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Reviewed Article:

An Experimental Investigation of Alternative Neolithic Harvesting Tools

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Harvesting tools have seldom been found during excavations at Neolithic sites in North-Western Europe but cereal consumption was widely practiced in that region, as grain discovered in settlements showed. Several researchers have, over the last 50 years, highlighted this discrepancy between missing harvesting tools and the presence of cereal grains. They have tried to explain that cereals had therefore to be collected either with the help of bare hands or with tools made from other materials than flint. The aim of this paper is to present, through experimental archaeology and the analysis of use-wear traces, that tools made from organic material such as shell, wood and bone could have been used to harvest cereal plants. To achieve this aim, a large variety of experimental tools have been created and tested on fields of typical cereal types of the Neolithic, such as *Triticum monococcum* or einkorn wheat, *Triticum dicoccum* or emmer wheat, *Triticum aestivum* or naked wheat, and Hordeum vulgare or barley. The result of these experiments has been analysed quantitatively with regards to the achieved harvested surface, grain yield, and harvesting speed. Also, the use-wear traces on these tools as polish, striations, edge rounding, and edge damages created by these different cereal plants have been studied. The results could serve as reference to interpret unusual archaeological material differently in the future.

> Harvesting done with tools made from alternative materials such as shells, wood or bone can thus result in a similar grain yield and speed as tools with flint inserts. If, as in this case, there are almost no differences in reaping cereals with shell or flint inserts, could both materials have been used?

Methodology

26 different harvesting tools have been made for this experiment. These were shell inserted sickles, wooden sickles, deer mandibles, cattle ribs, and bare shells. The design of these tools has been developed according to the few archaeological traces found of such harvesting tools.

Shell inserted sickle

These follow the design of entire hafted sickles with flint inserts discovered at the early Neolithic site in Karanovo, Bulgaria (Gurova, 2016) and at the underwater site of La Marmotta in Italy (Mazzucco, *et al.*, 2022). They consist of a curved, wooden frame with four to seven flint inserts placed at a 45°angle into a grove. Also, sickle inserts with a similar angular gloss made from flint have been identified in LBK and Rössen sites in North-Western Europe (Bakels, 2009; Bakels and van Gijn, 2015). These composite tools with a denticulated edge appeared to be widespread in the Early and Middle Neolithic in North-Western Europe.

The shell types for the inserts of these experimental sickles were chosen according to their potential availability during the Neolithic. The first shell type elected was the flat oyster type (*Ostrea edulis*), which is still grown on the Dutch coast. Fresh, entire oyster shells of that type were taken for the experiment. These were broken into pieces and attached with spruce pitch into the wooden handle. The edges of the oyster shell were not retouched (See Figure 1).

The second shell type selected was the freshwater mussel (*Unio crassus*). It was and still is native to the rivers of North-Western Europe and can easily be collected and transformed into inserts. Archaeologically, a late Neolithic cereal harvesting knife has been found made from such a freshwater mussel (Pétrequin, et al., 2006). For the experimental tool, the shells were broken into halves and the sharp and thinner edges placed at a 45°angle into the wooden frame. The cutting edge of all inserts has been retouched to improve its sharpness (See Figure 2).

Wooden sickle

These sickles follow closely the shape of an archaeological tool found at the site of La Draga, Girona, Spain. This site, dating to the 6th millennium BC (Bosch Lloret, 2006), yielded many wooden tools preserved in a wet environment. One of these items, made of oak (*Quercus sp caducifoli*), has been classified as a sickle used for cutting reed and cereals (Terradas, et al., 2017). So far, it is the only discovered wooden tool believed to have been used to gather cereals. The experimental tools were accordingly 30 cm long, 14 cm wide and 2 cm thick and made of oak wood. They have a long handle to grasp the sickle comfortably and a curved cutting edge . The cutting-edge ends in a point, where cereal stems can be gathered (See Figure 3).

Deer mandible

In 1964 J.A. Brown published an article on the use of deer mandibles as harvesting tools by native North Americans to collect plants, especially grass to roof their houses (Brown, 1964). During experiments, Brown could demonstrate that the use-wear traces left on such mandibles resembled the traces found on archaeological finds. Based on this information, deer mandibles were included in the experimental tools. The tools were between 33.5 cm to 34.5 cm long, 6cm to 7 cm wide and up to 2 cm thick. The teeth were used as they were for reaping (See Figure 4).

Cattle rib

Archaeological traces of a bone implement such as cattle ribs used for cereal harvesting have not been encountered in the literature. Still, as this thesis focuses on potential organic materials used for reaping, it was judged interesting to find out if a tool made from bone could be effective. Bone tools are known to have been widely used in the Neolithic such as needles, awls, or points (Lüning,1968; Vermeersch and Burnez-Lanotte, 1998). Could a bone tool with a flat shape such as a rib therefore have been used for reaping? For that hypothesis, long cattle ribs were collected, and their edges sharpened to increase their effectiveness. These ribs were between 34 cm and 38 cm long, 6 cm to 3 cm wide and 1.5 cm to 2 cm thick (See Figure 5).

Shells as handheld devices

Small, handheld harvesting tools made from flint have been found in archaeological contexts, at neolithic lake-site villages of Southern Germany (Schlichtherle, 1992). These tools were made from a single flint blade covered on one side with pitch tar and placed into a straight wooden frame. Also, in a simpler format, they were just a single blade covered unilaterally with tar and textile or bark. This cover is believed to protect the harvester's hand while the flint blade is used to snap off cereal ears (Anderson, 1999). Another archaeological example of a handheld device is a freshwater mussel shell with a dented cutting edge and two holes in its shell. It is believed to have been used in the late Neolithic as a harvesting knife (Pétrequin, et al., 2006).

Based on these examples, eight shells (four freshwater mussels and four oysters) were employed as harvesting knives. For the hand-held oyster shells, two tools were made of entire shells and two were fragments of one larger shell. The entire shells were between 8 cm and 8.5 cm long, 6.5 cm wide, and up to 4 mm thick. The oyster fragments were between 6 cm and 6.5 cm long, 5 cm to 5.5 cm wide and 3 to 5 mm thick. The oysters are of the flat, Dutch type *Ostrea edulis* (See Figure 6).

For the hand-held freshwater mussel, the entire shells were used. They have the following size: Length: 6.5 cm to 7.5 cm, width: 3.5 cm to 4 cm and thickness up to 1 mm (See Figure 7).

The dorsal sides of all oyster and mussel shells were covered with pitch to avoid hurting the harvester's hand while reaping. The sharp, ventral part was left as originally found.

Harvesting locations

The reaping was done in two locations in South-Western Germany during the month of July 2022. The first site was in the city of Lorsch, at the UNESCO world heritage site of a Carolingian monastery dating from the 9th century AD. There at the "*Lauresham*" open-air museum, fields 100 m long, 6 m wide and with a 60 cm high ridge in the middle have been planted with *Triticum aestivum,* or naked wheat in an organic method (Kropp, 2022). As no pesticides or herbicides were used, grass and invasive weeds as the thistle or the blueweed were present. Also, *Triticum dicoccum* or emmer wheat could be gathered at "*Lauresham*", but it was planted in a conventional way with the use of herbicide and pesticides.

The second location was at the University of Hohenheim in Stuttgart, Germany. This university specialises in agricultural sciences, and has extensive fields, where a large variety of cereals are planted, tested, combined, and improved. *Hordeum vulgare* or barley, and *Triticum monococcum* or einkorn wheat were reaped there. All cereals were planted conventionally with the use of pesticides and fungicides.

Quantitative harvest calculations

During the harvest, the size of the collected area was measured in m². Once the reaping time of three times one hour per tool was achieved, the length of the harvested area was measured and multiplied by the width of the strip.

The grain yield has also been calculated: The total yield of the reaped fields has been obtained from the person in charge at Lauresham and Hohenheim. This yield is indicated in t/ha, meaning ton over one hectare or 1000 kg over 10,000 m² of surface. In the case of this experiment the yield for organically grown *Triticum aestivum* at Lauresham was 8.3 t/ha (Dorn et al., 2023). The field of *Hordeum vulgare* (Streck, 2023) had a grain yield of 5.5 t/ha and *Triticum monococcum* of 5.8 t/ha (Rrecaj, 2023*)*. For *Triticum dicoccum* the grain yield of the field at Lauresham could not be obtained. Therefore, the grain yield of 7.9 t/ha (Rrecaj, 2023*)* from the field at the Heidfeldhof has been used. As both fields were planted conventionally and had a sandy soil composition, it was assumed that they had a similar yield.

To compute the grain yield of the reaped surface, the following calculation was done: the yield was converted from t/ha to kg/m². Then it was calculated based on the harvested surface. While 19m² of *Triticum aestivum* was gathered during the first hour of harvest with a hafted sickle with oyster shell inserts, this would result in close to 16 kg of grain reaped (19 m² x 0.83 kg = 15.77 kg).

The harvesting speed has also been computed. For that, the surface (in m²) was divided through the minutes spent reaping (usually 60 min.). This results in a m²/min. figure, which could be compared to the different cereals and tools. As an estimated 1/3 of the reaping time has been used to transport the stems to the border of the field, it had to be added to the recorded reaping time. This made the results comparable to other cereal harvesting experiments.

Use-wear analysis

Before and after the harvest, all reaping tools were analysed under a stereo microscope. For that, a Leica M 80 instruction microscope was used. The microscope was connected to a Leica MC 120 HD camera to provide a digital picture. The pictures were taken at three magnifications (7.5x, 25x and 60x) with a scale bar of 2 mm (for 7.5x), 1 mm (for 25x) and 500 µm (for 60x). Also, a metallographic microscope was used to analyse the different tools at higher magnifications. For that, a Leica DM 2700 M metallographic microscope together with a digital camera Leica MC170 HD was employed. Pictures were made with two magnifications (100x and 200x) and saved with a 200 µm (for 100x) and a 100 µm (for 200x) scale bar.

Cereal Harvesting Results

Triticum aestivum

Triticum aestivum, was collected with nine different tools. The hafted sickles with oyster or mussel shell inserts and the wooden sickle achieved the best results with at least 29 m² surface reaped within three hours. With the deer mandible, it was possible to harvest 9 m² within one hour. This means an extrapolated 27 m² reaped within three hours. The uprooting of stems contributed to 5 m² of harvested surface or computed 15 m² for three hours. With the hand-held oyster and mussel shells and by hand not even 5 m² could be collected within 3 hours. The worse results were recorded with the cattle rib. Reaping had to be stopped after a few minutes, as the tool became blunt very fast and did not cut through the stems after that (See Figure 8).

In terms of grain yield, the best result could be achieved with the hafted sickle with oyster shell inserts. More than 15 kg of *Triticum aestivum* could be collected within one hour. This yield drops sharply to 10 kg and 8 kg during the following two hours since the sickle lost two inserts. Other tools like the wooden sickle or the hafted sickle with mussel shell inserts only achieved a yield of close to 10 kg per hour. Worse are the hand-held oyster and mussel shells with a yield of less than 1.5 kg per hour. Snapping off ears by hand resulted in 2 kg of yield per hour, which was a better result than with hand-held shell tools (See Figure 9).

Triticum dicoccum

Triticum dicoccum was the cereal which could be harvested the easiest and fastest of all tested types of grain. Out of the nine tested tools, four of them resulted in at least 47 m² of cereals collected after three hours. Even uprooting, although only tested for one hour, could achieve as much as a hafted sickle with shell inserts, or a wooden sickle. The mandible also yielded more than 10m² of harvested surface after one hour. Cattle rib, as already seen with *Triticum aestivum,* didnot cut through the stems of *Triticum dicoccum*. The cutting edges became blunt very fast and resulted only in, after a lot of hacking, uprooting the stems. As such, reaping with this tool proved impossible and the trial had to be abandoned. Snapping off ears with shells also yielded good results, although far less in comparison when sickles were used (See Figure 10).

The grain yield of *Triticum dicoccum* was reported with 7.9 t per hectare slightly lower than the above *Triticum aestivum*. Reaping with a hafted sickle with oyster shell inserts resulted in a maximum of 14.77 kg of grain harvested per hour. With a wooden sickle or a deer mandible, around 10 kg of grain could be collected per hour. Handheld tools resulted in around 2-4 kg of reaped grain (See Figure 11). However, this grain consisted only of ears, making it easier to use at a later stage.

Hordeum vulgare

Hordeum vulgare was collected with seven different tools. Also, here the sickles (shell and wood) were the most effective with more than 30m² of surface harvested after three hours. Uprooting and the deer mandible also proved to be suitable for reaping substantial surfaces. However, the cattle rib proved unsuitable, and the harvest was abandoned after a few minutes. Surprisingly, snapping off ears was quite successful with close to 8 m² reaped with the hand-held oyster and mussel shells. This is a better result than for *Triticum aestivum*, although the reaping was more difficult due to the low height of the plant (See Figure 12).

The grain yield for *Hordeum vulgare* is significantly lower than compared to *Triticum aestivum* and *Triticum dicoccum*. As such, the harvest with a hafted sickle with mussel shell inserts resulted in a yield of only 7 kg of grain per hour, about half compared to the same tool with *Triticum dicoccum*. With hand-held shell tools, it was possible to collect close to 1.5 kg of cereals (See Figure 13).

