Dominika Kofel
Institute of Archaeology and Ethnology, Polish Academy of Sciences
dmnkkster@gmail.com

# To Dye or Not to Dye: Bioarchaeological Studies of Hala Sultan Tekke Site, Cyprus

## Abstract

Dated to the Late Bronze Age (Late Cypriot II: 1450–1200 BC and Late Cypriot III: 1200–1050 BC), the site of Hala Sultan Tekke brought to light interesting evidence of textile production and possible fabric dyeing. Finds of loom weights and spindle whorls together with remains of dyer's croton (*Chrozophora tinctoria*), field gromwell (*Buglossoides arvensis* syn. *Lithospermum arvense*), and shells of *murex* allow opening a discussion over the methods and reasons for undertaking the time and cost-consuming procedure of dye production. The present article, through an examination of finds and an analysis of plant macrofossils and molluscs, tests a hypothesis of textile dyeing at the Late Cypriot city of Dromolaxia Vizatzia.

## Streszczenie

### Farbować czy nie farbować. Badania bioarcheologiczne na stanowisku Hala Sultan Tekke, Cypr

Podczas badań archeologicznych prowadzonych na terenie miasta Dromolaxia Vizatzia datowanego na okres późnej epoki brązu (okres późnocypryjski II: 1450–1200 p.n.e. oraz późnocypryjski III: 1200–1050 p.n.e.) odkryto liczne ciężarki do krosna oraz przęśliki. Znaleziska sugerują, że jednym z ważniejszych elementów gospodarki stanowiska Hala Sultan Tekke było wytwarzanie tkanin. Natomiast odkrycie skupiska pokruszonych muszli ślimaków morskich z rodziny rozkolcowatych (*Muricidae*) oraz identyfikacja, podczas przeprowadzonych analiz archeobotanicznych, nasion należącej do rodziny wilczomleczowatych *Chrozophora tinctoria* oraz nawrotu polnego (*Buglossoides arvensis* syn. *Lithospermum arvense*) pozwala na podjęcie dyskusji na temat metod oraz powodów, dla których podejmowano czaso- oraz kosztochłonny proces produkcji barwników do tkanin. Poprzez analizę artefaktów i badania makroskopowe szczątków roślinnych oraz mięczaków artykuł podejmie próbę weryfikacji hipotezy na temat farbowania tkanin w Dromolaxia Vizatzia w późnej epoce brązu.

**Keywords:** Bronze Age, Cyprus, textile production, archaeobotany

## Introduction

The archaeological site of Hala Sultan Tekke (HST) is located in the south-eastern part of Cyprus, *c.* 7 km from Larnaca (Fig. 1). The investigations have been undertaken within the Late Cypriot town of Dromolaxia Vizatzia. Due to the large area potentially taken by the settlement, the archaeological research was divided into smaller sections (Fig. 2). The exploration started in the 1970s in the so-called Area 8 and was continued intermittently for almost four decades (Fischer 2012a: 73). Over time, a series of houses arranged around a central courtyard were uncovered. Some of the buildings were constructed of large, finely-cut stones ('ashlar blocks'). Several of the houses had sophisticated features, such as carefully-paved rooms with their own wells interpreted as 'bathrooms'. In between the buildings, a street *c.* 4 m wide, which appeared to continue on the same alignment further to the south, was detected (Åström *et al.* 1977; 1983; Åström 1989). In addition to the regular excavations, trial trenches were dug to the north of Area 8 (currently City Quarter 1, CQ1) in the 1970s and at the end of the 1990s. The finds shed new light on the


Fig. 1. Map of Cyprus and the East Mediterranean with localisation of Hala Sultan Tekke.

