1985; see also Richter 1989, 53; 1991, 113 for the opposing opinion). In the case of Ginnerup, aDNA analysis of bones from the 2001/2003 excavation campaigns has indicated that the horses were wild (Librado et al. 2021, see below). The abundance of horse remains at Ginnerup, relative to the nearby sites of Fanerup, Kainsbakke and Kiral Bro, suggests that the horse was of special importance at Ginnerup. The animal's specific role in the economy and beyond at Ginnerup, and the significance of the finds in both a local and a broader European context, requires further study. The horse bone assemblage at Ginnerup, given its large size, potentially holds an important key to the history of the recovery of wild horse abundance in northern Europe during the Atlantic period and the domestication of the horse.

As demonstrated most recently in the case of the nearby PWC site of Kainsbakke (Klassen et al. 2020, 455–464), the analysis of animal bones from Neolithic sites not only has an obvious potential in relation to economic and environmental studies, but also for an understanding of ritual and cultural traditions and relations. The species represented, the skeletal elements selected for specific treatment and the nature of this treatment can all provide important information. This is obvious too in the case of Ginnerup, with its large number of remains of wild mammalian species, including ritually significant animals such as brown bear and Eurasian elk. Of special interest in this regard is the quantity and frequency of bones of wild horses and the possibly intentional deposition of horse mandibles. The placing of pig scapulae under a stone and the scapula of *Bos* sp. with a cut-out, evoking Mesolithic traditions, further demonstrate the site's potential relative to studies of beliefs and traditions.

Ancient DNA analyses of the horse bone assemblage

Over the past decade, improvements in the molecular and computational techniques employed in ancient DNA research have provided increased sensitivity and resolution in studies of the molecular past (Orlando et al. 2021). While the first complete ancient genome was only sequenced in 2010,

ancient DNA studies now typically include genome-wide sequence information for hundreds of specimens, including those from non-human species such as the horse (Orlando 2020), as well as also other animal (Frantz et al. 2020) and plant domesticates (Kistler et al. 2020). Recent work on horses has completely rewritten the history of horse domestication from its earliest stages (Gaunitz et al. 2018; Librado et al. 2021) to modern times (Fages et al. 2019). While such studies have focused primarily on mapping horse genetic diversity at the global, pan-Eurasian scale, they would not have been possible without the genome sequences collected from many local archaeological sites. These have revealed that horse populations were highly geographically structured prior to domestication and uncovered local horse genetic lineages that became replaced following the expansion of modern domesticates some 4200 years ago (Librado et al. 2021). Preliminary work successfully recovered authentic ancient DNA from all eight specimens analysed from Ginnerup (from the 2001/2003 excavations; partly unpublished). Two of these showed DNA preservation levels compatible with economical whole genome sequencing, thereby indicating a promising potential for future genetic analyses of material from the site. The Ginnerup horses shared genetic affinities with horses excavated at the Corded Ware culture site of Hohler Stein in Germany (Hendel 2012; Noack 2012), thus providing an example of an extinct lineage, which was typical of north-western Europe in the 3rd millennium BC.

Further work at Ginnerup is therefore paramount to characterising the evolutionary history of the horse lineage that once roamed Danish landscapes, both in terms of its origins and its extinction dynamics, as well as in relation to horse populations in other Eurasian regions at this time. Coupled with DNA analysis, the exceptionally rich horse bone assemblage preserved at Ginnerup also provides a unique opportunity to examine at fine resolution patterns that hardly fossilize yet remain key to understanding the nature of underlying human-horse relationships. For example, DNA variation present in individual genomes can inform on sex (Schubert et al. 2017), coat coloration phenotypes (Ludwig et al. 2009), size (Makvandinejad et al. 2012), speed (Bower et al. 2012) and other locomotory characters, such as ambling (Wutke et al. 2016), as well as kinship (Monroy Kuhn et al. 2018), inbreeding (Ringbauer et al. 2021), population size and more. Such DNA-informed prediction, however, requires high-quality data at specific genomic loci, which can only be obtained in a cost-effective manner by using capture technologies. Ongoing work therefore aims to screen the entire assemblage of horse bones at Ginnerup to identify those specimens showing sufficient DNA preservation for genome characterisation and phenotype prediction. The latter will facilitate the new capture technology recently developed by Orlando's research group within the framework of the ERC PEGASUS project, which targets ~200,000 genomic loci aimed at ancestry and kinship profiling, as well as phenotype prediction. Ancestry, kinship and phenotype mapping across the entire Ginnerup site will aid understanding of the nature of the assemblage, as hunting and herding management strategies do not target the same animal characteristics. Future work will therefore not only advance current models of horse evolution but also help in understanding the repertoire of human activities developed by TRB/PWC people at the site.

