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Abbreviations

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Additionally, the following abbreviation is used:

BCILL Bibliothèque des cahiers de l'Institut de Linguistique de Louvain

The Wool Age: Traditions and Innovations in Textile Production, Consumption and Administration in the Late Bronze Age Aegean*

Marie-Louise Nosch

Abstract: Textile technology is often considered an important, yet unchanging and non-innovative technology of the Bronze Age. This paper explores traditions and innovations in Aegean textile technology and highlights the use of a series of new materials and techniques, in particular, the introduction of wool fibres, new ways of spinning and weaving, and derived innovations such as the use of plant dyes, mordants and murex dye. Very few archaeological textiles from the Aegean Bronze Age have so far come to light, but innovations and changes can be apprehended through the study of sheep bones, palaeobotany, textile tools and iconography, as well as through textile terminology.

»During the early days of his existence, man depended upon animal skins and furs to keep him warm. But as the years passed, his susceptibilities became more tender and his hide less coarse. A sheep-skin wrapped carelessly round the body may be better than nothing for keeping out the cold – but only just. Inflexible and uncomfortable, it would not fit *homo sapiens* as well as it had the sheep. Inevitably, man began to look around for something that would keep him warm more elegantly and more comfortably than an evil-smelling hide. At some point in history, he found that the long thin fibres produced by plants and animals could be twisted together to form a thread. These threads could then be interlaced to provide a flexible, warm and supremely comfortable material such as he had never known before. He had discovered cloth«[1].

A textile as a binary structure in itself is in essence one of humanity's most brilliant and stable technologies; especially in the Aegean Bronze Age when flax meets wool, wool engenders dye and mordant technologies, and domestic production is transformed into palace-monitored industries which impact on the environment, labour organisation and economies, the production of textiles generates a series of innovations which transformed the existing commercial networks, and modified the visual expression of identities and culture.

In Mycenaean times, textile production already had a more than 4000-year-old history in Greece. The basic technology of twisting fibres into yarn and interlinking yarns in a binary system dates back further than the Neolithic, and basically continues until today in our clothing. What has dramatically changed over the past 10,000 years is the fibre material from which yarn is made: flax, wool, silk, cotton, nylon and viscose; another significant modification includes the techniques and tools with which yarn is spun and woven into fabric, from Neolithic spindle whorls to spinning jennies, from prehistoric looms to the treadle loom in the Middle Ages, the jacquard looms in the early modern period and digital looms today.

In this paper, textiles form the framework for discussing the concepts of traditions and innovation in the Late Bronze Age Aegean from technological and organisational perspectives. I also examine *derivative innovation areas* engendered by Neolithic innovations in fibre technologies.

* I thank Joanne Cutler, Malgorzata Siennicka, Kalliopi Sarri, Joanna Smith, Lise Bender Jørgensen, Antoinette Rast-Eicher, Orit Shamir, Anna Michailidou, Sabine Karg, Eva Andersson Strand, Ulla Mannering and Jörg Weilhartner for discussing this topic with me and for their original ideas and valuable suggestions.

1 Introductory paragraph in Cook 1993, xi.

I will begin with an outline of the fibre innovations of both flax and wool. These are related to the innovations in animal breeding patterns and practice as observed primarily through the Linear B documentation and Aegean archaeology, as well as to the innovations in the cultivation of textile crops. Then the paper discusses the various innovations in textile techniques, which also led to innovations in clothing and textile uses: from skin and fur, to felt and textiles, including clothing and sails. These changes are mirrored in traditions and innovations in the Mycenaean textile terminologies as evidenced by the Linear B documentation; thereafter, the paper illustrates some traditions and innovations in the administration of textile production and in how textiles are recorded graphically and rendered textually. The textual, terminological and logographical rendering of textiles can illustrate how textiles are perceived by administrators, and their role of textiles in the Bronze Age economies. Finally, the organisation of textile production in households and workshops, and the archaeologists' interpretations of them, may shed light on Bronze Age innovations in more general terms. I will present some influential academic concepts of innovation and tradition and discuss how far they are applicable to the field of textile technologies.