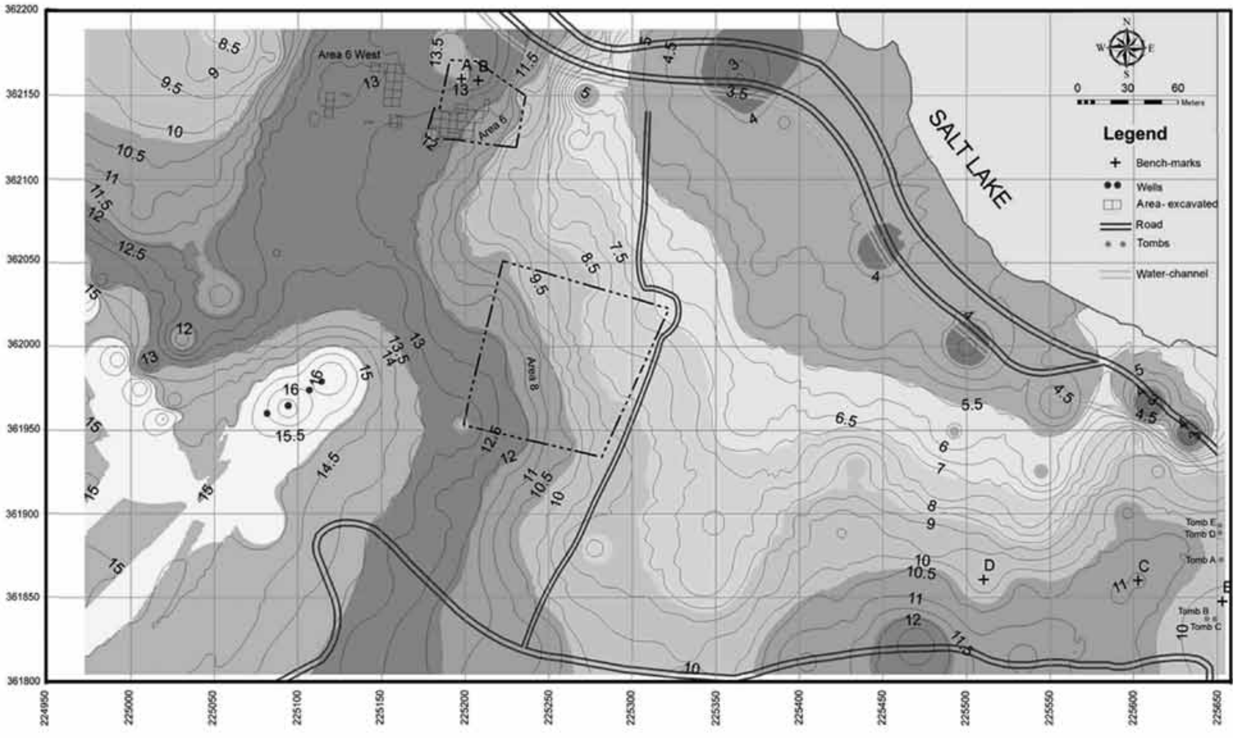


Fig. 2. Plan of Hala Sultan Tekke with localisation of the areas or city quarters researched until 2017 (drawing by M. Al-Bataineh).

occupation of the settlement dated to the first half of the Late Cypriot period (*c.* 1350 BC) (Åström 2001: 57–61). In 2010, a project titled '*New Swedish Cyprus Expedition*' was launched. The exploration started in CQ1, which is one of the three town quarters discovered and partly exposed. The others, CQ2 and CQ3, lie to the west of CQ1. Each of them was most likely inhabited by people of various professions. Based on the pottery, the life-span of this Late Bronze Age town lasted roughly from 1300 BC to 1150 BC. Around the mid-12th century BC, the town was destroyed and abandoned, never to be occupied again (Fischer 2011; 2012a).

The hitherto conducted excavations allowed determining the localisation of various settlement parts, workshops for various productions, and a possible cemetery. Additionally, three stages of site occupation have been

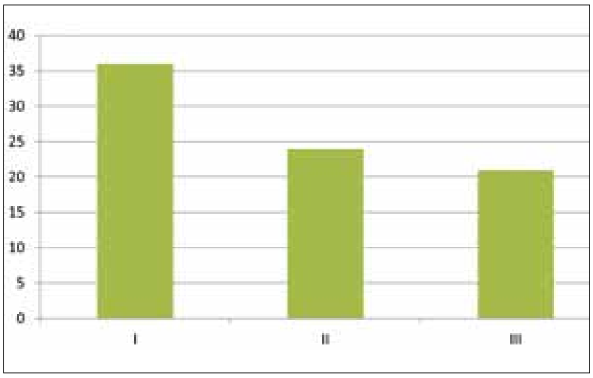


Fig. 3. Number of loom weights per strata (based on Svensson 2011; Fischer 2011; 2012b; Fischer, Bürge 2013; 2015; 2016; Miltiadous Johansson 2014).