Isotope analyses

As part of the radiocarbon dating procedure, bone samples selected for potential ¹⁴C dating were first tested for collagen preservation via collagen extraction and isotope measurements at the Archaeology Isotope Laboratory in the Department of Archaeology, Simon Fraser University, Canada.

Sample preparation consisted of taking approximately 200 mg from each bone sample and then extracting collagen by methods outlined by M. P. Richards and R. E. M. Hedges (1999), with an additional ultrafiltration step (Brown et al. 1988). The extracted collagen was then analysed for carbon, nitrogen and sulphur isotopes using a Thermo Flash elemental analyser and Thermo Delta V mass spectrometer in the Archaeology Isotope lab.

Collagen extraction was undertaken for a total of 24 bone samples and the results of the extraction and subsequent isotope analyses are presented in Table 4. Most of these samples ($n=20$) yielded well-preserved collagen, with only a small number ($n=4$) having very low collagen yields or no collagen preserved. The collagen preservation criteria (C:N and C:S ratios, yields, %C, %N, %S) are included in Table 4. Measurement errors (1σ) for the isotope analyses are $\delta^{13}\text{C} = \pm 0.1\text{‰}$, $\delta^{15}\text{N} = \pm 0.2\text{‰}$, and $\delta^{34}\text{S} = \pm 0.5\text{‰}$.

Of the 24 samples we prepared for collagen extraction, 12 were then selected for radiocarbon dating, and entire bone samples were sent to the two radiocarbon labs for sample preparation and dating (see above).

We have carbon, nitrogen and sulphur isotope data for 20 faunal samples, all from terrestrial mammals from the site. These include seven cattle (*Bos* sp.), two roe deer, one red deer, five wild horse, and five sheep/goat (species identification by J. Kveiborg) (Table 4). Of the cattle, two were further identified as wild cattle (*Bos primigenius*) and one as domesticated (*Bos taurus*). The carbon and nitrogen isotope data are plotted on Figure 22, and the carbon and sulphur isotope data are plotted on Figure 23.

As the analyses were all undertaken on bones of terrestrial animals, and Denmark is a region with mainly C3 plants, the $\delta^{13}\text{C}$ values for the fauna all fall within the expected range for collagen from C3 consumers in prehistoric Denmark, clustering around -22‰ (Fischer et al. 2007). Interestingly, the two roe deer and one red deer have the most depleted (negative) $\delta^{13}\text{C}$ values, closer to -23‰ . There is some evidence that $\delta^{13}\text{C}$ values for fauna from closed forest canopies are more negative (Van der Merwe/Medina 1991), so this may explain the values obtained for these deer. However, as can be seen in Figure 22, one of the cattle and one sheep/goat also have these more negative $\delta^{13}\text{C}$ values, so the pattern is unclear. Indeed, there is a rather wide range of $\delta^{13}\text{C}$ values, with some cattle and horse specimens having $\delta^{13}\text{C}$ values closer to -21‰ , which could indicate that the animals were grazing in more open environments.

The $\delta^{15}\text{N}$ values for most of the fauna are also as we would expect from a temperate C3 environment, with these herbivores plotting around 5 or 6‰, which is a commonly observed $\delta^{15}\text{N}$ value for terrestrial herbivores at prehistoric sites in northern Europe (Richards/Hedges 2003; Hedges et al. 2004). What is somewhat unusual are the low $\delta^{15}\text{N}$ values for the five wild horses, which have values closer to 3‰. Horse $\delta^{15}\text{N}$ values do appear to be a sensitive indicator of climate (Richards et al. 2017) and when measured together with other herbivores from the same site, it has been observed that they are lower than those of other herbivores (Stevens et al. 2010). This may be a result of these horses grazing in different areas to the cattle and sheep/goat, where plants had lower $\delta^{15}\text{N}$ values or, indeed, of horses selecting different plants than the other herbivores, specifically those with lower $\delta^{15}\text{N}$ values. Further analyses of bones of horses and contemporaneous herbivores from this site, and other Danish Neolithic sites, will help us understand whether this was a common occurrence.