Triticum monococcum

Surprisingly, uprooting appears to be the best harvesting method for *Triticum monococcum*. Extrapolating the $10m^2$ of uprooted surface after one hour, would mean about $30m^2$ reaped in three hours. This is better than the results obtained with any of the other tools for this cereal type. This could be because the roots can be easily extracted as the soil is sandy and loose and no grass and weeds are present. The plant is also very high and can be easily grasped. In contrast, the wooden sickle is not very effective as it cannot cut or saw through the stems. Even a chopping motion does not separate the stems from the roots. Also, the hand-held shell tools are the least effective tools with no more than $1.2m^2$ collected within one hour (See Figure 14).

The grain yield achieved by each tool for *Triticum monococcum* is among the lowest of all tested cereals. It reaches close to 6 kg of grain per hour by means of uprooting or with a hafted sickle with mussel shell inserts. With the deer mandible, a maximum of 4 kg can be collected. The use of handheld shell tools results in less than 1 kg of grain collected per hour. This is due to a combination of a low yield and a small, reaped surface (See Figure 15).

Conclusion of quantitative harvesting results

The best performing tool type in this experiment was the hafted sickle with oyster shell inserts followed by the hafted sickle with mussel shell inserts, the wooden sickle, and the deer mandible. The cattle ribs, by contrast, were not effective. Uprooting by hand also proved adequate, particularly with *Triticum monococcum* but not with *Triticum aestivum*. This supports the claim that uprooting cereals in organically planted fields on compact soils is difficult and might not have been widely practiced in neolithic North-Western Europe (Bakels, 2009; Bakels and van Gijn, 2015). It might only be suitable in very dry and loose soils as seen in ethnographic context on the island of Lanzarote (Anderson and Peña Chocarro, 2015). Hand-held shell tools used as harvesting knives are slow and snapping ears off by hand is often faster. This puts into question the effectiveness of these tools.

Analysis of Qualitative Harvesting Results

All tools used during the experimental cereal harvest showed marked use wear traces. These traces were macroscopic as gloss on shells or bone, worn cutting edges and strong abrasions on inserts, but also microscopic as striations, polish, and edge rounding.

Oyster shell inserts showed the strongest alterations during this experiment, as large parts of the cutting edges were worn off by the action of the cereal stems (See Figure 16). Still, these were also the most effective tools, staying sharp throughout the entire cereal harvest.

Mussel shell inserts were less affected by the abrasion of cereal stalks, as they showed less edge rounding, and their original retouches were still visible after the harvest. However, they became blunt rapidly, thus reducing the collecting speed and forcing the harvester to change the technique from cutting to sawing, ripping, and finally uprooting. Use-wear traces were very visible, be it striations, polish, edge rounding and edge damages (See Figure 17).

The cutting edges of the oak wood sickles were also strongly altered during the harvest. They became rounded, developed a polish and could after a short while not cut through stems anymore. These were then either hacked through or uprooted. Also, the edges of the tools changed, depending on the different type of cereals gathered. *Triticum aestivum* and especially the grass cut together, damaged the wooden edge very strongly (See Figure 18). *Triticum monococcum* with its thin stems and loose roots, enabled uprooting and the cutting edge suffered only small damages.

Deer mandibles almost did not change their shape during the harvest. The teeth as cutting agents remained in terms of use-wear traces the same (See Figure 19). Only the bone segments before and behind the teeth (diastema and ramus) showed some polish, and striations. Finally, the damaged incisor teeth at the front part of the mandible could be seen as additional indication of a cereal harvest.

Following this experiment, cattle ribs are believed not to be suitable for harvesting cereals. The experiment showed that the edges of these became rounded and blunt within a few minutes and could not sustain a prolonged grain harvest (See Figure 20).

Hand-held shells, be it oysters, or freshwater mussels, showed strong alterations after being used to snap off cereal ears for three hours. Not only did the outer shell become worn away, but also the harder inner shell became dented, cracked up and in some cases fell off. Use-wear traces were visible as polish, striations, and edge rounding (See Figure 21). Very visible were the abrasion of the interior shell, changing from a dull brownish colour to a shiny bluish surface (See Figure 22).

All these actions left long-lasting traces on all tools which could easily be identified with the naked eye or through a microscope. Since such obvious reaping traces were visible on experimental tools it is believed that such marks could also be found on archaeological material. A future step would therefore be to compare the above presented traces with Neolithic material and determine if similar marks could be discovered. If these were present in archaeological finds, it could explain the use of alternative materials to make sickles and harvesting knives during that period.

Comparison between Flint and Shell Based Sickles

In 2019, a team around N. Mazzucco had reaped 400 m² of *Triticum aestivum* in Tuscany, Italy during 15 hours with a reported total yield of 150 kg. In 2016, they managed to reap 80m² of *Triticum monococcum* within 10 hours in Provence, France. Finally in 2020, close to Burgos, Spain, they harvested 300 m² of *Hordeum vulgare* in 8 hours (Mazucco, et al., 2022, S2). For *Triticum aestivum* this would result in a speed of 0.44 m² per minute (400m²/15 hours/60 min), for *Triticum monococcum* 0.13 m²/min. and for *Hordeum vulgare* 0.63 m²/min. The grain yield for *Triticum aestivum* was compounded to 10 kg per hour (150 kg/15h) (See Table 1).

Experimental results in the Mediterranean	Surface harvested in m2	Hours harvested	Total yield in kg	Harvesting speed in m2/min	Yield in kg per hour
Tuscany, Italy, T. aestivum	400	15	150	0.44	10.00
Provence, France, T. monococcum	80	10		0.13	
Burgos, Spain, H. vulgare	300	8		0.63	

TABLE 1. OVERVIEW OF EXPERIMENTAL HARVESTING RESULTS (MAZZUCCO ET AL., 2022, S2).

In the frame of this cereal harvesting experiment, the reaping speed was recorded at a maximum of 0.35 m² per min (21 m²/60 min.) for *Triticum dicoccum* achieved with a hafted sickle with oyster shell inserts. For hand-held shell tools, the speed was around 0.08 to 0.02 m²/min (5 m²/60 min.). These figures are lower than the velocity recorded in the above-mentioned experiments because an estimated 1/3 of the harvesting time has been used for carrying the stems to and from the field. Without carrying the stems, the collecting speed would have increased by 1/3, resulting in a maximum speed of 0.53 m²/min (0.35m² /0.66) for *Triticum dicoccum* with a hafted sickle with oyster shell inserts. For hand-held shell tools the speed would reach 0.12m²/min. Thus, the absolute reaping speeds achieved during this experiment would have been between 0.53m²/min. and 0.12m²/min (See Table 2). These speeds are similar to or above the experimental results on *Triticum aestivum* and *Triticum monococcum* (See Table 1; (Mazucco, et al., 2022, S2).

Experimental results in Germany	Tools used	Surface harvested in m2	Hours harvested	Speed in m2/min (incl. carry stems)	Speed in m2/min (reaping only)

Lauresham, Germany, T. aestivum	Sickle with oyster shell inserts	21	1	0.35	0.53
Lauresham, Germany, T. monococcum	Sickle with oyster shell inserts	19	1	0.32	0.48
Lauresham, Germany, H. vulgare	Wooden sickle	20	1	0.33	0.50

TABLE 2. OVERVIEW OF FASTEST HARVESTING SPEEDS ACHIEVED DURING THE EXPERIMENT INCLUDING AND EXCLUDING CARRYING AND BINDING STEMS. TABLE BY MARC-PHILIPP HÄG.

Harvesting done with tools made from alternative materials such as shells, wood or bone can thus result in a similar grain yield and speed as tools with flint inserts. If, as in this case, there are almost no differences in reaping cereals with shell or flint inserts, could both materials have been used?

Conclusion on Alternative Harvesting Tools

In summary, it can be stated, that after the use of 26 tools on four different cereal fields, and an exhaustive data analysis, implements made from alternative materials such as shell, wood or teeth could have been employed for cereal reaping during the Neolithic. The efficiency in terms of speed and surface harvested, appears to be high and even equal to sickles or harvesting knives with flint inserts. In this case, the selection of materials to build reaping tools would have been very much a cultural and not a technological choice if these tools enabled a harvest within a few weeks. It is now up to us archaeologists, to find among the excavated remains of shells, wood, and mandibles of that period, any use-wear traces pointing towards a cereal harvest use.

Keywords tools
food
agriculture

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Gallery Image

FIG 1. (TOOL 3887) HAFTED SICKLE WITH OYSTER SHELL INSERTS. PHOTO BY MARC-PHILIPP HÄG.

FIG 2. (TOOL 3688) HAFTED SICKLE WITH FRESHWATER MUSSEL SHELL INSERTS. PHOTO BY MARC-PHILIPP HÄG.

FIG 3. (TOOL 3889) OAK WOOD SICKLE. PHOTO BY MARC-PHILIPP HÄG.

FIG 4. (TOOL 3671) DEER MANDIBLE. PHOTO BY MARC-PHILIPP HÄG.

FIG 5. (TOOL 3891) CATTLE RIB. PHOTO BY MARC-PHILIPP HÄG.

FIG 6. (TOOL 3684) HAND-HELD OYSTER SHELL. PHOTO BY MARC-PHILIPP HÄG.

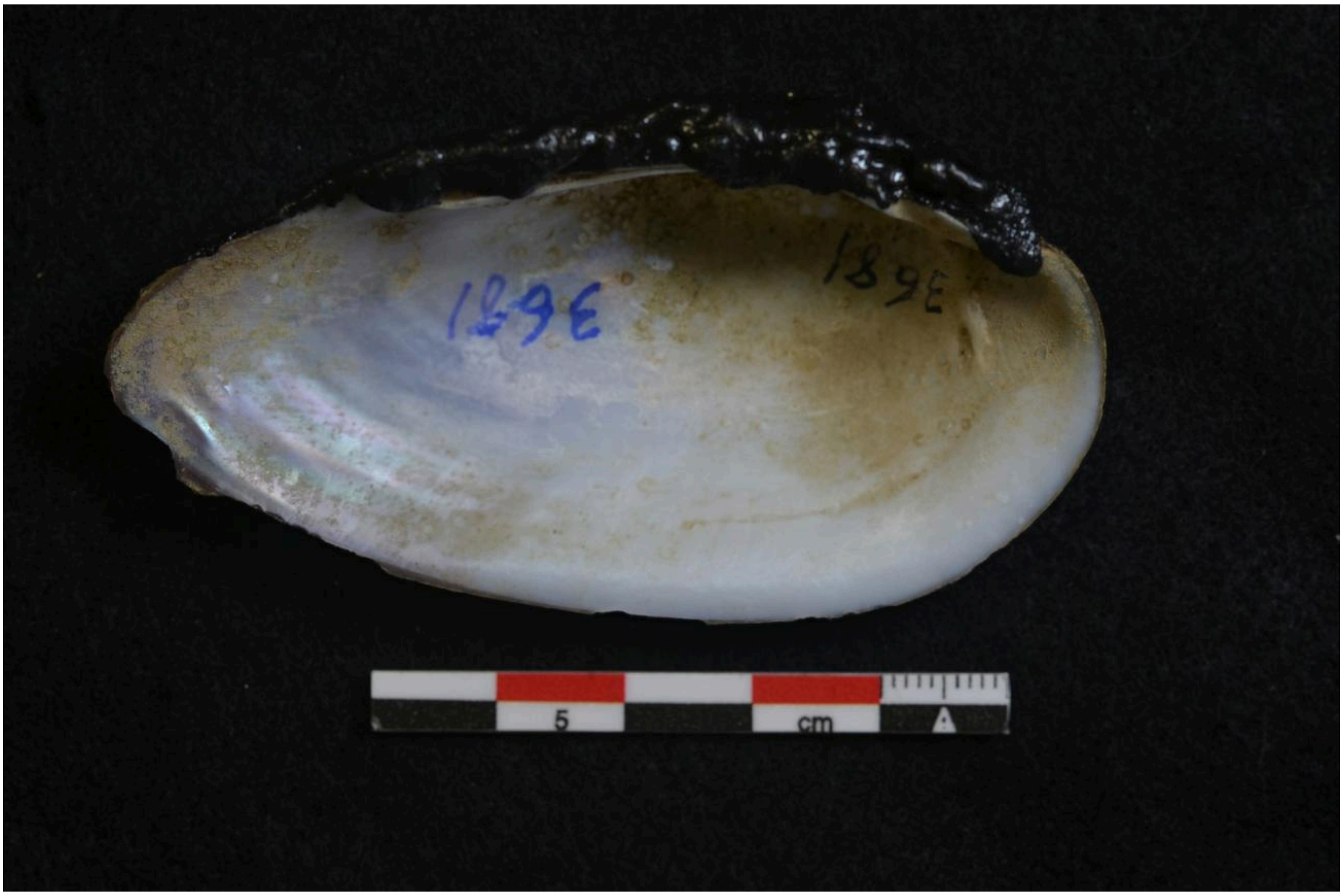

FIG 7. (TOOL 3681) HAND-HELD FRESHWATER MUSSEL SHELL. PHOTO BY MARC-PHILIPP HÄG.