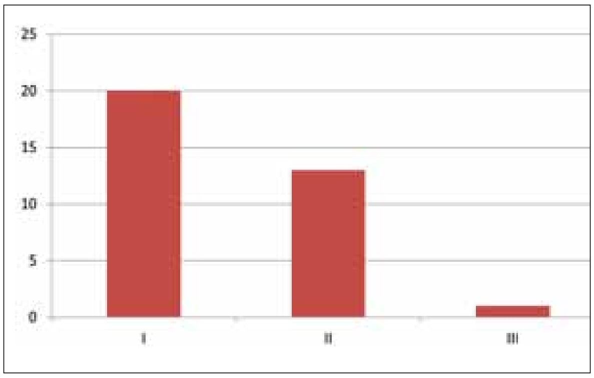


Fig. 4. Number of spindle whorls per strata (based on Svensson 2011; Fischer 2011; 2012b; Fischer, Bürge 2013; 2015; 2016; Miltiadous Johansson 2014).

recognised, which can be differentiated by a change in the colour of the soil and a shift in the construction technique of stone structures. Both Stratum 1 and 2 are dated to the 12th century BC. Unfortunately, precise dating of all the strata is not possible due to calibration plateau that occurs from roughly 1225–1130 BC. Additionally, there were artefacts that include jewellery, tools and weapons of bronze, and objects of stone and bone. The locally-produced pottery was of high quality and so were the imports mainly from the Mycenaean cultural area. The finds of copper slag, furnace walls, fragments of at least five *tuyères*, and pieces of raw copper along with moulds point to production of metal objects (Fischer, Bürge 2015; 2016).

Uncovered structures, together with artefacts and other materials, indicate that in the 13th century BC Dromolaxia Vizatzia was a developing town going through a period of intensification of industrial and commercial activities. The growth was possible due to the location of the town on the shore of the Mediterranean Sea. The surrounding area has been referred to as the 'fertile crescent of Cyprus' on account of its productive agricultural land and density of its population (Åström 1965: 119, note 19).

Undoubtedly, one of the most important components of the Late Bronze Age economy was textile production, the importance of which is reflected by numerous finds, including spindle whorls and loom weights. Throughout six years of research,[1] a total number of 81 loom weights and 34 spindle whorls were uncovered in three strata of occupation (Figs 3, 4). The question of usage of particular textile production tools was discussed at several occasions (*e.g.* Svensson 2011; Miltiadous, Johansson 2014 with further references), therefore it will not be addressed in the present paper.

Apart from the artefacts, bioarchaeological data including molluscs and plant macroremains potentially indicating dye or pigment production in the town were uncovered both at the site and in the analysed soil samples. More than 25 kg of *murex* shells were discovered in the area to the south of R40 (trench 16B) (Fischer, Bürge 2016). The preliminary studies showed that the assemblage was dominated by *Hexaplex trunculus* (Reese forthcoming), however, since further studies are being conducted, a possibility of occurrence of other species can be assumed. The plant macroremains identified in the soil samples include finds of field gromwell (*Buglossoides arvensis* syn. *Lithospermum arvense*), dyer's croton (*Chrozophora tinctoria*), terebinth (*Pistacia* sp.), olive (*Olea europeae*), and grape (*Vitis vinifera*), which may be indirectly and directly associated with textile and dye or pigment production.

The aim of the article is to verify the possibility the aforementioned bioarchaeological relics were used in the production of dyes for fabrics. Archaeobotanical and archaeomalacological data will be checked against experimental and ethnographical studies in order to examine the possible methods of use of the investigated resources.

## Material and methods

In total, 126 soil samples were collected during three seasons of archaeobotanical research, when 802 litres of

[1] The article presents data available in 2015. Since then both the archaeological and archaeobotanical researches have evolved.

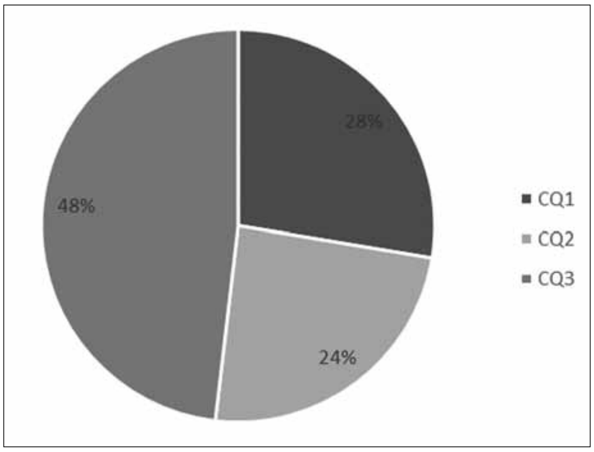


Fig. 5. Percentage share of economic plant remains per city quarters CQ1, CQ2, and CQ3 at Hala Sultan Tekke.