Traditions and Innovations in Animal Breeding Patterns and Practice

Sheep in the Aegean Bronze Age[2]

The Aegean has archaeozoological traces of sheep since the seventh millennium BC, at Knossos[3], the Franchthi Cave[4] and in Thessaly[5]. The shift is highly evident at the Franchthi Cave: remains of wild animals define the Upper Palaeolithic and Mesolithic layers, but from the beginning of the Neolithic, ovicaprid bones suddenly form 90% of the faunal remains[6].

In Early Neolithic farming sites in Greece, the sex and age ratios seen in the archaeological bone remains suggest meat consumption rather than animals kept for wool, according to Halstead[7]. In the Early Bronze Age there is an increase in the number of ovicaprids and in their age, suggesting that they were kept and maintained for their wool and milk. This forms part of what Andrew Sherratt termed the Secondary Products Revolution (commonly abbreviated SPR in later scholarly literature)[8].

Sheep and goats can be exploited for various resources, such as wool, milk, hides, horn, sinew and meat. These resource exploitations can be divided into two types: the living animals yielding milk and wool, and the slaughtered animals yielding hides, sinew and meat. Of these raw materials, it is significant that only meat and milk are immediately consumable and exploitable: wool, milk, meat, sinew, horn and hides can increase durability and value through processing into yarn, fabrics, strings, cheese[9], dried meat, and tanned skins. All these processes take time and require skill, tools, and techniques, but also increase the processed commodities' value considerably. From these processes stems the rise of specialisations and technical knowledge and eventually what we, using a modern term, would call professions.

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2 Cherry 1988, 6–34; Halstead – Isaakidou 2011, 67 f.

3 Isaakidou 2006.

4 Payne 1975.

5 Halstead 1981.

6 Payne 1975, 130: »The point of most obvious and immediate contrast between the Mesolithic and the Neolithic is the abundance in the Neolithic of *Capra* and *Ovis*. Straight away, in phase E1, they are more than 90%, and thereafter usually at least 70%. *Ovis* is absent in the Palaeolithic and Mesolithic layers (…)«. For the dating of the Neolithic seeds in Knossos and Franchthi Cave to the early 7th millennium, see Perlès et al. 2013.

7 Halstead 1981.

8 Sherratt 1981; 1983.

9 Lactose tolerance is supposed to have developed along with the SPR, but lactose intolerance is less problematic if the milk is transformed into cheese and yoghurt, see Sherratt 1981, 277.

While highly convincing as an interpretative model, SPR nevertheless remains a model: not all innovations implied in the SPR model can be documented archaeologically[10]. Paul Halstead and Valasia Isaakidou question the evidence for a fourth to third millennium BC horizon of innovation as had been outlined by Sherratt. More recent faunal, archaeobotanical, palaeoecological and biomolecular studies suggest that the use of secondary products began earlier than the fourth to third millennium BC and that the intensity of use varied greatly between regions, periods and social contexts. They argue that the social and economic contexts would have had a strong influence on the degree to which the various secondary products as innovations were adopted[11]. Valasia Isaakidou recently analysed the faunal remains at Knossos and concluded that the Knossos Neolithic strata favour meat consumption. Sheep are slaughtered at a young age (between six months and two years for 50% of the assemblage) and there is a general scarcity of mature adult animals and a predominance of adult females[12]. In the Bronze Age faunal remains, by contrast, she finds an increased proportion of adult and male bones[13]. This denotes that regarding wool textile production, the SPR unfolds fully in the Bronze Age at Knossos.

In the context of this paper, it is important to note that while the SPR brought about a series of innovations, weaving was not one of them. This technology existed long before wool textile production, with the earliest evidence so far being central European Palaeolithic textile and basketry impressions on clay[14].