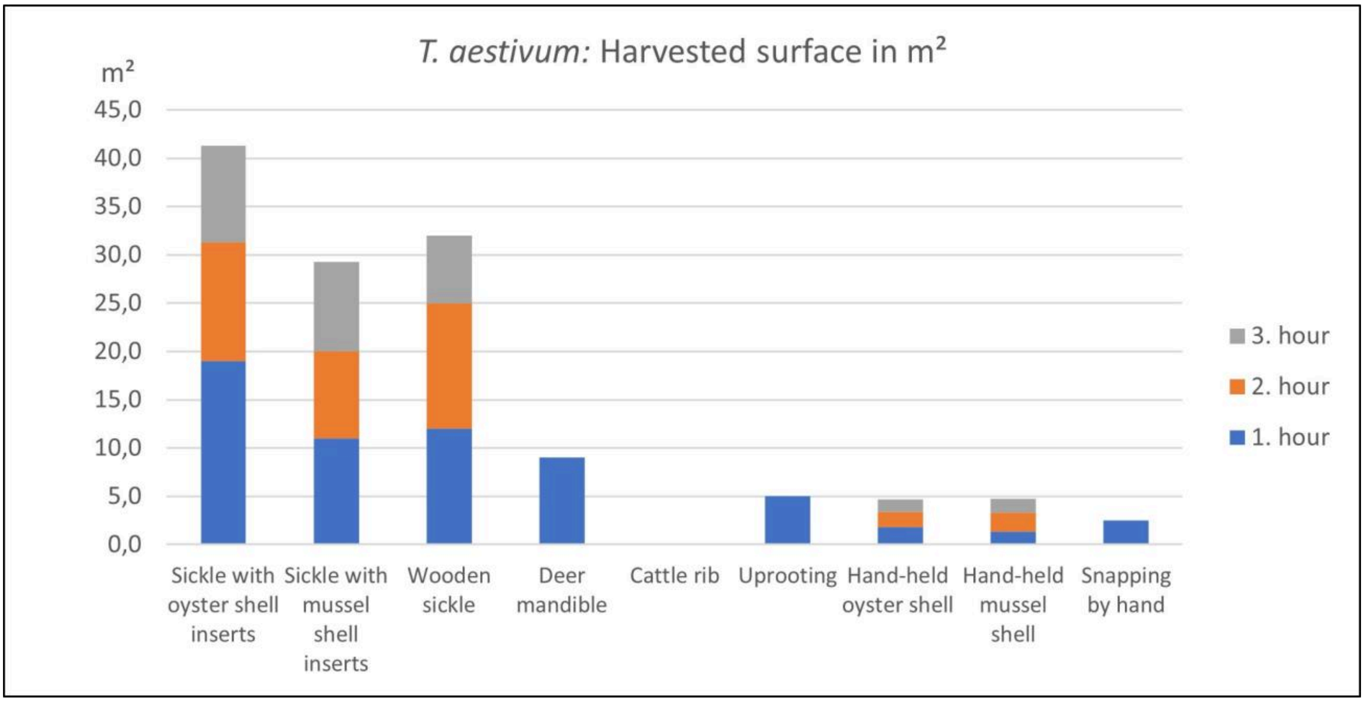

FIG 8. HARVESTED SURFACE IN M² OF T. AESTIVUM.

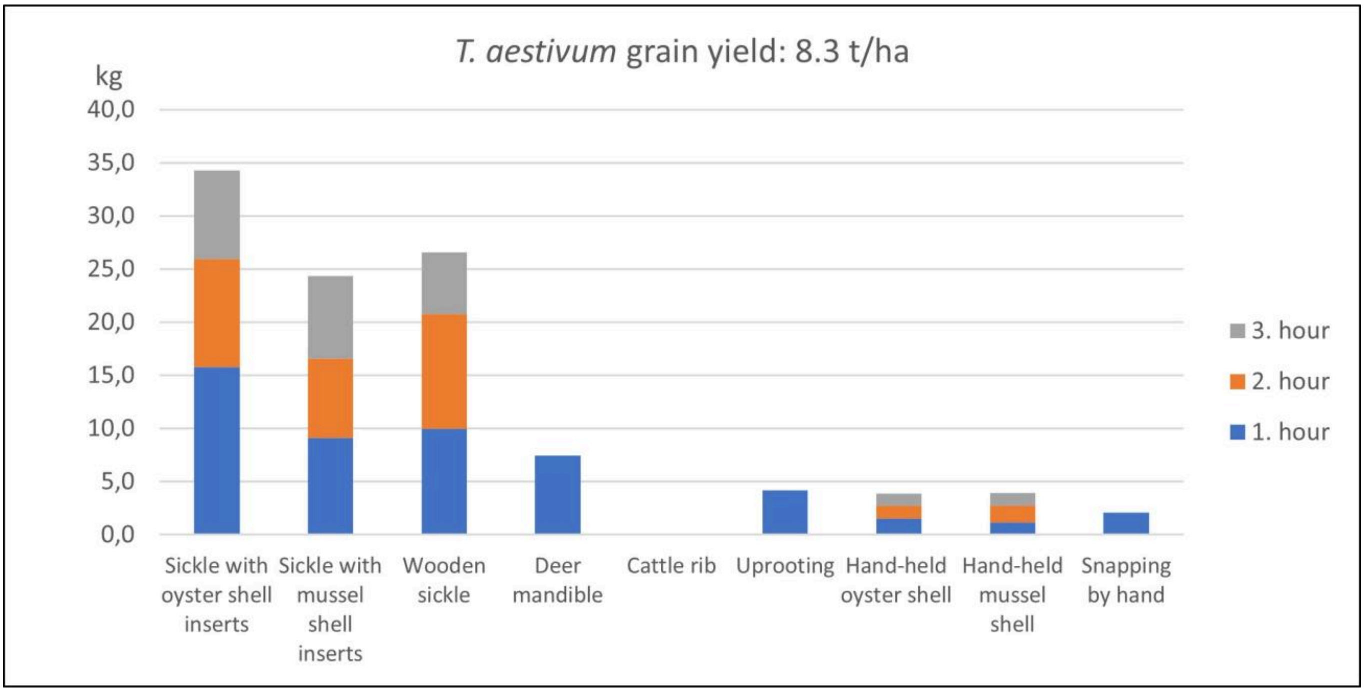

FIG 9. GRAIN YIELD IN KG OF T. AESTIVUM OBTAINED WITH DIFFERENT TOOLS.

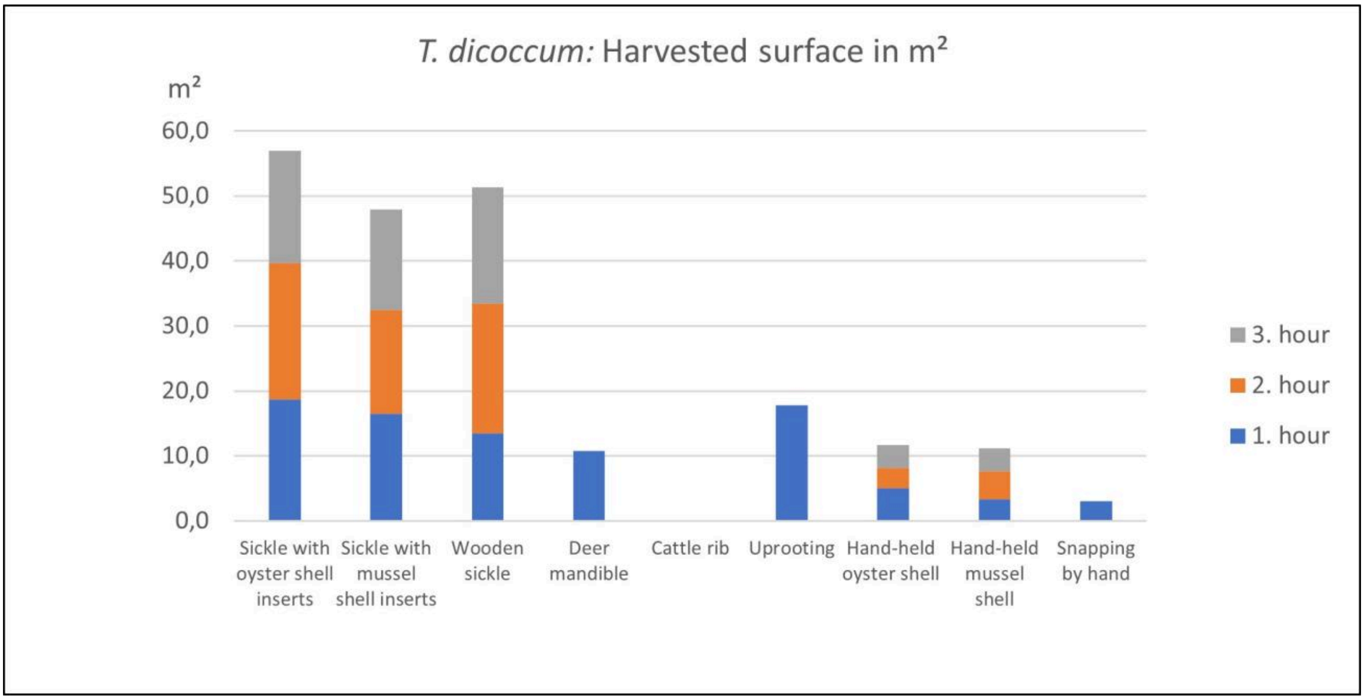

FIG 10. HARVESTED SURFACE IN M² OF T. DICOCCUM.

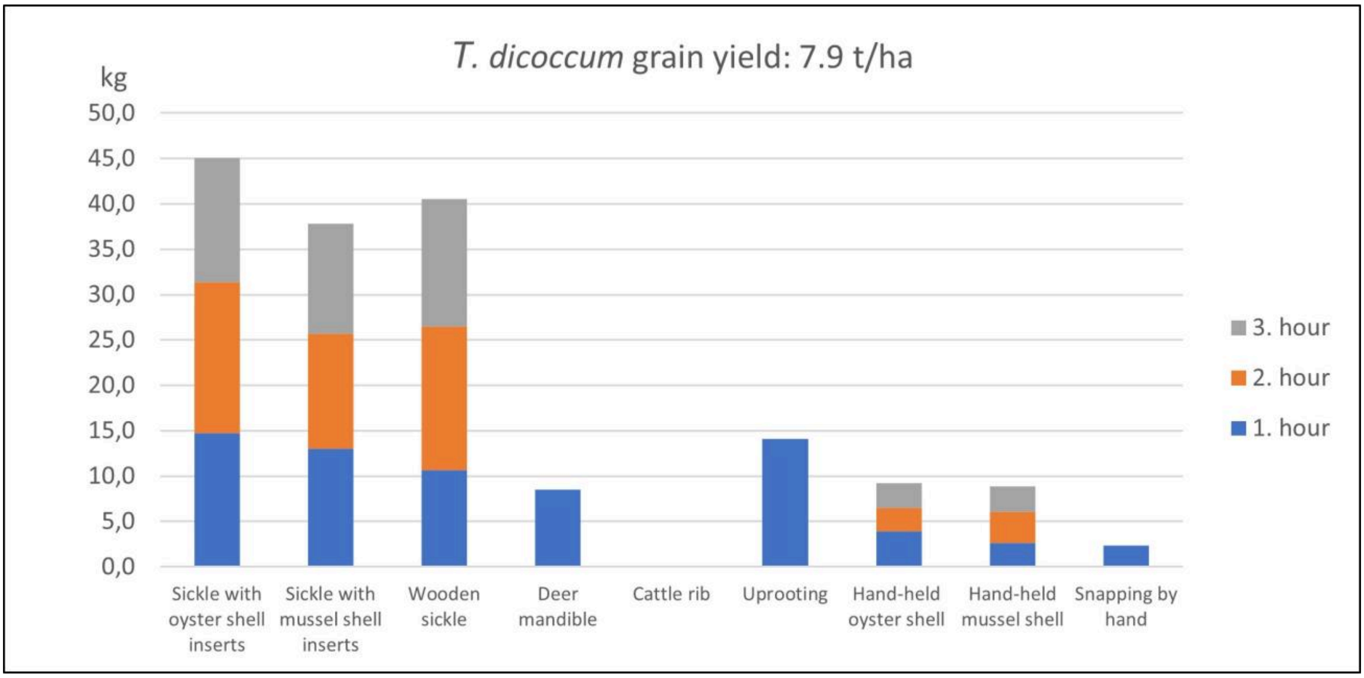

FIG 11. GRAIN YIELD IN KG OF T. DICOCCUM OBTAINED WITH DIFFERENT TOOLS.