soil were floated with the manual bucket flotation system. Each soil sample was dispersed in water and then gently stirred to release the botanical remains. The watery solution from the upper part of the bucket was then poured through a set of sieves (0.5 mm and 0.25 mm mesh size). The next step was to pour fresh water onto the soil remains at the bottom of the bucket, and then the operation was repeated until no soil was left. Sieves retained both the heavy and the light residues after silts and other particles smaller than 0.25 mm were rinsed through. Residues were dried and the heavy elements were separated from the light elements. They were then sorted using a low-power stereo microscope at 6.3–40× magnification. The macroscopic plant remains and pieces of charcoal were picked from differently-sized residues. Plant macrofossils were identified on the basis of their morphological characteristics, whereas charcoal was determined on the basis of anatomical characteristics. Charcoal was identified under a metallographic microscope at 50–1000× magnification. All plant macrofossil and charcoal identifications were checked against the botanical literature (Cappers *et al.* 2006; Jacomet 2006; Neef *et al.* 2012; Crivellaro, Schweingruber 2013) and compared with a modern reference collection of the Department of Palaeobotany, W. Szafer Institute of Botany, Polish Academy of Sciences, and the Bioarchaeological Department of the Silesian Museum. The nomenclature follows Mirek *et al.* (2002), Cappers *et al.* (2006), and Crivellaro, Schweingruber (2013).

## Results

The main focus of the following paper was put on the results of dyes and pigments production. Nevertheless, general archaeobotanical results are also presented.[2] The first archaeobotanical analyses were undertaken in the 1970s (Åberg 1976; Hjelmqvist 1976; 1979). Both plant macrofossils (incl. charcoal) and impressions on pottery sherds and clay were researched. The studies concluded that olive, grape, and common fig (*Ficus carica*) belonged to the most common remains identified at the site. Meanwhile, the majority of the crops was represented by barley (*Hordeum vulgare*) (Hjelmqvist 1979). In the case of charcoal – terebinth, Cyprus pine (*Pinus brutia*), and olive tree were the most prevalent (Åberg 1976; Schoch 2001). The new archaeological project at HST enabled new sampling and analysis of plant macrofossils. Thus far, roughly 700 seeds and fruits of 29 different species were studied. The assemblages from the town quarters seem to be of quite unified composition. Economic plants, such as cereals, grapes, olives, almonds (*Prunus dulcis*), colocynth (*Citrullus colocynthis*), common figs, and others were present in each part of the settlement (Fig. 5). It seems that olives and grapes were the most common economic plants found at the site. They were scattered around the settlement in relatively high quantities. Herbs, weeds, and grains were most abundant in CQ3. The accumulation of macroremains of the economic plants in one of the contexts of this city quarter, along with a significant amount of ash (Fischer, Bürge 2016: 45) and animal bones, might indicate a dedicated space for food preparation or storage. CQ2 yielded finds of field gromwell, while in CQ3 – besides olives and grapes – fragments of almonds, common figs, and dyer's croton were found. The analysis of charcoal revealed a genus of terebinth and a species of the Cyprus pine.

## Discussion

Dyeing of textiles might have been inspired by body-painting used for embellishment as well as for conferring magical powers or sexual appeal, which might have been at some point transferred onto clothing. The earliest dyes or colouring substances were undoubtedly discovered by accident through staining by parts of plants (Koren 1993: 16). Choice of colours and plants strongly depended on the locally-available vegetation; the more exotic, the more valuable they became. Their value might have

[2] This publication discusses plant macroremains that might have been used in the process of dye or pigment preparation. Therefore, the matters of other, not related species and their quantiles, distribution, and interpretation were omitted. For further information, *cf.* Kofel forthcoming.

depended on symbolic meanings related to religion, status, sex, age, and/or wealth (Sarpaki 2001: 202; Koren 2005: 198). Together with textiles that themselves acted as visible symbols of power and wealth, dyes could transmit information about the rank of specific persons, places, and environments (Gleba 2011: 5), and thus help differentiate their users from others (Sarpaki 2001: 203).