Herding in the Aegean Bronze Age

John Cherry has highlighted the Bronze Age patterns for ancient herding management strategies. These strategies are aimed at »maximizing economic return, or minimizing the expenditure of labour, or reducing the risk of subsistence crisis, or – very often – some combination which goes some way towards satisfying all these aims«[15].

There are several important ways of executing herding management strategies and these are clearly employed in the Late Bronze Age Aegean as we can verify in the Linear B tablets:

1. Monitoring reproduction schemes by castration (KN Da-Dg and Dn series).
2. Creating and monitoring reproductive flocks (KN Dk and Dl series).
3. Manipulating the sex balance in the sheep flocks by isolating one sex, such as the ewes (KN Dk and Dl series).
4. Manipulating the age balance in the flocks by isolating some lambs (*ki*), yearlings (*WE*) and adult animals (OVIS).
5. Specific combinations of or specialisations of animal species, such as the widespread monoculture of sheep, cows or horses.
6. Decreasing the number of animals or kinds of animals by specific slaughter patterns.

These strategies profoundly impact on herding praxes in the Mycenaean palace flocks. Furthermore, we can see that these herding praxes are also internalised in the palace administrations, since specialised scribes record each of these strategies on tablets stored in separate departments. Thus not only are ewes and lambs recorded by one group of scribes (120, 119, 118), while scribe

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10 See constructive criticism in Isaakidou 2006, 96. She emphasises how Sherratt's model provides useful evidence of the diffusion of technological innovations, but cannot be extended to demonstrate a systematic and comprehensive exploitation of a new technology. See also Halstead – Isaakidou 2011, 61 f.

11 Halstead – Isaakidou 2011, 61 f.

12 Isaakidou 2006, 101.

13 Isaakidou 2006, 107.

14 Adovasio et al. 1996; Svoboda et al. 2009; Richter 2010; Mazare 2014. See also Halstead – Isaakidou 2011, 67: »Neolithic figurines from Greece suggest textiles played a significant role in projecting social identity well before the fourth–third millennium horizon of the SPR«.

15 Cherry 1988, 6.

117 records the castrated wethers, but the first group's tablets are stored in the North Entrance Passage (I2 and I3), and the latter scribe's in the East West Corridor.

There is a general tendency to perceive transhumance[16] as solely conditioned by the necessities of the environment, landscape and climate and to disregard it as a cultural praxis[17]. Whether transhumance was practised in the Aegean Bronze Age is debatable. John Cherry is reluctant to accept generally practised transhumance, while Vance Watrous finds evidence for it both in Early Bronze Age Myrtos in Crete, and Early Iron Age Karphi in central Greece[18].

In the Linear B records there is no evidence of transhumance, instead we have attestation to a specialised pastoralism set in a defined system on a large scale and with a strong element of ›state‹ intervention[19]. It seems to be a unique situation in ancient animal-breeding history of the Aegean. Thus in many respects, parallels from ethnographic sources or comparative studies of herding in other cultures and continents are not pertinent[20]. They may be introduced for analyses of ancient breeding praxes but are not necessarily reliable parallels for the highly specialised Mycenaean pastoralism[21].

The Properties of Bronze Age Wool

Following the domestication of sheep and goats in the Neolithic, Bronze Age wool gradually developed new properties[22]:

1. Decreased hairiness and increased volume of under-wool
   This made the wool more spinnable and gave rise to a wider range of yarn qualities, which in turn could be used to produce a broader spectrum of fabric qualities.
2. Increasing fibre uniformity
   Histograms of fibre qualities show how primitive breeds have a large variety of fibres; gradually fleeces become more homogenous and have more and finer fibres (Fig. 1).
3. Gradual stop or control of the natural moulting of the fleece
   A shepherd would not want his sheep to lose their wool randomly; he would wish to collect it, preferably in a limited time frame. Instead of constantly combing and plucking the wool throughout the moulting season, the control over the moulting process places sheep herding in a more structured and seasonal scheme in which wool collection becomes organised and fixed in time.