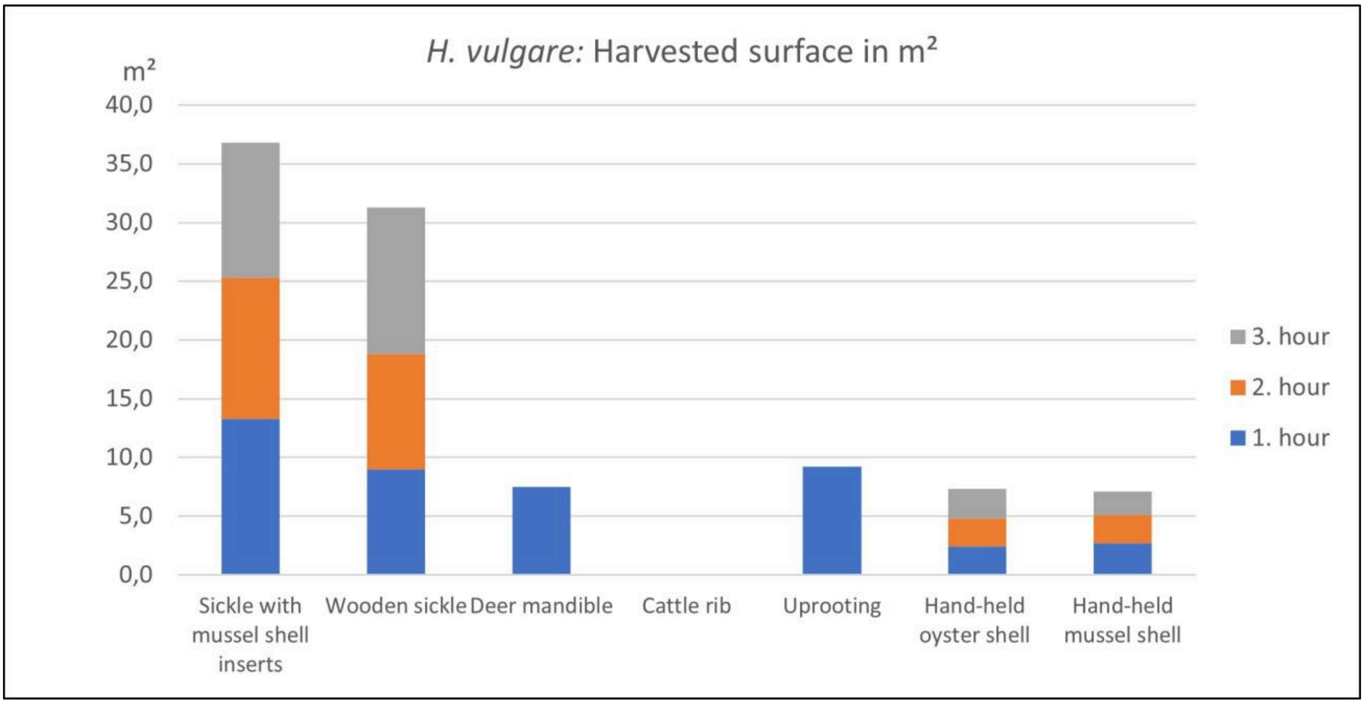

FIG 12. HARVESTED SURFACE IN M² OF H. VULGARE.

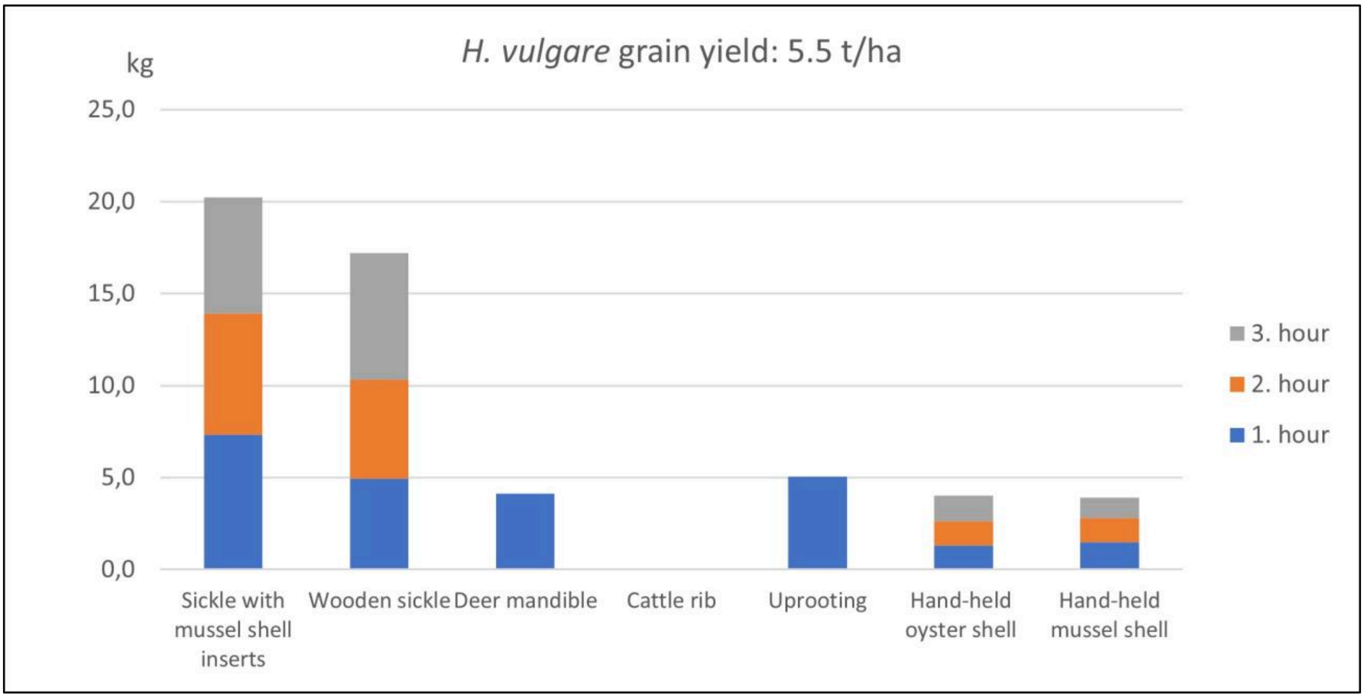

FIG 13. GRAIN YIELD IN KG OF H. VULGARE OBTAINED WITH DIFFERENT TOOLS.

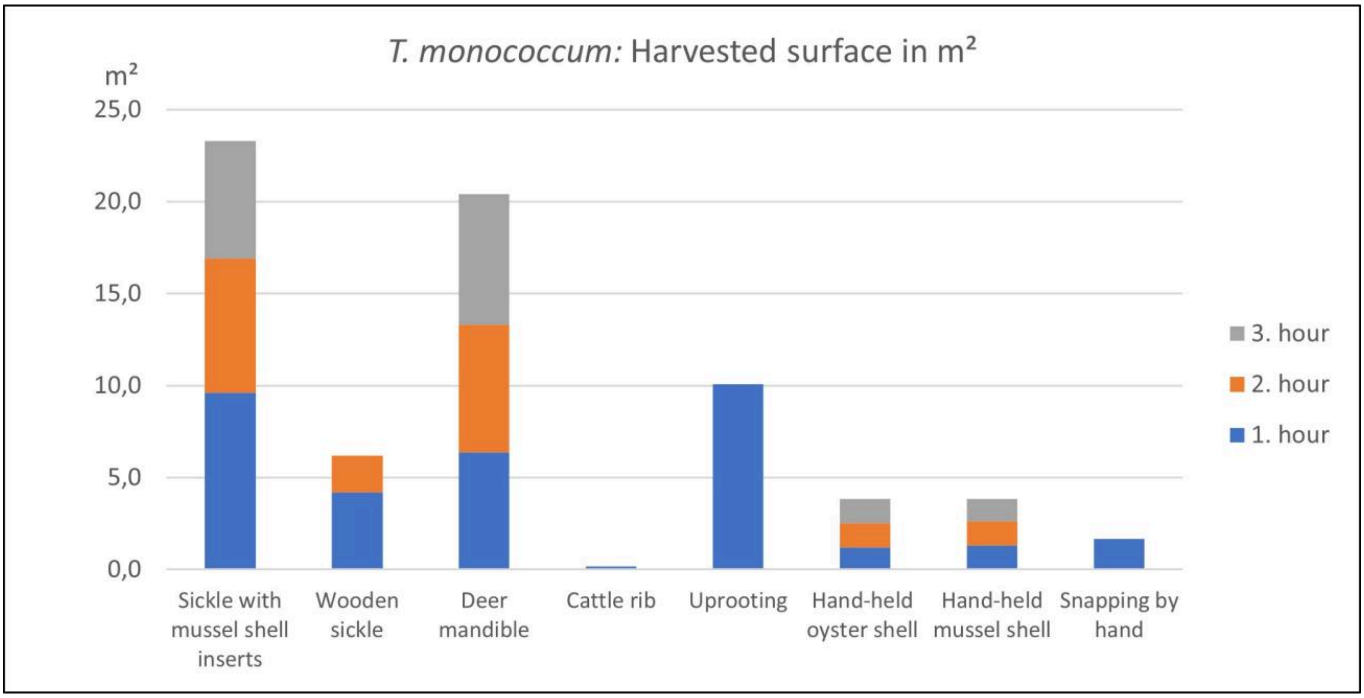

FIG 14. HARVESTED SURFACE IN M² OF T. MONOCOCCUM.

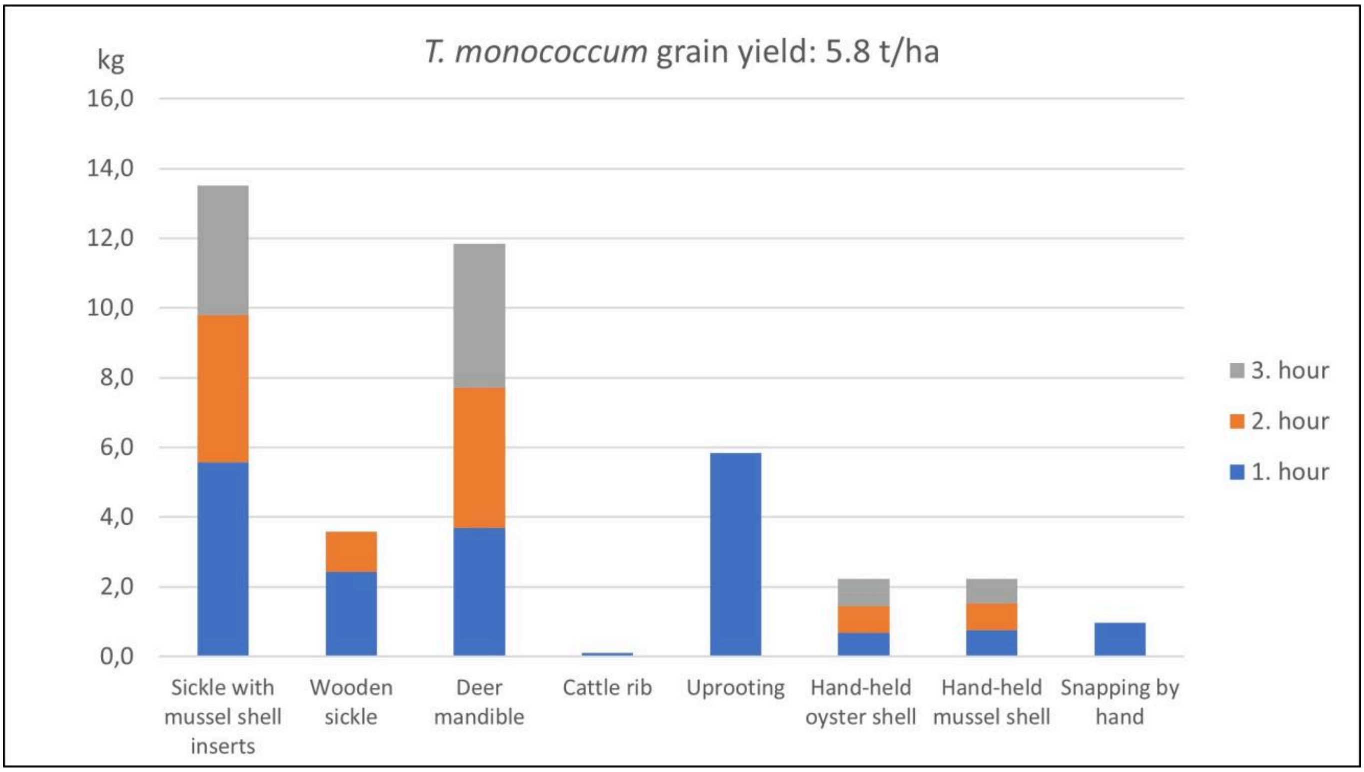

FIG 15. GRAIN YIELD IN KG OF T. MONOCOCCUM OBTAINED WITH DIFFERENT TOOLS.