### Dyes and pigments

Finds of broken molluscs shells or macrofossils of plants do not directly indicate textile dyeing at a given site (Koren 2013: 63). They might be remains of consumption or production of pigment or other colourant. At the same time, finding crushed *murex* shells at an archaeological site does not necessarily indicate that the snails served as food (Koren 2013: 63), but more likely illustrates production of a pigment (Koren 2013: 64) or, if additionally brought to a soluble form, a dye (Koren 2013: 63). For that reason, chemical studies of textile production tools could help verifying whether the yarns were dyed, and if so whether they were dyed with molluscs and/or plant dyes. This could be achieved by tracing remains of dye on, *e.g.*, loom weights in the course of a chromatographic analysis.

Before moving on to the discussion regarding dyeing, a short consideration of differences between a dye and a pigment is required. The simplest differentiation would be as follows: a pigment is a substance that is essentially insoluble in water, whereas a dye is water-soluble (Koren 2013: 62). In this vein, a pigment is a dry colour that may also be transferred into fibres but needs to be immersed in a water solution, or rubbed or pounded into the material. A binder, such as milk, bone marrow, or other sticky substance (*e.g.* tree resin), is required to fix the pigment to the textile. Consequently, a dye is a liquid containing colouring matter meant to impart a particular hue to, in this case, fibre (Koren 1993: 18). At the same time, dyeing of textiles involves a chemical reaction which creates a bond between the dye and the fibre (Koren 1993: 18). The true dyeing includes a penetration of dye molecules into the interior of the textile and forming of strong physico-chemical, non-washable bonds with the fibres. However, if oxidised, dye might become a solid pigment merged to the walls of the vat (Koren 2013: 62).

Dyes can be grouped and divided in various ways. The most general division is based on the properties of dyes in the dyeing process and might be described as substantive (direct) and adjective (mordant dyes). The first, unlike the second, can be fastened to a fibre without an intermediary or stabilising agent (Koren 1993: 26) and is represented by saffron and turmeric (Koren 1993: 27). The second group consists of mordant and vat dyes. Mordant dyes need mordant to fasten the dye to the fibre. The most common colours obtained are red, shades of purple, and yellow, which may be acquired from madder and other rubiaceous plants, insects, flavonoid dyes, gallotannins, and dyewoods (Ellis 2003: 157). Mordant dyeing involves using mediator substances, such as salts of aluminium, iron (Ellis 2003: 156), tin, or tannins obtainable from sumac leaves or oak gall 'nuts' (Koren 1993: 26). Those substances both fix the dye to the fibre and may influence the tones of the colour (Ugulu *et al.* 2009: 411).

Vat dyes undergo two chemical processes before being fixed to the fibre (Koren 1993: 27). Reduction occurs by fermentation in an alkaline solution (Ellis 2003: 156) that in Antiquity was produced by adding decomposed or stale urine, vegetable ashes, or lime water (Koren 1993: 27). To attain the final form of a blue or purple insoluble dye, wet fibres need to be exposed to the air (Koren 1993: 27; Ellis 2003: 156).

### Dye preparation

Experimental and ethnographical studies showed that preparation of the colourant out of *Muricidae* shells is a time-consuming and rather unpleasant procedure (Verhecken 1994: 33). The snails can be found close to the sea, among rocky shores overgrown with seaweeds. They have to be collected alive and preserved this way until the procedure begins because the dye is formed just after the snail dies (Koren 2013: 46). After the shell is cracked, only the meaty part including the gland with the pigment is placed in a vat. Snail meat is a necessary nutrient for the reductive bacteria also present in the snail (Koren 2013: 48). Nonetheless, it bears emphasising that detecting whether the archaeomalacological material was used for dye preparation is indeed difficult and therefore broadly discussed (*e.g.* Carannante 2010), while the shells are sometimes suggested to have had an ornamental purpose (*e.g.* used as pendants).