We were also able to measure the $\delta^{34}\text{S}$ values of these fauna, and these data (compared to the $\delta^{13}\text{C}$ values) are plotted on Figure 23. Relatively few faunal $\delta^{34}\text{S}$ values are available from this time in northern Europe, and especially in Denmark, and these are among the first reported data for Danish Neolithic sites. Sulphur isotopes are both an indicator of diet and of mobility, as they can be used to identify food source locations (Nehlich 2015).

Table 4. Ginnerup, feature A4. Isotope analyses and collagen preservation criteria for faunal samples.

Lab. no. (S-SFU)	ID (x-no.)	Context/layer	Species	Element	%yield	^{13}C	^{15}N	^{34}S	%C	%N	%S	C:N	C:S
2598	x1134	K1030/layer 7	<i>Bos cf. primigenius</i>	humerus	0.0	–	–	–	–	–	–	–	–
2604	x1251	K1039/layer 6	<i>Bos cf. primigenius</i>	calcaneus	3.9	-22.4	4.6	12.2	24.8	8.9	0.2	3.2	437.7
2619	x1408	K1037/layer 4	<i>Bos cf. primigenius</i>	metacarpus	2.0	-21.3	4.8	14.9	38.8	13.6	0.2	3.3	549.0
2612	x1196	K1002/layer 6	<i>Bos cf. taurus</i>	phalanx 1	2.4	-22.4	6.4	14.0	28.9	10.0	0.1	3.4	537.8
2621	x1608	K1037/layer 4	<i>Bos cf. taurus</i>	ulna	0.4	–	–	–	–	–	–	–	–
2601	x1231	K1002/layer 6	<i>Bos sp.</i>	calcaneus	5.4	-21.9	4.1	13.9	28.6	10.3	0.2	3.2	493.6
2607	x1649	K1037/layer 4	<i>Bos sp.</i>	calcaneus	4.3	-22.7	4.4	14.5	32.4	11.9	0.1	3.2	584.4
2608	x1877	K1041/layer 4	<i>Bos sp.</i>	scapula	3.5	-21.7	5.7	12.6	28.0	10.1	0.1	3.2	561.4
2609	x1532	K1030/layer 7	<i>Bos sp.</i>	sesamoidea	0.0	–	–	–	–	–	–	–	–
2616	x1309	K1040/layer 5	<i>Bos sp.</i>	humerus	9.3	-21.5	5.0	15.4	37.2	13.4	0.2	3.2	557.1
2600	x1537	K1030/layer 7	<i>Capreolus capreolus</i>	metatarsus	2.9	-23.1	4.8	14.5	29.9	10.6	0.2	3.3	491.1
2620	x1594	K1037/layer 4	<i>Capreolus capreolus</i>	metapodia	3.2	-22.8	5.7	8.1	25.1	8.6	0.1	3.4	561.6
2610	x1553	K1030/layer 7	<i>Cervus elaphus</i>	metatarsus	2.9	-22.7	4.7	13.3	26.1	9.3	0.1	3.3	511.1
2602	x1385	K1002/layer 6	<i>Equus ferus</i>	mandibula	0.5	–	–	–	–	–	–	–	–
2605	x1260	K1039/layer 6	<i>Equus ferus</i>	mandibula	4.4	-22.4	3.4	12.7	26.5	9.3	0.1	3.3	514.1
2611	x1541	K1030/layer 7	<i>Equus ferus</i>	metacarpus	4.1	-21.5	3.1	14.1	31.0	11.1	0.1	3.3	658.5
2613	x1411	K1002/layer 6	<i>Equus ferus</i>	mandibula	5.9	-22.0	3.2	13.8	30.9	10.9	0.1	3.3	570.8
2615	x1251	K1039/layer 6	<i>Equus ferus</i>	coxae	3.6	-21.6	3.0	13.9	29.8	10.7	0.1	3.3	589.6
2618	x1679	K1038/layer 5	<i>Equus ferus</i>	mandibula	2.4	-21.5	3.1	13.1	26.7	9.4	0.1	3.3	565.6
2599	x1532	K1030/layer 7	<i>O. aries/C. hircus</i>	radius	2.8	-21.9	4.7	15.1	34.6	12.3	0.2	3.3	488.1
2603	x1567	K1002/layer 6	<i>O. aries/C. hircus</i>	radius	1.4	-22.4	6.4	10.8	23.2	8.1	0.2	3.3	300.9
2606	x1607	K1037/layer 4	<i>O. aries/C. hircus</i>	radius	3.2	-22.3	6.7	11.5	22.5	8.0	0.1	3.3	462.5
2614	x1662	K1002/layer 6	<i>O. aries/C. hircus</i>	radius	2.4	-22.6	5.7	14.4	29.0	10.3	0.1	3.3	541.8
2617	x1367	K1038/layer 5	<i>O. aries/C. hircus</i>	metatarsus	4.9	-22.2	7.1	14.1	30.7	10.7	0.2	3.3	492.7