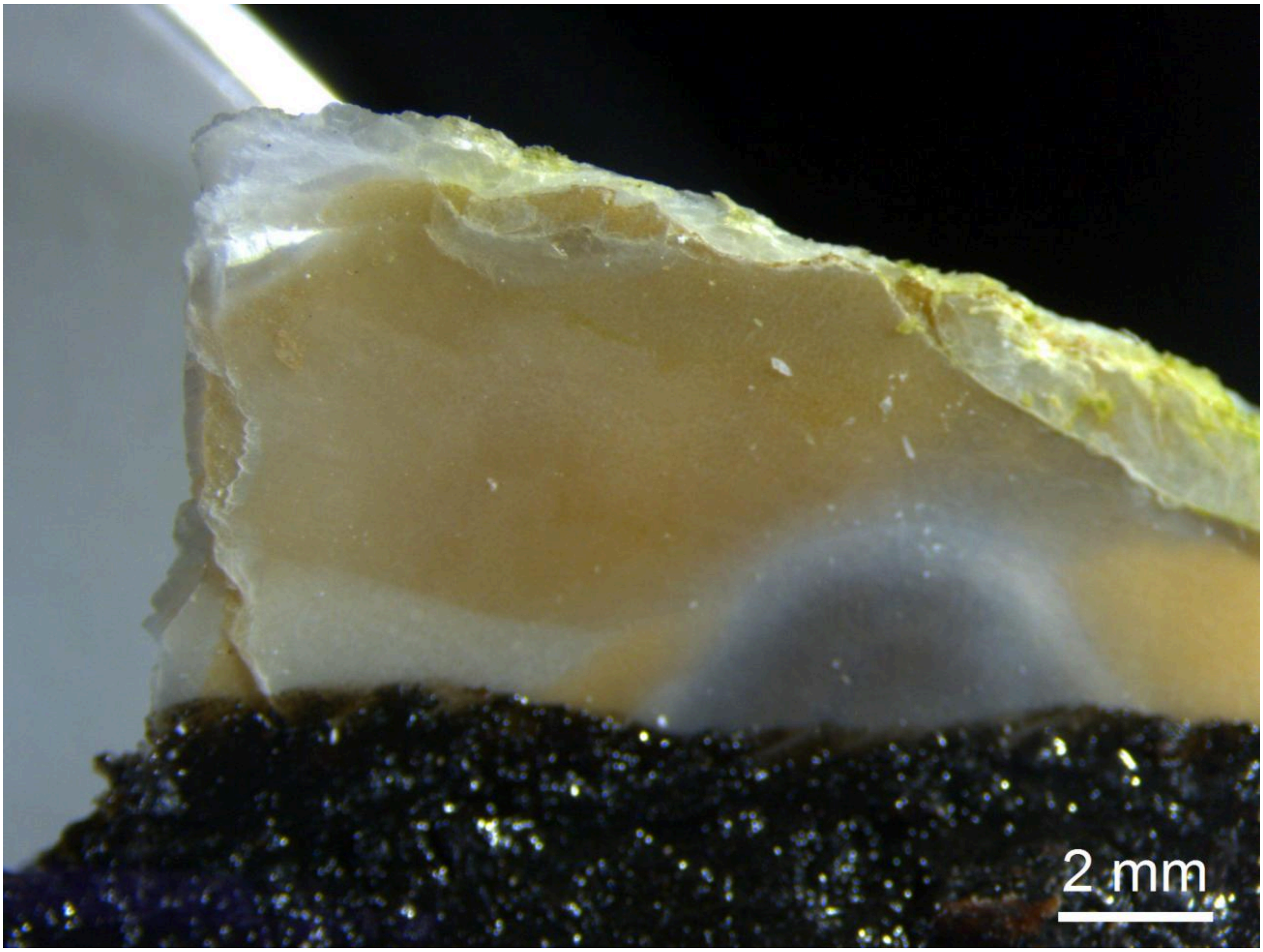

FIG 16A. (TOOL 3887) OYSTER SHELL INSERTS BEFORE HARVESTING T. DICOCCUM. STRONG SHORTENING AND EDGE ROUNDING VISIBLE

FIG 16B. (TOOL 3887) OYSTER SHELL INSERTS AFTER HARVESTING T. DICOCCUM. STRONG SHORTENING AND EDGE ROUNDING VISIBLE

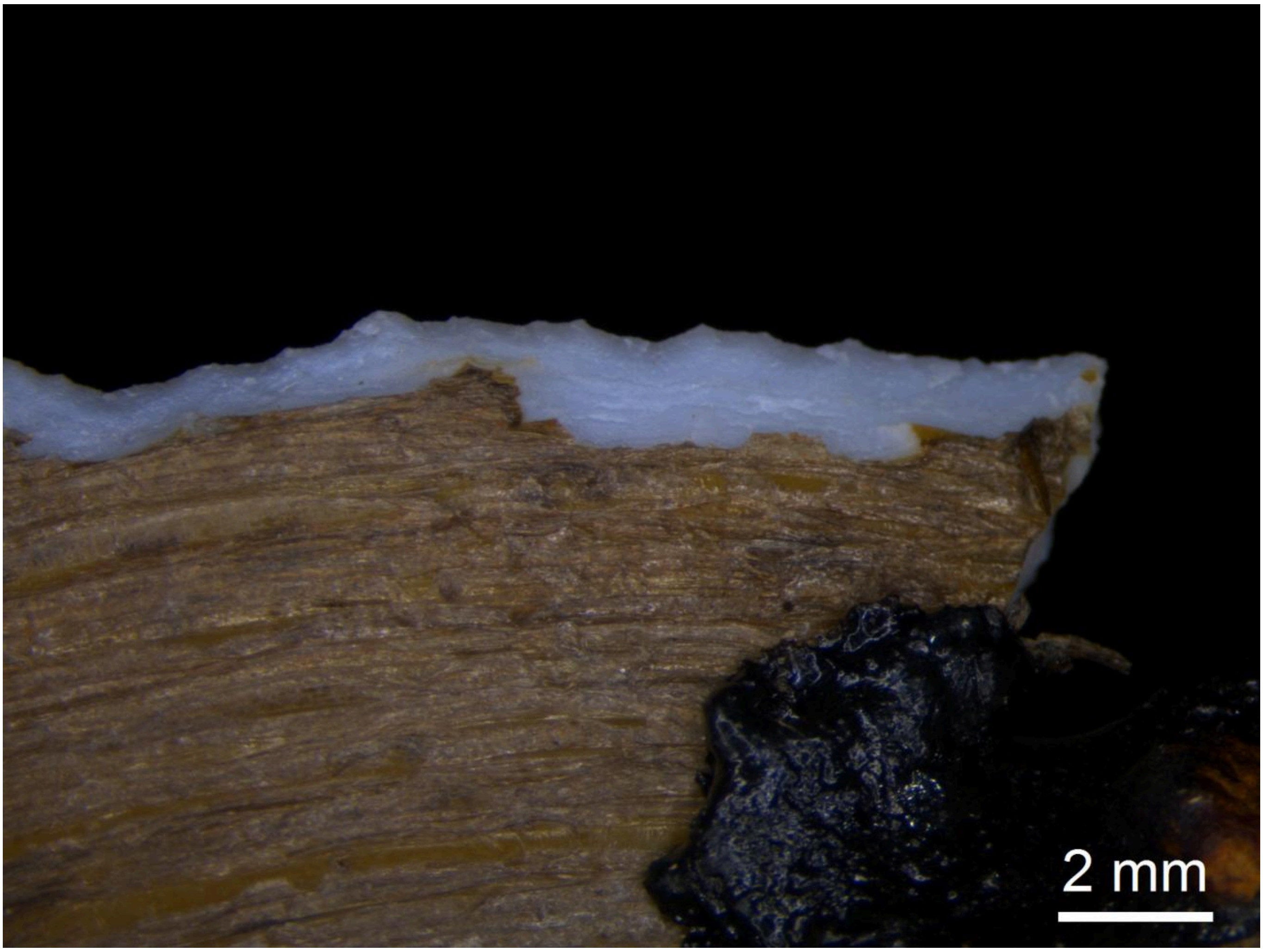

FIG 17A. (TOOL 3690) MUSSEL SHELL INSERT BEFORE HARVESTING H. VULGARE. STRONG EDGE ROUNDING VISIBLE.

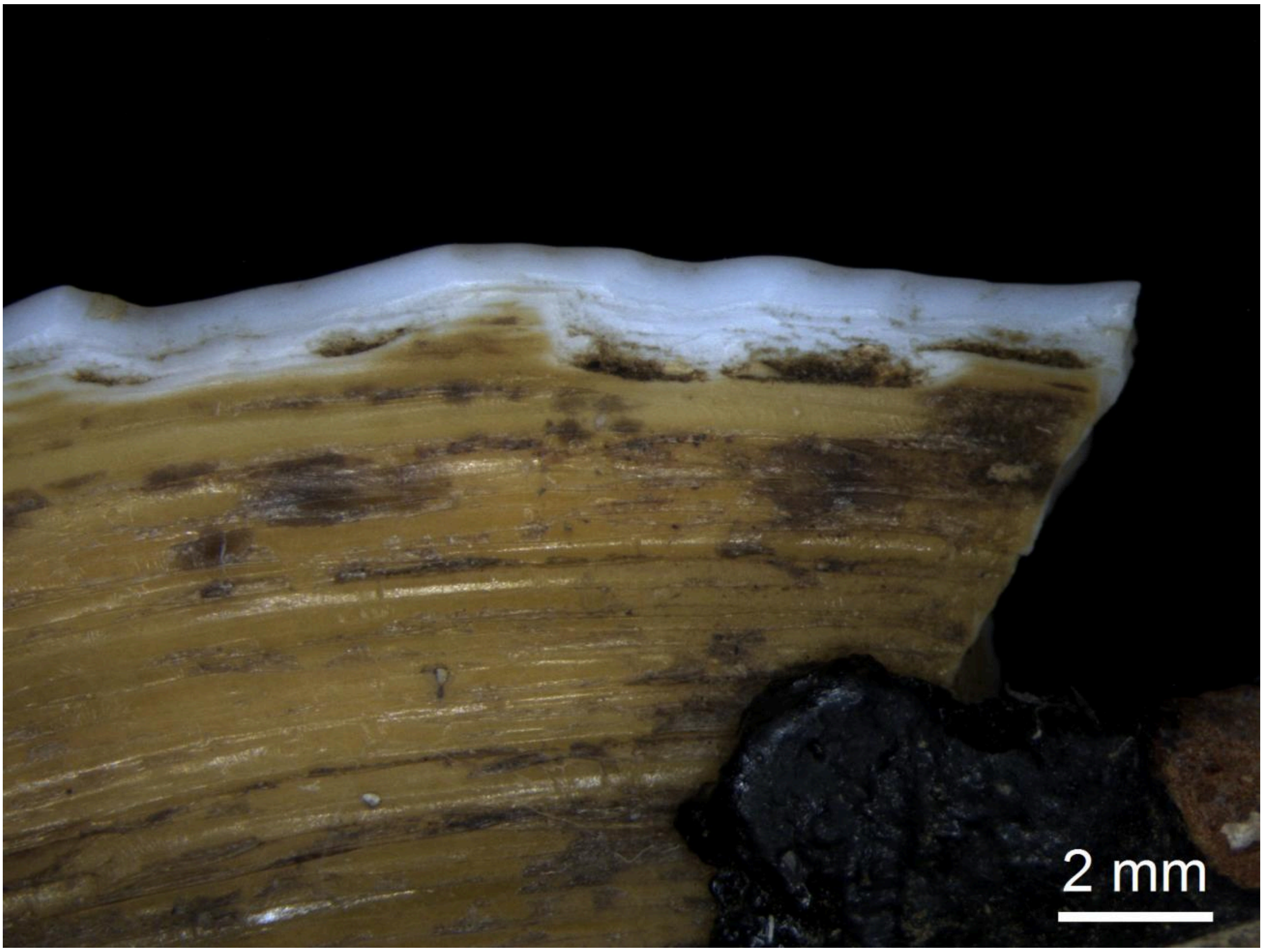

FIG 17B. (TOOL 3690) MUSSEL SHELL INSERT AFTER HARVESTING H. VULGARE. STRONG EDGE ROUNDING VISIBLE.