The process of dye production involves reduction and oxidation. During the former, the dye vat has to be covered so that the atmospheric air and sunlight do not affect the solution (Koren 2013: 44). A slab of stone or wood, which would be opened only for short periods to stir the content, was used as a lid (Koren 2013: 51). During the whole process, the mixture had to be kept at moderately hot temperature but not boiled (Koren 2013: 52).Vats were probably placed in a pit with smouldering wood pieces placed around in order to maintain relatively constant warm to hot temperatures (Koren 2013: 53). Oxidation was conducted by exposing the ready liquid to sunlight. Then, the pigment, free from the strong stench of decomposing mollusc tissue, was formed (Verhecken 1994: 34). The final colour was dependent on the original colour of the raw pigment and it might have varied from reddish-purple to bluish-purple (violet) (Koren 2013: 44). The textile was then soaked in the dye bath. If required, the textile or yarns might have been then re-inserted into the dye bath in order to obtain a richer and darker hue (Koren 2013: 61).

Most of the archaeological dyeing installations have been found close to shorelines. That is a strategic location for processing the collected sea snails from the nearby waters (Koren 2013: 58). Alkaline conditions are necessary to conduct dyeing (Verhecken 1994: 34), therefore seawater, which is naturally slightly alkaline, might have been used during the preparation of the dye bath. If required, more basic salt could have been added during the process (Koren 2013: 43). Other materials that could have been used in Antiquity to produce alkaline solutions are: stale urine, ashes of certain plants ('soda ash'), wood ash ('potash') (Koren 2013: 54), and lime with or without ash (Koren 2013: 55).

**Plants as colourants**

Producing colourants from plants seems less complicated. In the archaeobotanical material from HST, five taxa (dyer's croton, field gromwell, terebinth, grape, and olive) could be associated with textile and dye production.

Ethnographical studies indicate that dyes can be extracted from all parts of dyer's croton, which produces colours ranging from red to blue. Colours and shades are obtained through usage of mediator substances such as lime, salt, and ash that additionally combine colourants with fibres (Ugulu *et al.* 2009: 411). The dye acquired from *Chrozophora tinctoria* was, for example, used for colouring liqueurs, wine, pastries, linen, and Dutch cheeses. Its properties were supposedly known and used already in Antiquity (Uphof 1968: 128). Field gromwell occurs commonly in fields, fallows, and vineyards (Bojnanský, Fargašová 2007: 545). Roots of *Buglossoides arvensis* contain a purple dye commonly known as peasant's make-up (Ger. *Bauernschminke*) (Sauerhoff 2001: 116; Pustovoytov *et al.* 2004: 208). Such remains are commonly found in the archaeobotanical assemblages together with crops (Marinova 2003: 501; Cubero i Corpas *et al.* 2008: 88).

The genus *Pistacia* is estimated to have developed more than 80 million years ago (Parfitt, Badenes 1997) and is frequently noted in archaeobotanical material (*e.g.* Willcox *et al.* 2009). The wood was often used in carpentry, for construction, and as fuel, whereas its resin had medicinal applications (Potts 2012: 199). Moreover, galls and bark of *Pistacia* species are commonly known in Greece and the Mediterranean, where they are both used as a dye and a mordant (Sarpaki 2001: 213). Three species producing resin are common on Cyprus: *Pistacia atlantica*, *Pistacia lentiscus*, and *Pistacia terebinthus* (Crivellaro, Schweingruber 2013: 104–109). The last is claimed to be a prime source of resin in Antiquity (Nicholson, Shaw 2006: 435).

As mentioned before, the traces of olive and grape were the most common remains found at HST. Grapes and easily-storable dried raisins were used as a sugar-rich fruit and for wine fermentation (Zohary *et al.* 2012: 121). They might have also played a significant role in the dyeing procedure. During the fermentation process of winemaking, a salt of the tartaric acid (*potassium bitartate*) may be formed. This salt could be used in ancient dyeing as a mordant (Georgievics 2013: 161). On the other hand, the oil produced from olives, considered one of the most important fruits of the Old World, has been used in gastronomy, as lighting, fuel, and in cosmetics and medicines (Zohary *et al.* 2012: 116). Some authors (*e.g.* Christodoulou, Lyssiotis 2008: 10; Carannante 2010: 158) suggest that olive oil was used in the wool weaving process.