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16 For a discussion of transhumance in the Bronze Age as well as a valuable discussion of the history of research into pastoralism and transhumance by modern scholars, see Cherry 1988, 9.

17 Cherry 1988, 14 f.

18 Watrous 1977; Cherry 1988.

19 Cherry 1988, 17.

20 See the discussion of ethno-archaeology in Cherry 1988, 19 f. Hodkinson 1988 and Garnsey 1988 have emphasised that specialised pastoralism and transhumance are not natural outcomes based in a typical Mediterranean environment and climate. On the contrary, they are a result of very peculiar historical situations. Hodkinson 1988, 35–74 compares the situation in early modern Spain (the *Meste* of Castille) and southern Italy (the *Dogana* of Puglia) where large-scale transhumance and extreme sheep-herding specialisation were developed due to the large concentrations of land under a few wealthy families. Likewise, Hodkinson emphasises the Sarakatsani shepherds who conducted large flocks over long distances, but who were acting under large Turkish or Orthodox monastic estates and were profiting from the high demand for wool, meat and milk in the coastal areas, on the islands and in 19th and 20th century Athens.

21 Hodkinson 1988, 56: »Long-distance transhumant pastoralism has usually been dependent upon specific historical circumstances, such as the weakness of lowland agriculture, a high level of market demand for pastoral products and a unified (and, ideally, *dirigiste*) political authority«. See also Garnsey 1988, 19 f. For a late 18th-century AD approach to shepherding, see Daubenton 1795.

22 Ryder 1969, 495–521; Rast-Eicher – Bender Jørgensen 2013. It is important to notice that these developments did not only take place during the Bronze age but continue in historical periods.