In coastal areas where there is significant rainfall, soil, plant and animal $\delta^{34}\text{S}$ values are often elevated due to incorporation of marine sulphur (from sea spray and rainfall), which may have a higher $\delta^{34}\text{S}$ value than sulphur from more inland locations (sulphur derived from bedrock). Here we can see that most of the fauna does indeed have relatively high $\delta^{34}\text{S}$ values, around 14 ‰ (compared to marine organisms that often have $\delta^{34}\text{S}$ values closer to 18 ‰). This makes sense, given the location of the Ginnerup site close to the coast, and indicates that most of these animals were likely obtained locally, or from a region with similar $\delta^{34}\text{S}$ values. One animal does, however, stand out markedly: A roe deer has a $\delta^{34}\text{S}$ value of 8.1 ‰, meaning it was probably brought to the site from outside the local region, from an area much further inland than Ginnerup.

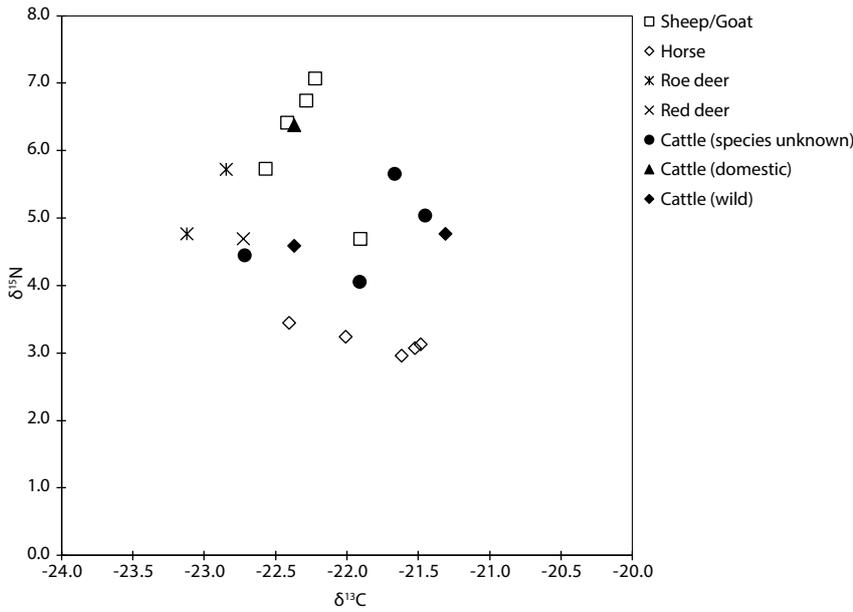


Fig. 23. Ginnerup, feature A4. Carbon and nitrogen isotope values for fauna (Graphics: M. Richards).