**Dyeing at HST**

In CQ3, an interesting structure, thought by the excavators (Fischer, Bürge 2016) to be probably related to textile dyeing, has been discovered. In Stratum 2, a 2.1 m × 2.7 m large basin built of a chalky, dense material was unearthed (Fischer, Bürge 2016: 44) (Fig. 6). The basin could have been used at certain stages of the process of textile, dye, or pigment production, such as *e.g.* wool cleaning. Grease and other elements, such as knots, plants, and excrements, needed to be removed. Unwashed wool is less durable than the processed fleece and dirty fibres produce a weaker thread. In addition, the dirt could hold viruses, bacteria, and smell of the sheep, which might be uncomfortable and dangerous to human health (Nobelen 2016: 20). Another process that the basin might have been used for is felting, during which hot water was applied to layers of animal hairs while they were repeatedly pressed. This caused the fibres to hook together and merge into a single piece of fabric (Fouchier 2009).

Alternatively, the basin could have been used to process flax into fibre. During the water retting, a dissolution of lignin and pectin binding the fibres with other plant tissues occurred (Kittel *et al.* 2014: 322).

Moreover, the excavators noticed pieces of a vat while excavating the basin. It might be suggested that the basin was used as a cleaning, retting, or felting container for wool or flax. Therefore, after the material was washed, it could be moved to nearby vats where dyes prepared from molluscs or plants were awaiting.

To conclude, no traces of flax fibre production have been detected at HST so far.[3] Hence, it may be suggested that wool was the main source used in textile production. Interestingly, among the natural fibres used in Antiquity, wool is thought to have been the easiest to dye, since it absorbed the colour faster than flax (Koren 1993: 18; Cybulska, Maik 2007: 186). Moreover, according to

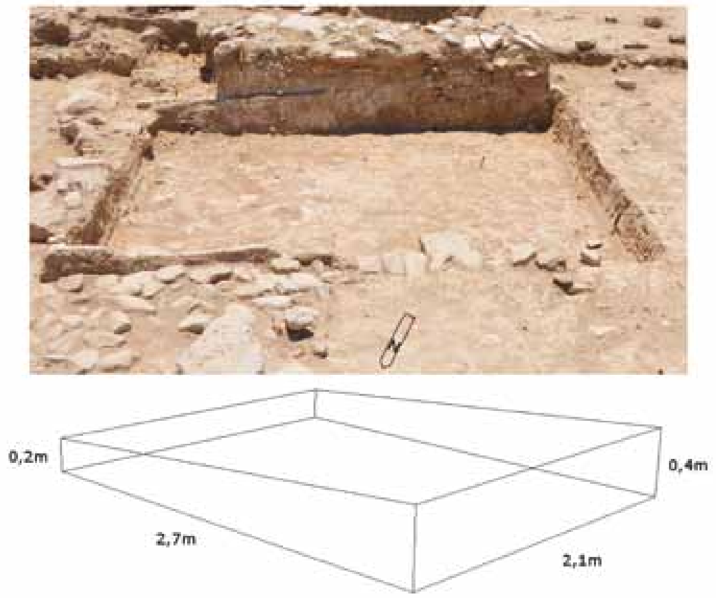


Fig. 6. Basin found in Stratum 2 (photograph by P.M. Fischer) and a sketch of its dimensions (drawing by K. Lubczyński).

Ugulu *et al.,* a low grade of reaction between wool and mordant substances would be a reason for the fibres to become of lighter colour (Ugulu *et al.* 2009: 411–412), which would allow to obtain more shades of a particular colour.

## Conclusions

Although further archaeobotanical and malacological studies are required, some general conclusions can be presented based on the recent study:

1. The basin found in CQ3 during the archaeological excavations in 2015 might have been used as a cleaning, retting, or felting container for wool or flax.
2. *Murex* shells, along with dyer's croton and field gromwell, could have been used for pigment or dye production at HST.
3. Traces of terebinth charcoal were discovered at the site. Therefore, if textiles were dyed, it is possible that one of the methods for fixing dye to the fibres was to use terebinth resin.
4. Terebinth bark and galls could have been used both as a dye and a mordant.
5. Olive oil produced at HST could have been used during the wool weaving process.
6. Wool was probably the main resource used in textile production, since practically no evidence for flax has come to light up to date.
7. Dyeing could have increased the value of the textiles produced in Dromolaxia Vizatzia, so that they became luxury trade goods.
8. Application of a chromatographic analysis on, *e.g.,* loom weights could help verifying if dyeing of yarns would take place at the site.

[3] In the 2017 season, one seed of flax (*Linum usitatissimum*) was found in the context of Stratum 3. Nevertheless, one seed is definitely not an indication of fibre production.

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