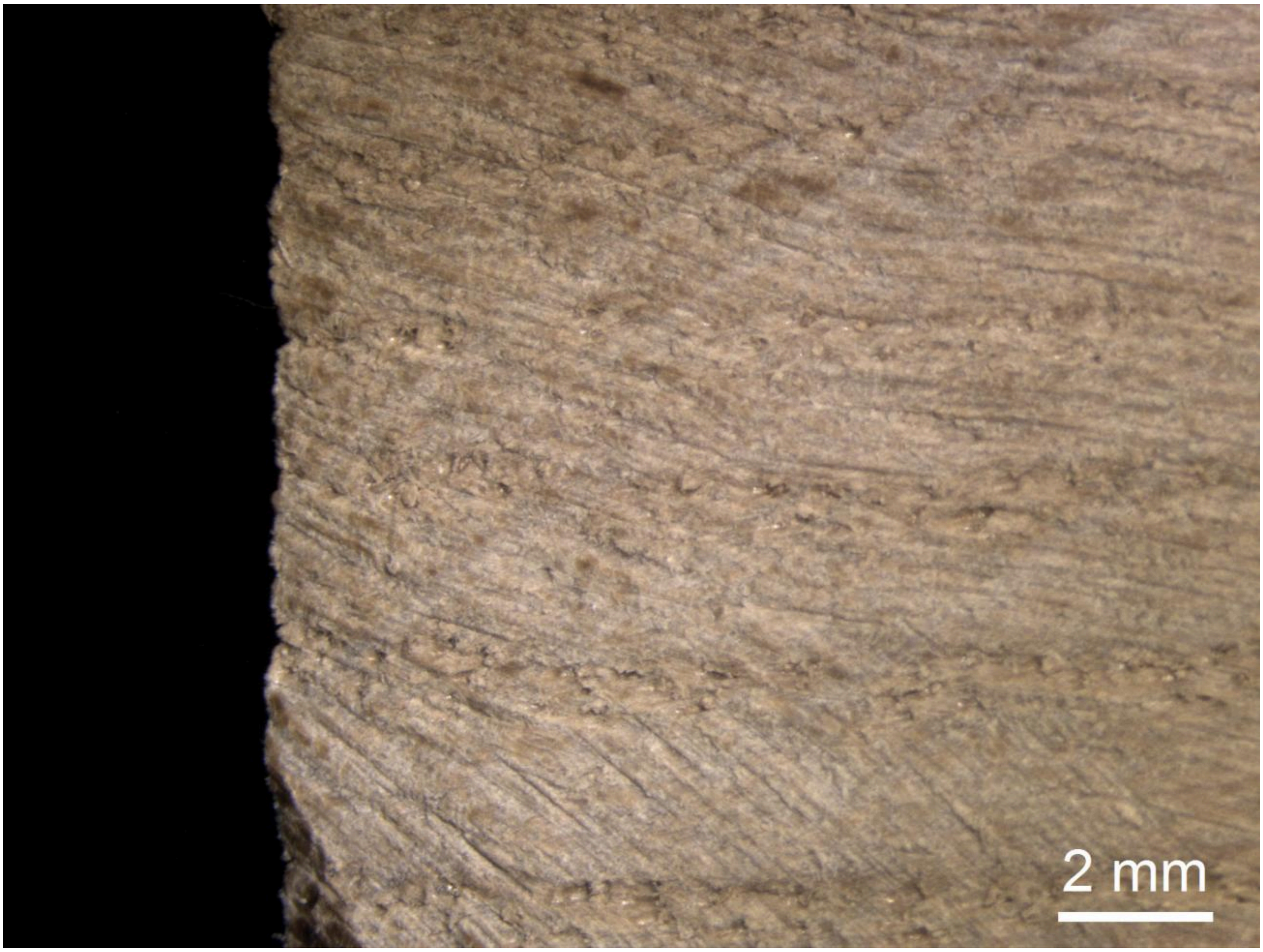

FIG 18A. (TOOL 3899) CUTTING EDGE OF WOODEN SICKLE BEFORE HARVESTING H. VULGARE. STRONG EDGE ROUNDING AND POLISH VISIBLE.

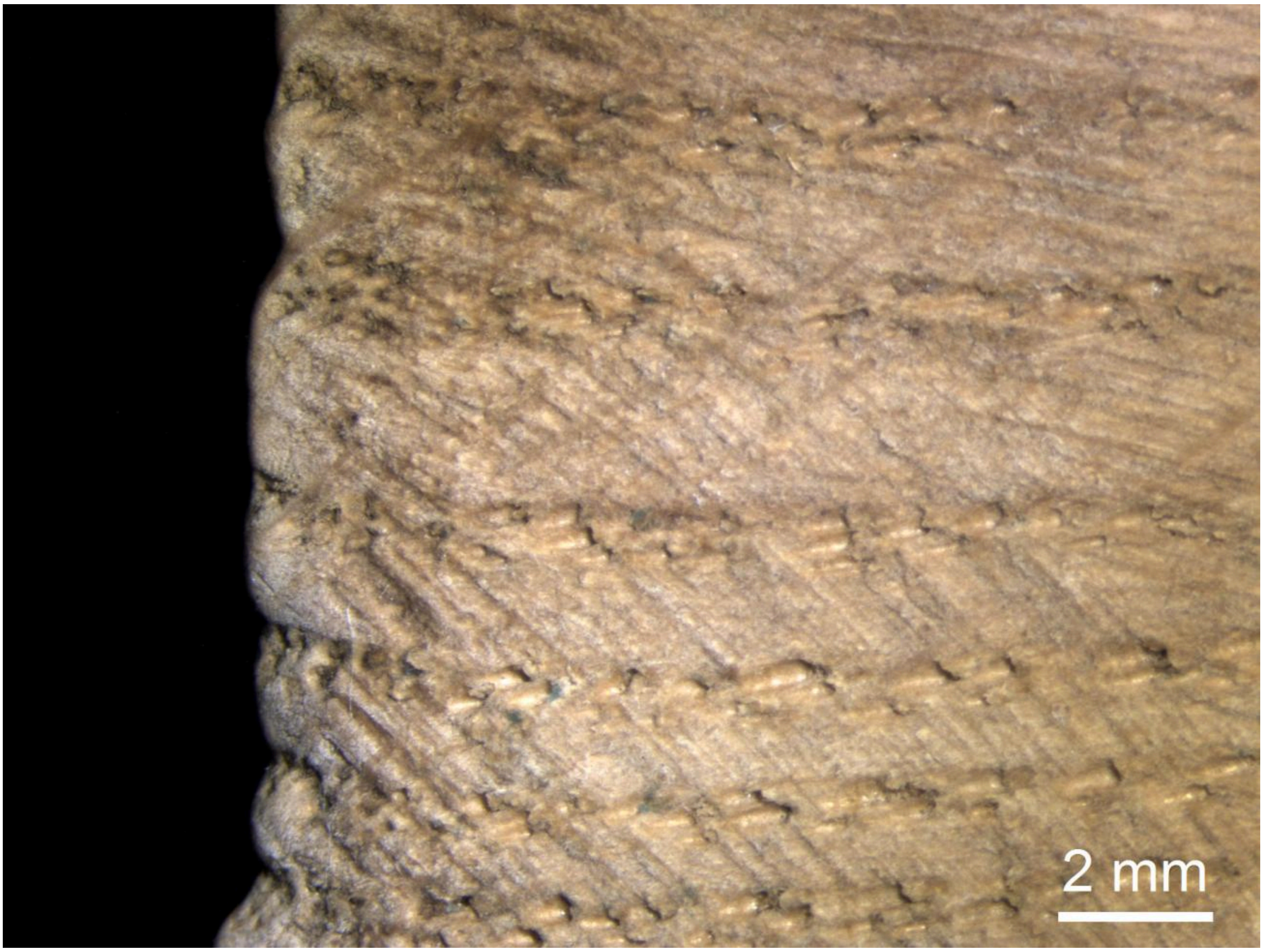

FIG 18B. (TOOL 3899) CUTTING EDGE OF WOODEN SICKLE AFTER HARVESTING H. VULGARE. STRONG EDGE ROUNDING AND POLISH VISIBLE.

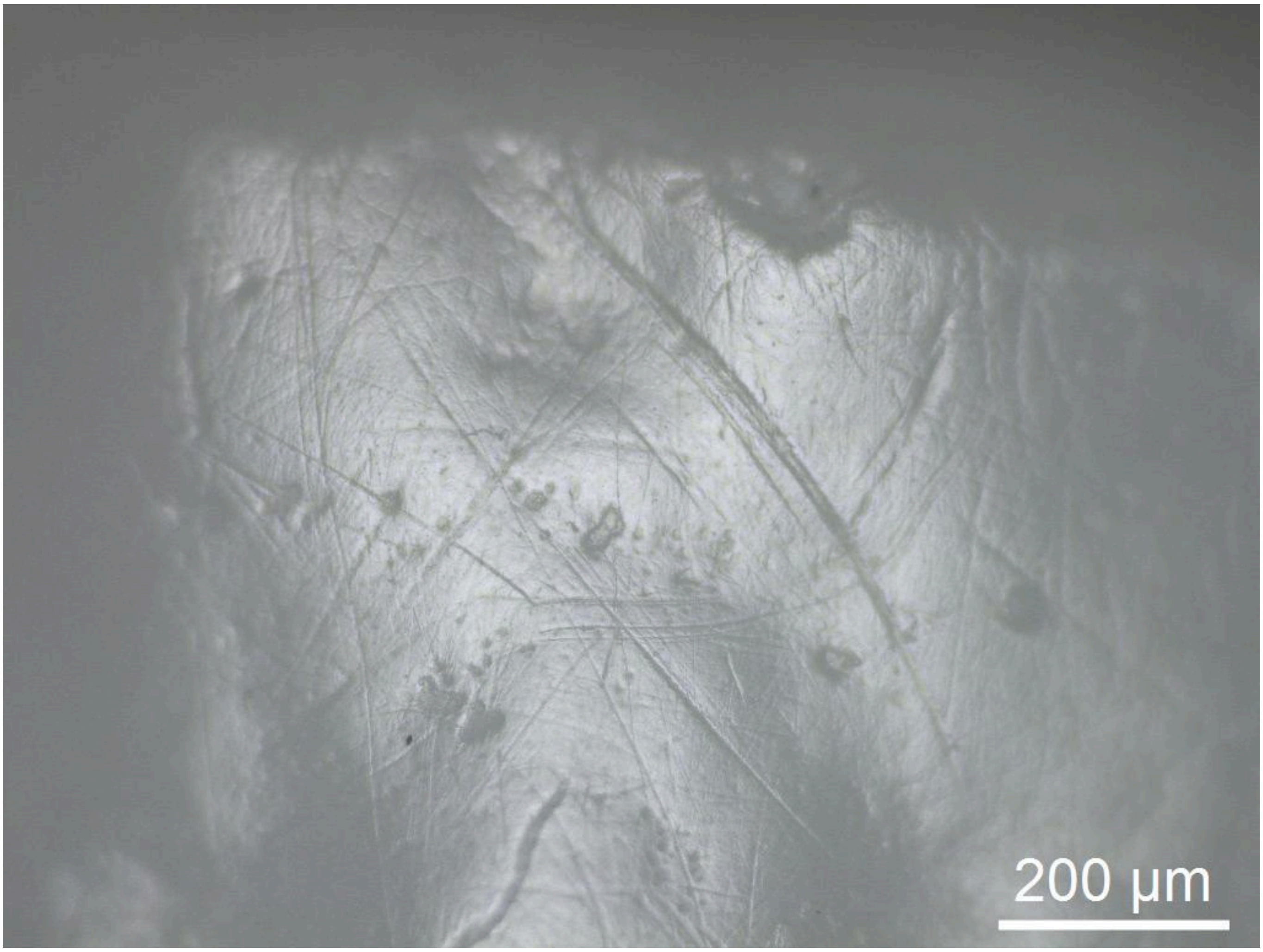

FIG 19A. (TOOL 3673) DEER MANDIBLE TOOTH BEFORE HARVESTING H. VULGARE. NO APPARENT CHANGES ON THE TOOTH EVEN UNDER THE METALLOGRAPHIC MICROSCOPE.

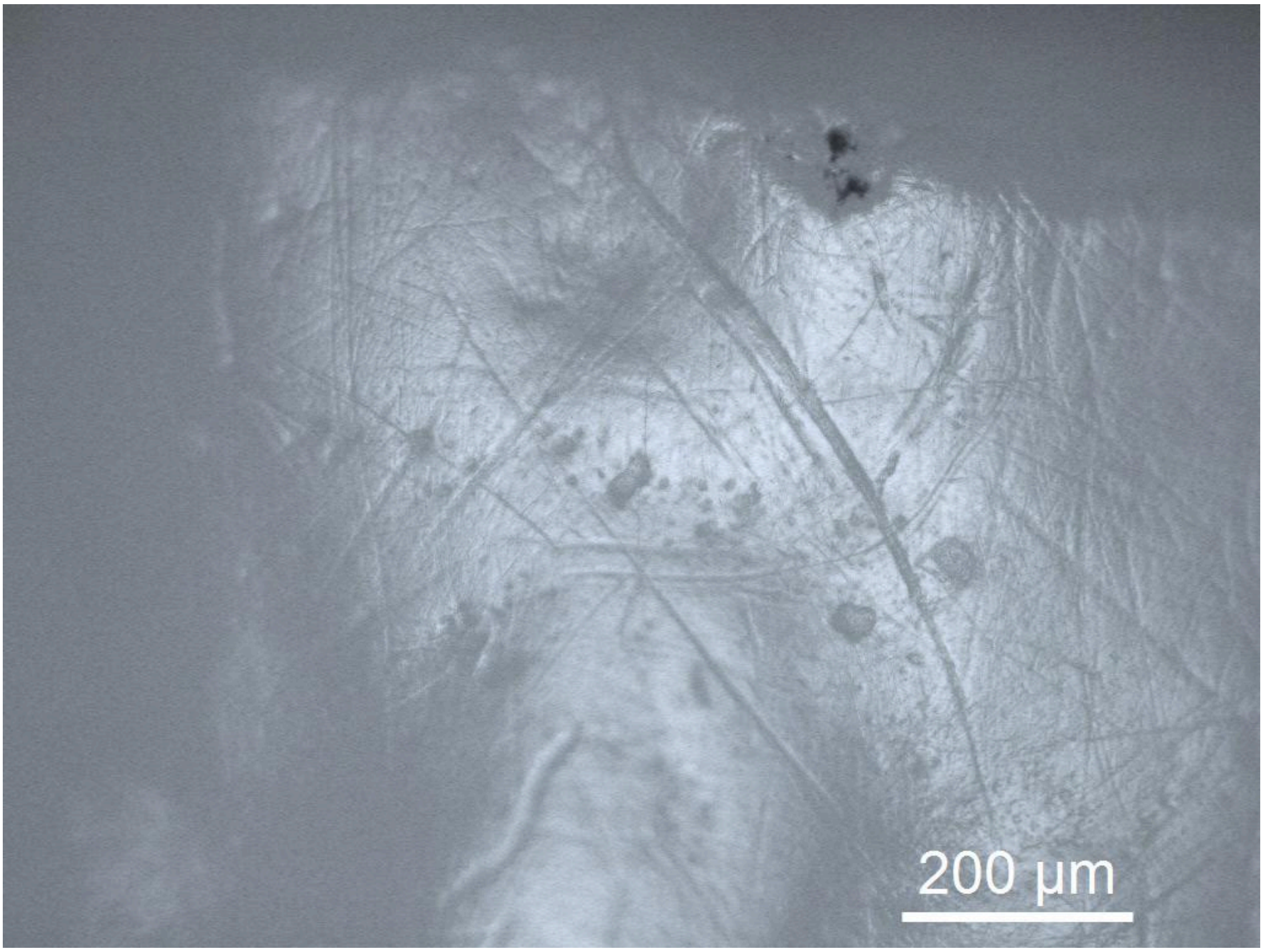

FIG 19B. (TOOL 3673) DEER MANDIBLE TOOTH AFTER HARVESTING H. VULGARE. NO APPARENT CHANGES ON THE TOOTH EVEN UNDER THE METALLOGRAPHIC MICROSCOPE.