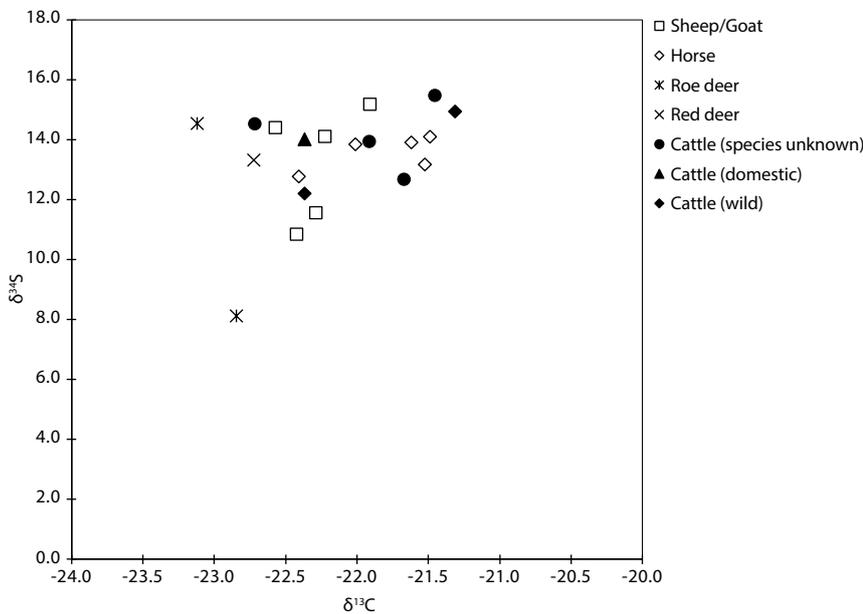


Fig. 24. Ginnerup, feature A4. Carbon and sulphur isotope values for fauna (Graphics: M. Richards).

These isotope data constitute the results of the first pilot study of the faunal remains from the site. They show that most of the fauna have the isotope values we might expect, i.e. similar to those for fauna from other Danish and northern European Neolithic sites. It is, however, evident that the horses have lower $\delta^{15}\text{N}$ values than the other herbivores, something that may be unique to the region at this time. There is also evidence of imported fauna being deposited at the site, given the anomalous $\delta^{34}\text{S}$ value for one of the roe deer. The isotope study will be significantly expanded as the project progresses, building up a more comprehensive database of faunal values, and with a particular focus on the horses to explore their anomalously low $\delta^{15}\text{N}$ values. As we obtain further $\delta^{34}\text{S}$ measurements, it will also be possible to discover whether there is further evidence for the importation of animals into the site. As the work develops, we may also be able to supplement these data with oxygen and strontium analyses of teeth to provide a better understanding of where these animals were living before they were deposited at the Ginnerup site.

Plant macro-remains

The archaeobotanical screening of soil samples from layers 4–7 in feature A4 revealed the presence of charred cereal grains in all cases; most abundantly in layers 6 and 7. No detailed analyses have yet been carried out, but barley (*Hordeum vulgare*) and naked barley (*Hordeum vulgare* var. *nudum*) were seen to predominate. Wheat (*Triticum* sp.), emmer/spelt (*Triticum turgidum* ssp. *dicoccon/aestivum* ssp. *spelta*) and bread wheat/durum wheat (*Triticum aestivum* ssp. *aestivum/turgidum* ssp. *durum*) have also been identified, but in smaller quantities. Fragments of hazelnut (*Corylus avellana*) shells and a seed of wild apple (*Malus sylvestris*) attest to gathering of plant resources.

Even though the archaeobotanical study still is at a preliminary stage it is noteworthy that the latest, uppermost layers in pit A4, hosting elements from the early PWC, contained abundant cereal remains. In contrast, the slightly later PWC deposits at the nearby Kainsbakke and Kirial Bro sites yielded only few traces of arable agriculture (Andreasen 2020). The Ginnerup site therefore has great potential to expand our knowledge of the plant-based economy at the transition from the TRB to the PWC.

Discussion: The character of A4 and the activities associated with it

The location of A4 within a natural feature, traces of flint knapping and food processing as well as the regular, undisturbed stratigraphy immediately remind of a regular settlement feature. However, a number of observations raise doubts regarding this straightforward interpretation. These observations comprise the nature of the shell deposits, the visibility of A4 from the surrounding landscape, its relation to certain or possible enclosure ditches on the site as well as possibly conscious depositions of select animal remains.