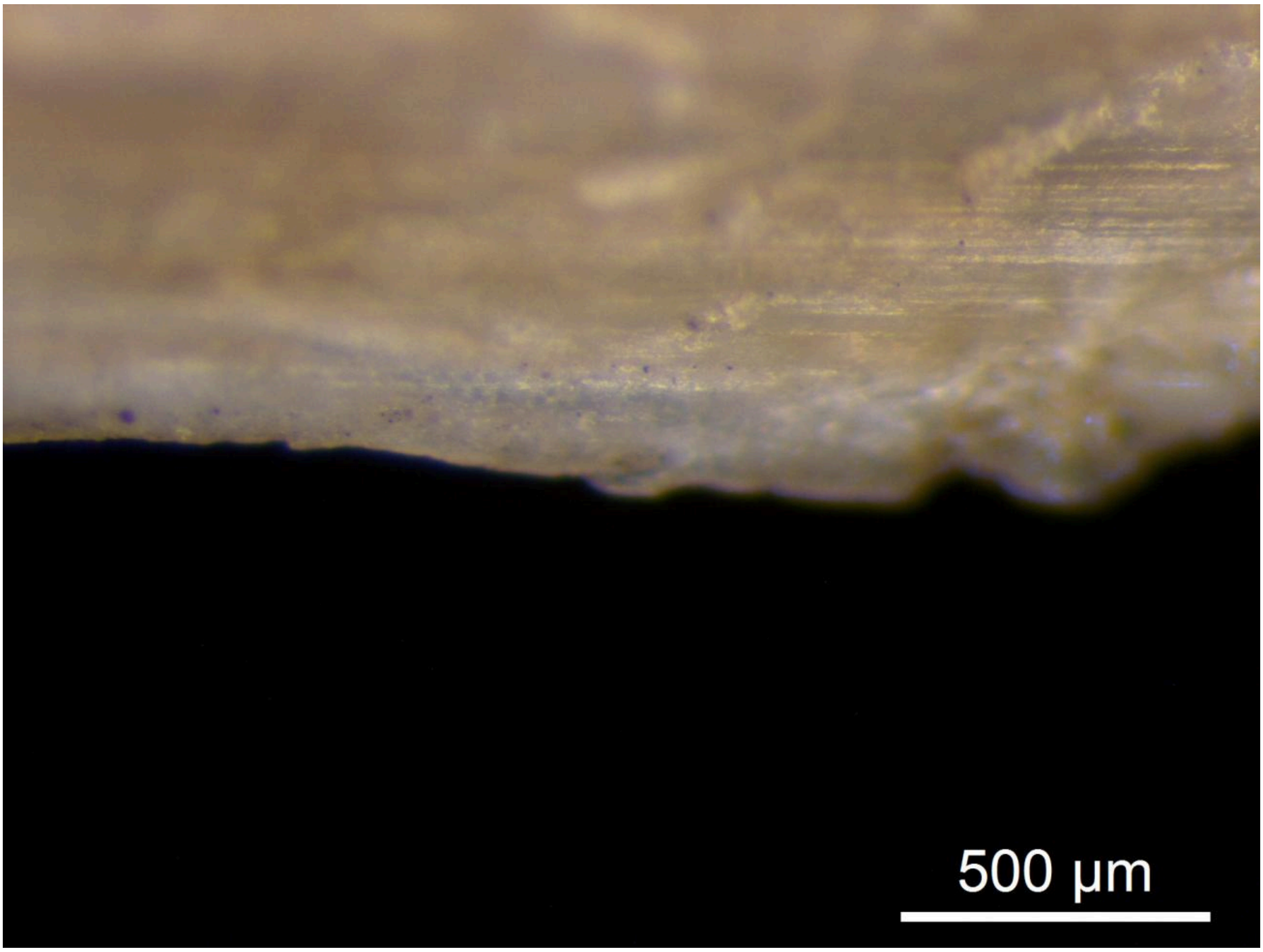

FIG 20A. (TOOL 4167) CUTTING EDGE OF CATTLE RIB BEFORE HARVESTING T. DICOCCUM. SHARPENING MARKS DISAPPEARED AFTER ONLY 5 MIN. OF REAPING. POLISH, STRONG EDGE ROUNDING AND FEW STRIATIONS VISIBLE.

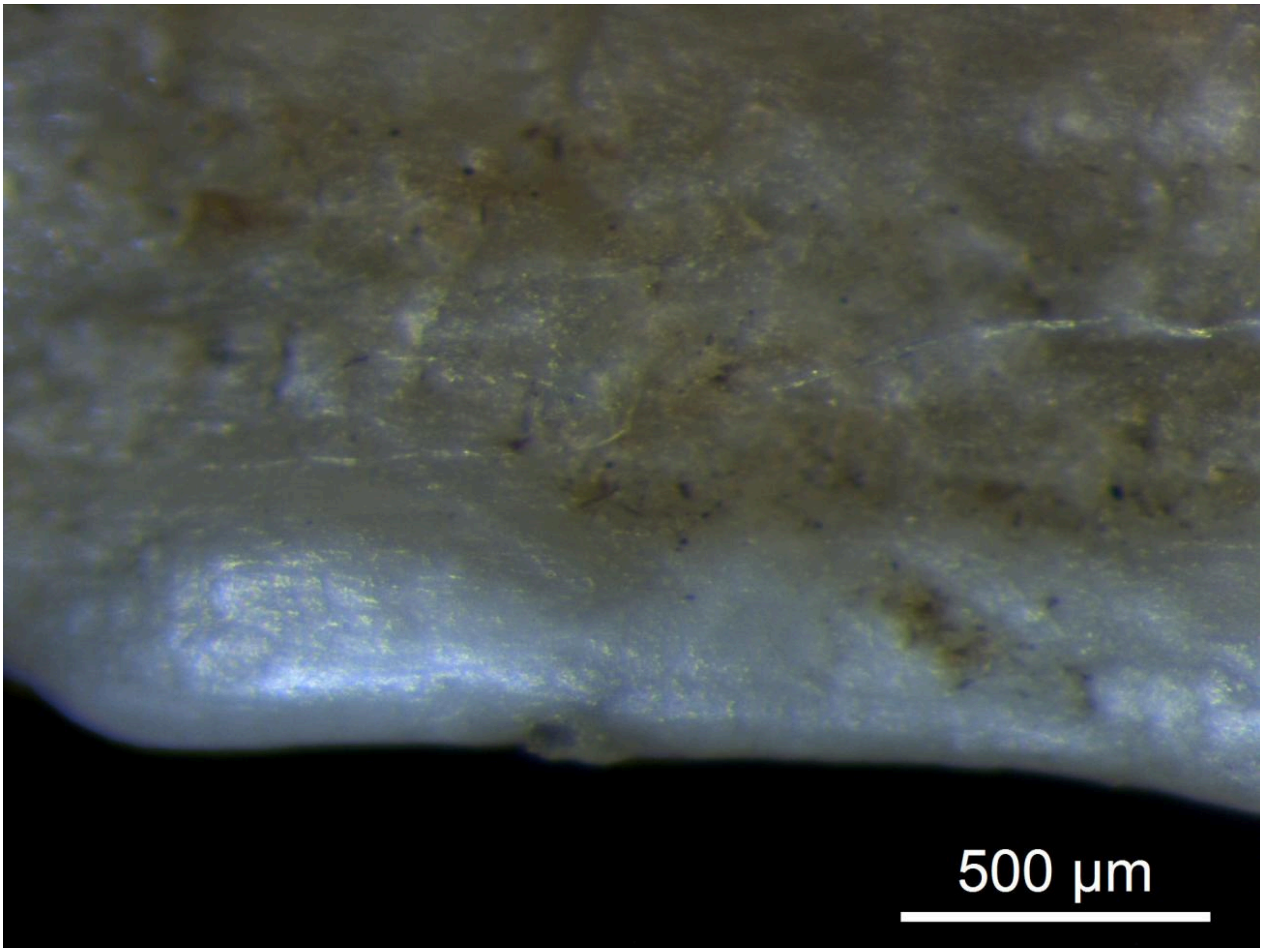

FIG 20B. (TOOL 4167) CUTTING EDGE OF CATTLE RIB AFTER HARVESTING T. DICOCCUM. SHARPENING MARKS DISAPPEARED AFTER ONLY 5 MIN. OF REAPING. POLISH, STRONG EDGE ROUNDING AND FEW STRIATIONS VISIBLE.

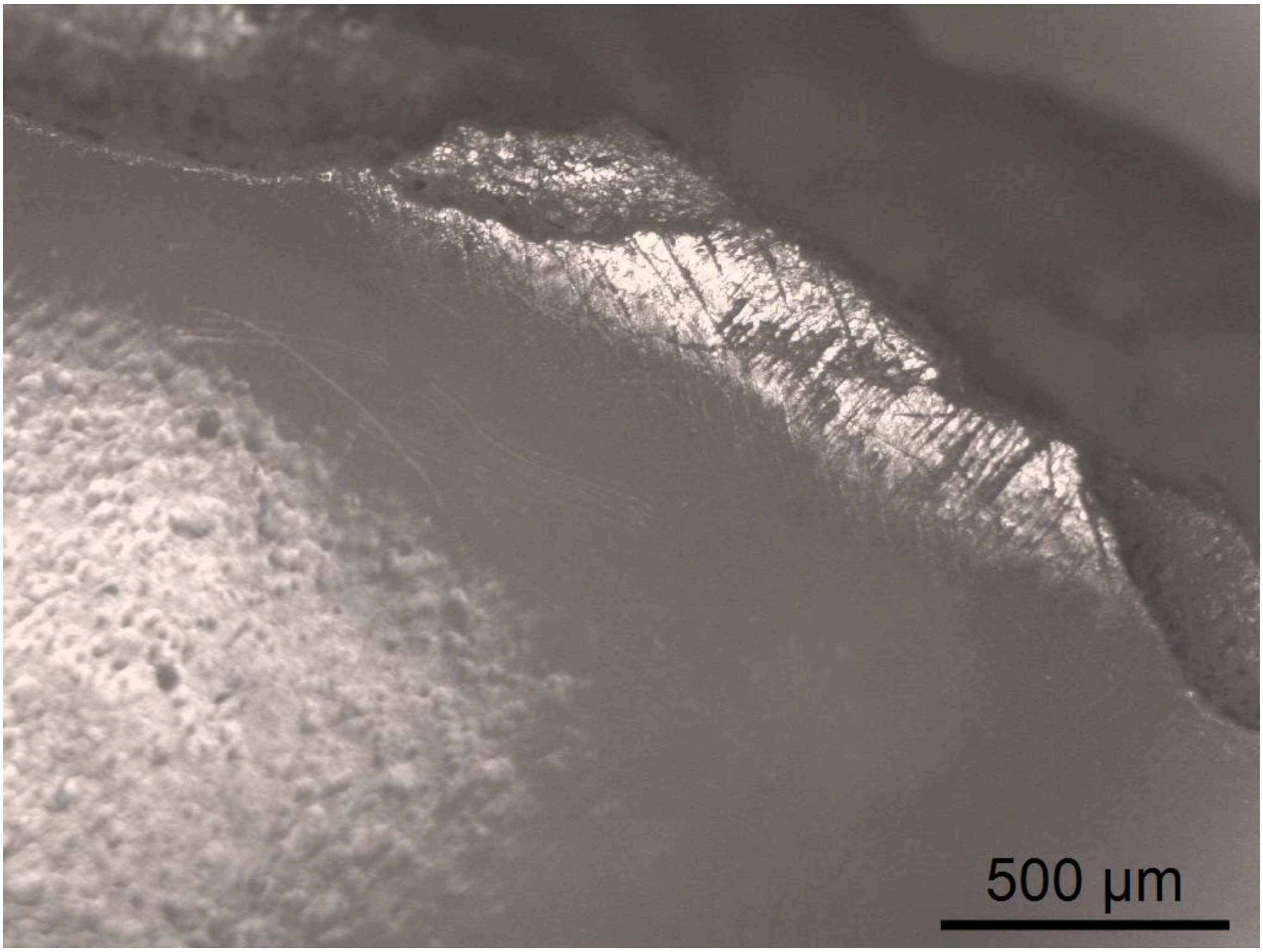

FIG 21A. (TOOL 3683) HAND-HELD OYSTER SHELL AFTER REAPING T. AESTIVUM. EDGE ROUNDING, POLISH, AND STRIATION AT 45° ANGLE VISIBLE.