Depositions of shells are common on Neolithic coastal sites in South Scandinavia, often forming shell middens showing continuity from the Late Mesolithic Ertebølle culture (Andersen, S. H. 2000). However, these middens are always located directly on the ancient coastline. Such shell middens are also known from the immediate vicinity of the Ginnerup site (no. 2 and 3 on Fig. 2). The shell deposits in A4 have a clearly divergent character. They are found several metres above the shoreline on top of a coastal cliff and they seemingly constitute deposits of comparatively regular thickness across larger areas. This possibly indicates a conscious “laying-out” of shells as contrasted to proper shell dumps typical of shoreline middens. Furthermore, as noted above, observations on the individual shells themselves indicate that at least part of them may not constitute discarded waste from meals (as typical for proper shell middens). Shell deposits comparable to those observed in feature A4 are known from a number of causewayed enclosures and isolated ditch segments of ritual nature. This is true for two other features (A1 and A3) at Ginnerup and for the nearby Kainsbakke site (Wincentz 2020, 44–56), as well as other sites, especially on Djursland, but also in other parts of Denmark (Klassen/Klein 2014, 315; Klassen/Knoche 2019, 88 fig. 6). These shell deposits probably constitute a “whitening” of surfaces in connection to ritual activity (Klassen/Knoche 2019, 89).

Ditch segments A1 and A3 at Ginnerup both face the prominent northern ravine. Not many years ago, a dirt road ran through the ravine, demonstrating the most plausible access route leading from the coast to the plateau in the Neolithic. This path may have determined the location of the ditch segments, which could therefore have been positioned for maximum visibility. The importance of this aspect in the construction of enclosures located on sloping ground has been discussed previously (Smith 1965, 19; 1971, 21;

Andersen, N.H. 1997, 282; Oswald et al. 2001, 104). In this respect, the use of marine shells as white markers in the fill of ditch segments makes perfect sense. A historical map from 1877 (Danish høje målebordsblade) shows a footpath leading from the valley bottom below the cliff, through the ravine in which A4 is located and further on across the plateau in a northwesterly direction (Fig. 3). While the slope is too steep today to be passable on foot (due to recent road construction), the situation was probably different in the Neolithic. A4 could therefore have been a ritual feature comparable to A1 and A3, and positioned using the same parameters of proximity to, and visibility from, an access path. Due to its location on sloping ground adjacent to the coastal cliff, the exposed shell deposits in A4 would have been clearly visible from far away when arriving by boat on Kolindsund.

The precise nature of the deposition of mandibles of wild horses found in A4 is not yet clarified and may reflect simple depositions of waste. It does, however, remind of the ritual depositions of mandibles of other species at the nearby Kainsbakke site (Wincentz 2020, 49 fig. 15). The scapulae of pigs and roe deer found below stones more clearly indicate that ritual depositions of select faunal elements have taken place in A4.

The archaeological evidence relating to function thus is ambiguous in A4. On one hand, we have indications of ordinary secular activities such as flint-knapping and food processing – even though at least the latter could have been carried out in a ritual context, too. On the other hand, the entire setting, its position and visibility in the landscape, as well as the possibly intentional arrangement of certain faunal remains on the shell layers, points toward a more complex function involving ritualised behaviour and doubtless close links to the contemporaneous ditch segments A1 and A3, and the enclosure-related site as a whole. Not least the numerous parallels to the ritual pit/ditch segment A47 at the Kainsbakke site are striking in this regard. No good parallels encompassing all characteristics of feature Ginnerup A4 are known. It may represent the first observed integration of a natural feature into a system of anthropogenic structures as part of an enclosure-related construction.

Given its distinct cultural setting, Djursland offers a unique opportunity to study the TRB-PWC transition at the turn of the 3rd millennium BC. The peninsula is rich in TRB sites of all kinds spanning the period from the earliest Neolithic to the Middle Neolithic Blandbjerg phase (MN A II), ending around 3000 BC. The elements related to the Bundsø-Lindø/late Ferslev phases (the conjoined MN A III/IV), recorded during the recent excavations at Ginnerup (flint axes and decorative elements on the pottery), indicate that the late TRB material from the site relates to the transitional stage MN A II–MN A III/IV. However, the final TRB period, the Store Valby phase (MN A V), is largely absent on Djursland. Instead, there are PWC sites dating from ca. 3000–2700 BC (Philippson et al. 2020, 275; Sørensen 1995). With its transitional character encompassing an initial PWC stage, Ginnerup is a key site for understanding the transformation from the TRB to the PWC. Furthermore, Ginnerup forms part of a series of certain or presumed ritual sites in the area that were in use at different points in time during the TRB-PWC transition. The Fannerup site located ca. 2 km west of Ginnerup (presumed ritual site with finds dominated by classical MN A II material: Eriksen 1984), is the oldest followed by Ginnerup (TRB MN A II/III material with Ferslev elements and early PWC) and Kainsbakke (classical PWC: Wincentz 2020), ca. 3 km to the northeast of Ginnerup. The three sites form a 'horizontal stratigraphy' indicating the frequent relocation of a regional site of ritual importance in course of the TRB-PWC transition (cf. Fig. 2).