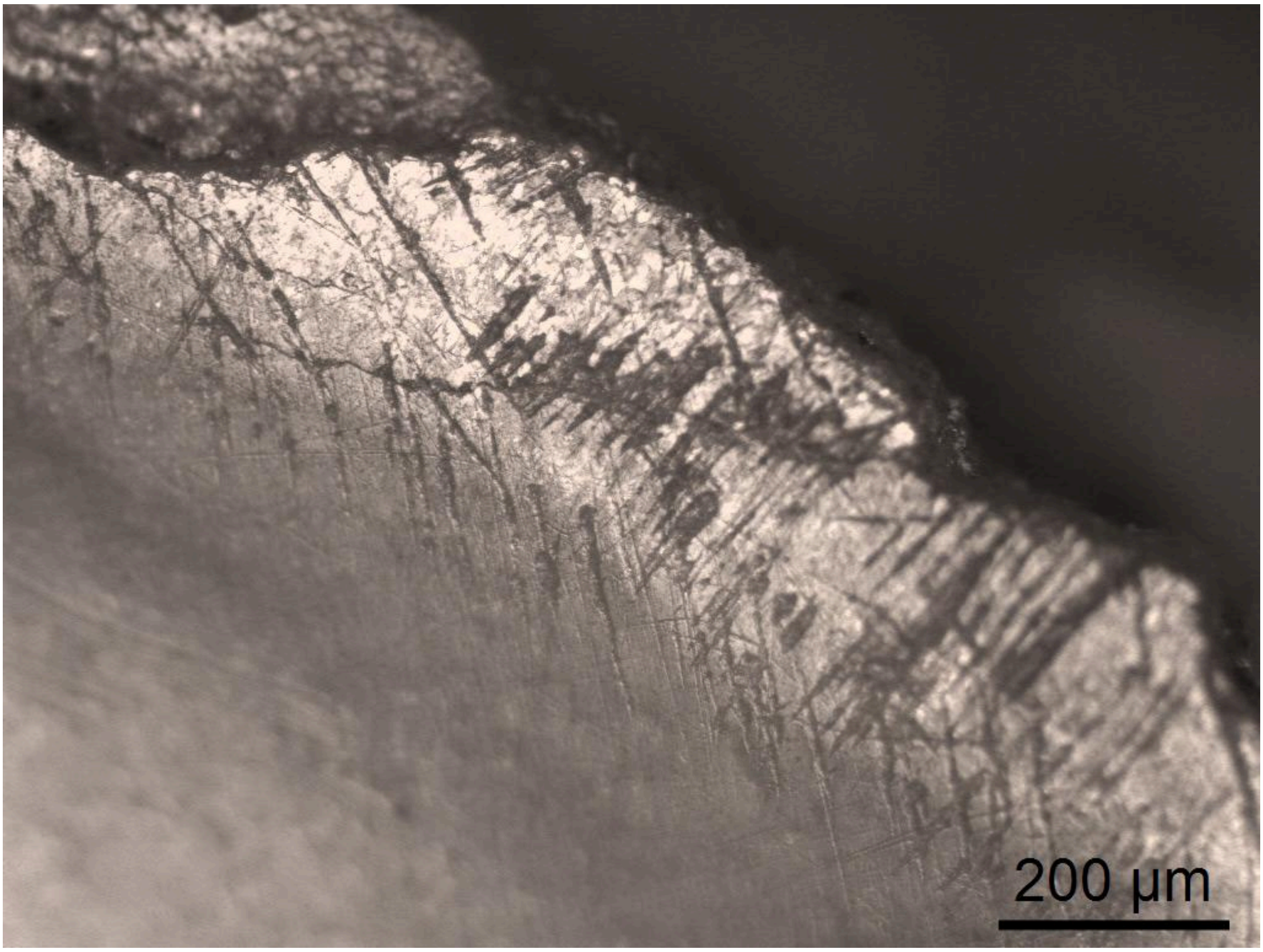

FIG 21B. (TOOL 3683) HAND-HELD OYSTER SHELL AFTER REAPING T. AESTIVUM. EDGE ROUNDING, POLISH, AND STRIATION AT 45° ANGLE VISIBLE.

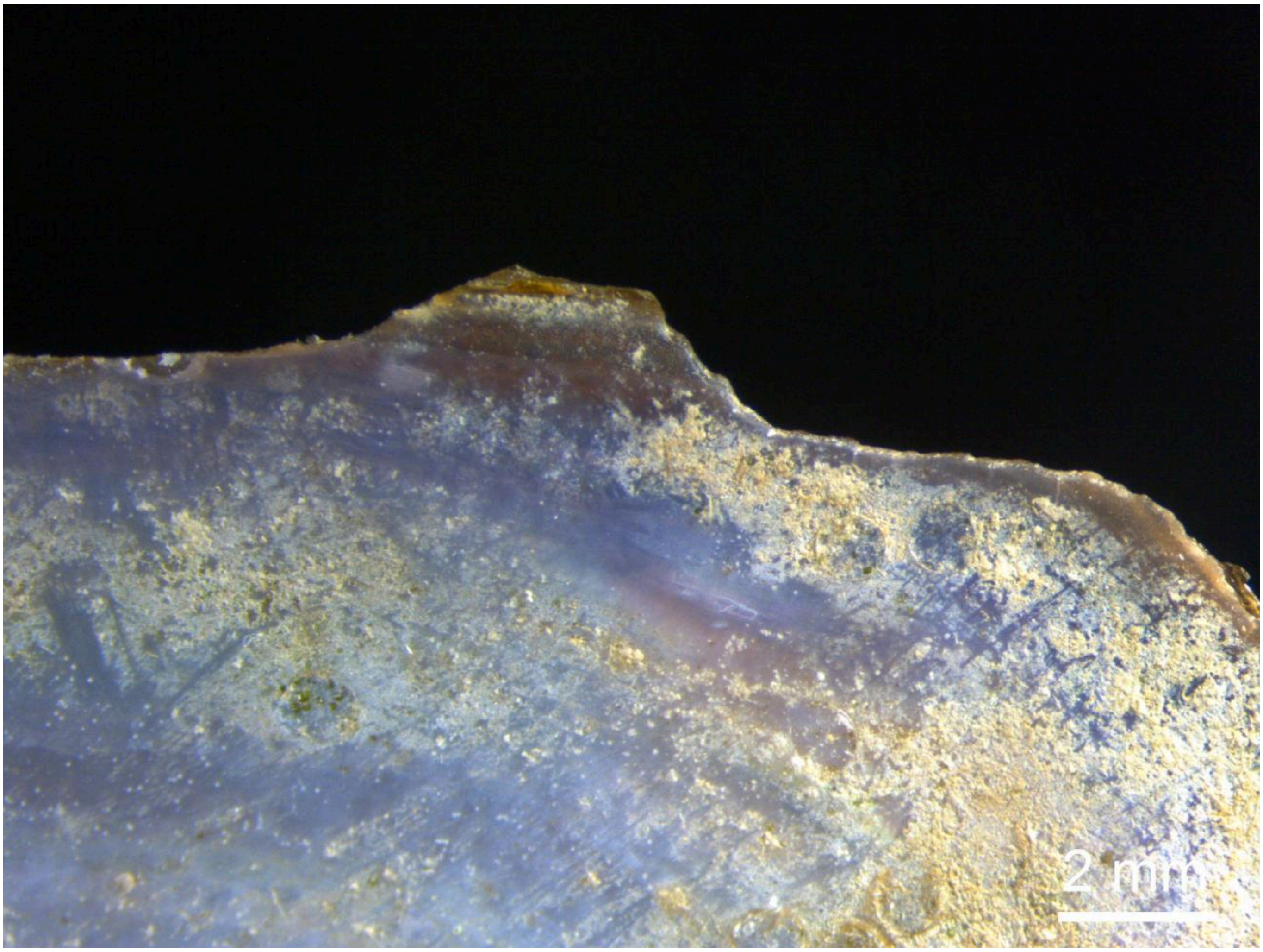

FIG 22A. (TOOL 3681) HAND-HELD MUSSEL SHELL BEFORE HARVESTING H. VULGARE. POST-HARVEST ABRASION TRACES VISIBLE ON SHELL INTERIOR.

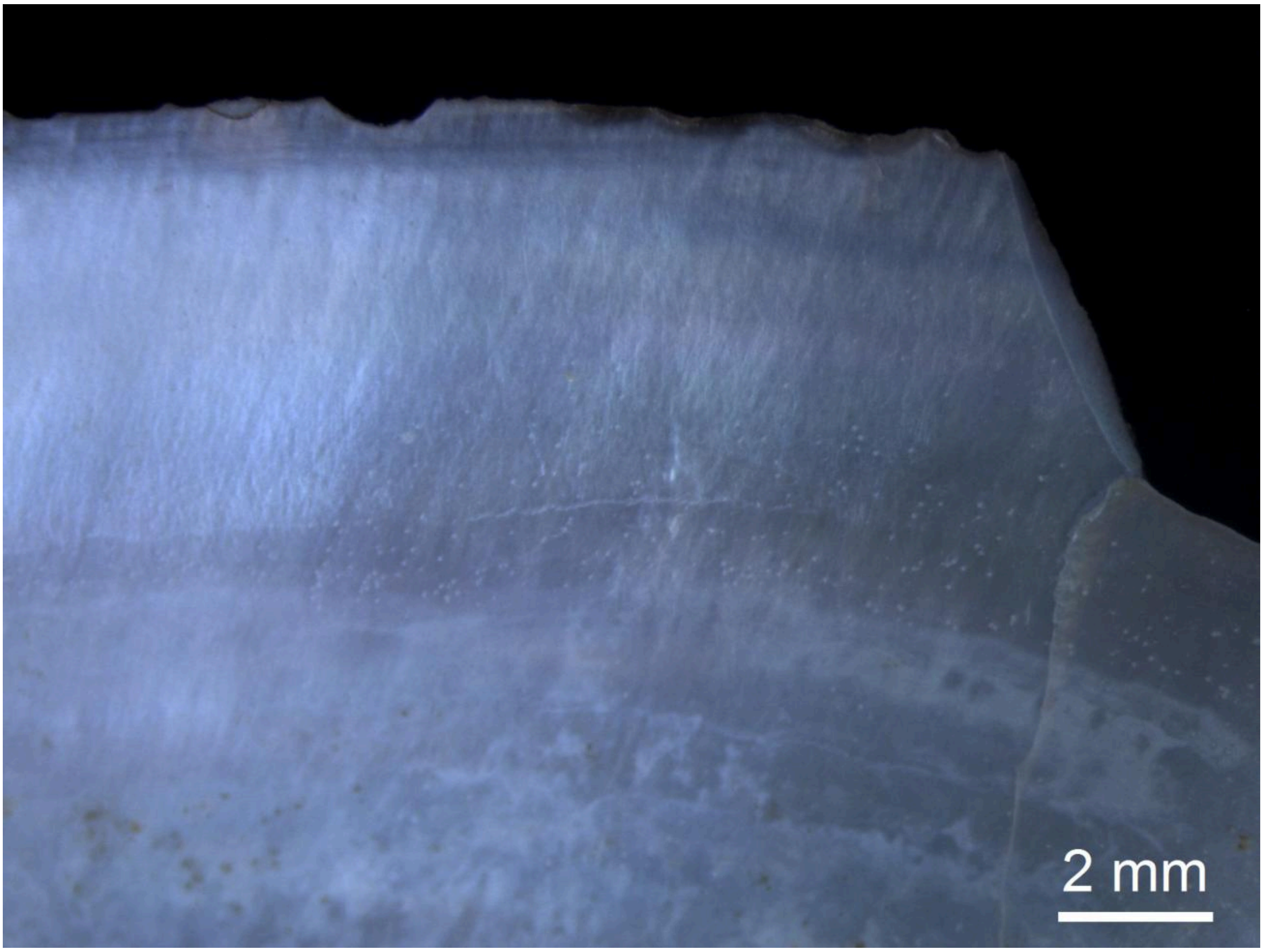

FIG 22B. (TOOL 3681) HAND-HELD MUSSEL SHELL AFTER HARVESTING H. VULGARE. POST-HARVEST ABRASION TRACES VISIBLE ON SHELL INTERIOR.