Conclusion: The Ginnerup site's potential and perspective relative to cultural history and current agendas

As is apparent from this preliminary presentation of the results of the new excavations and first stratigraphical analyses and investigations of the finds from feature A4, the Ginnerup site holds a huge potential for scientific advances in a whole range of fields. This is due to the excellent conditions of preservation for organic materials, combined with the extraordinary resolution of the well-dated stratigraphy, covering the development from the late, classical TRB (MN A Ib) to the earliest PWC over a period of approximately 200 years, which is represented by four distinct layers. This stratigraphy is unmatched at any other site in South Scandinavia, and the Ginnerup site is therefore both central and crucial to an understanding of the emergence of the PWC on Djursland. It holds a key position in elucidating the transition from the classical stage of the TRB (EN II–MN A I), through the transitional MN A II phase to a number of regional groups (PWC and several divergent, regional expressions commonly classified as Late TRB or MN A V) across large parts of southern Scandinavia and north-central Europe. This transition encompassed fundamental changes in all aspects of life of the Neolithic groups involved: settlement, economy, social organisation and ritual expressions, the historical importance of which is yet to be adequately recognised in Neolithic research (Johannsen et al. 2016). Further excavations and analyses at the Ginnerup site have, therefore, the potential to make a substantial contribution to our understanding of the processes that led to the transformation of the uniform, genuine southern Scandinavian expression of TRB groups relying heavily on food production, into regional expressions partly drawing on external cultural developments and a partial return to Mesolithic economic strategies – not only in the PWC, but also in at least some of the Late TRB groups (e.g. Jensen et al. 2018; Schmölcke 2000; 2001).

The large numbers of bones of wild horse recovered from Ginnerup deserve additional comment when discussing the potential of the Ginnerup site. These remains not only allow new chapters to be written on the zoology and genetics of the last wild horses in Denmark but for hitherto unknown aspects of the human-horse relationship in the Neolithic to be uncovered. Data derived from analyses of these horse bones and the natural environment around Ginnerup, as revealed by zoological and stable isotope analyses as well as future pollen analyses from two nearby localities, also have enormous potential relative to informing and qualifying human actions in response to present-day challenges, more precisely the current biodiversity crisis. One of many approaches to counteract this crisis are much debated rewilding projects in Denmark and Europe as a whole, in which horses play a key role (Köhler et al. 2016; Linnartz/Meissner 2014; Grønne et al. 2016). It is documented that feral and semi-feral horses may prevent succession towards closed woody vegetation in natural areas and thereby help supporting a more diverse flora and fauna including numerous rare and endangered species. Feral horses further enhance biological diversity through effects such as their dispersal of seeds and their provisioning of dung for numerous dung-dependent insects and fungi. It is, however, still incompletely known how the ecology of these horse-curated open landscapes relates to those of the past, much less degraded ecosystems. The Ginnerup horses offer the opportunity to answer this question for the first time in Scandinavia by comparing feeding habits and ecological effects of modern feral horses in current rewilding projects with data on the same aspects as derived from the investigation of bones from and paleoenvironmental studies on and around the Ginnerup site. A pilot study at "BIOCHANGE – Center For Biodiversity Dynamics In A Changing World" at Aarhus University in collaboration with Moesgaard Museum and East Jutland Museum is currently ongoing. By following this path, the Ginnerup-investigations are also part of

an ongoing trend in using data from the past to shape a better Anthropocene (Boivin/Crowther 2021; Swanson et al. 2021).

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