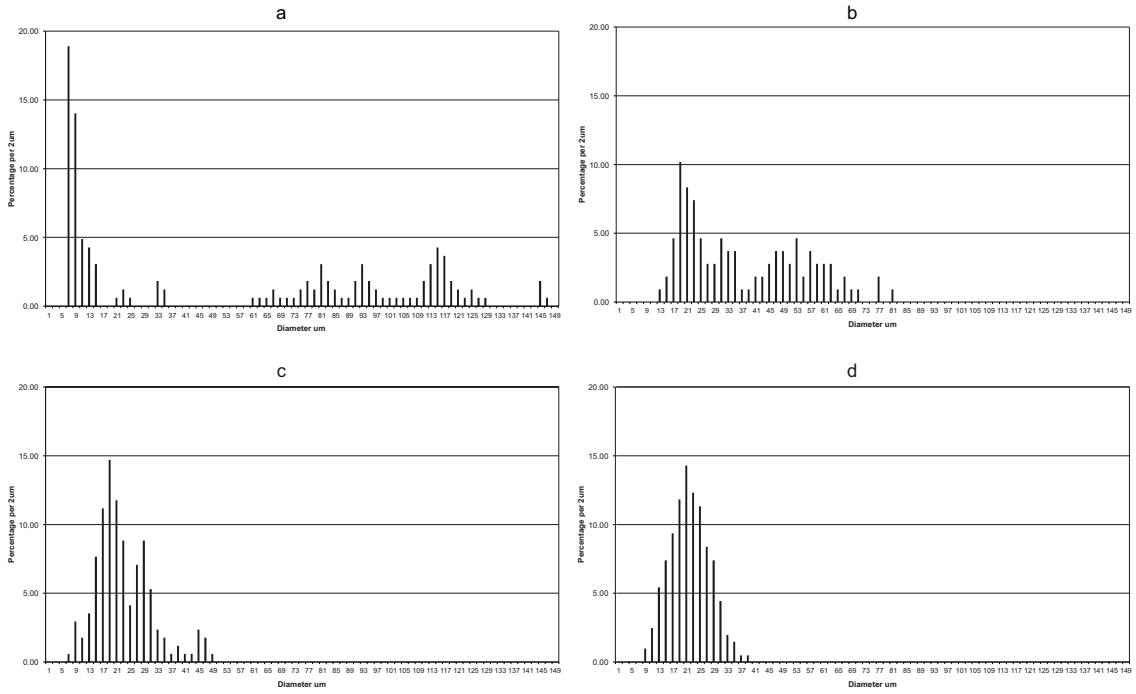

Fig. 1: Four histograms illustrating the four types of wool and their development over time: a. the hairy type, with a wide range of fibre diameters; b. mixed fibre type, with fibres of 13–80 microns; c. coarse and fine fibres; d. fine wools with fibres of c. 15–25 microns. The hairy type (a) has two distinct properties, hair and wool. In the subsequent types (b. c. d), hair disappears and wool becomes finer and more homogenous (after Rast-Eicher – Bender Jørgensen 2013, courtesy of authors)

4. Natural pigmentation could be altered or manipulated to achieve breeds of desired colours
   The natural pigmentation of sheep can be black, brown, reddish, grey and yellowish to white. White wool and light hues are especially desirable in order to be able to apply dyes. Experimental archaeology also demonstrates how the basic shades in pigmentation result in a wide spectrum of hues when over-dyed in one dye bath. This again enlarges the range of yarn and fabric types.

These new properties arose from the targeted selection of animals with the desired characteristics via strategies of out-breeding and cross-breeding. It is thus a specialisation and the product of gradual innovation in the hands of shepherds. It is tempting to assume that the shepherds' experience and knowledge of these processes and properties would enhance their status in Bronze Age societies. In the Linear B records at Knossos, about 330 shepherds are recorded by their personal name and the place name to which they are affiliated. Firth concludes that 38% of these names can be interpreted as Greek male names[23].

In English, the ›shepherd‹ is the keeper of ›sheep‹ which gather in a ›flock‹. Other animals are ›herded‹ by a ›herdsman‹, and gathered in a ›herd‹. Interestingly, in Mycenaean Greek, there is a specialist vocabulary on herding: the ›shepherd‹ is called *po-me*, *poimēn* (cf. ποιμήν), while the ›goat-herd‹ is a_3*-ki-pa-ta*, *aigipastās* (cf. αἴξ, πατέομαι), the ›swine-herd‹ *su-qo-ta*, *sug*^{w}*ōtās* (cf. συβώτης), and the ›cow-herd‹ *qo-u-ko-ro*, *g*^{w}*oukolos* (cf. βούκολος). In the first millennium BC Greek, *poimēn* becomes a general designation of the herdsman of sheep or oxen regardless, and then specialises again into a shepherd only for sheep and goats (cf. the same semantic development of πρόβατα, first denoting domestic animals in general and then towards the end of the first millennium BC restricting its meaning to sheep/goats). From the occupational designation *poimēn* derives the verb ποιμαίνω.

23 Firth 1995, 95; Landenius Enegren 2008, 37 questions the interpretation of this percentage.

Brent Shaw[24], followed by John Cherry[25], views nomadic pastoralists as an archetype in contrast to farmers. He emphasises the cultural dichotomy in antiquity between farmers and nomads. I do not see evidence for such strict typological divisions in the Aegean, apart from the exceptional situation in the Mycenaean palace system.

Archaeological Evidence for Wool Textiles in the Second Millennium BC Aegean and Beyond

Regrettably, textiles and other organic remains are rarely preserved in the Aegean. At MBA Akrotiri, Thera, about 50 fragments of wool thread were discovered[26]; at LBA Chania in Crete, a tiny carbonised textile ribbon was recovered combining nettle (of uncertain identification), linen and goat hair[27]. At Arslantepe in Anatolia, the analysis carried out on a preserved textile fragment from the Royal Tomb revealed one of the world's oldest pieces of what is probably a goat hair textile, dated to 3000/2900 BC[28].

In a tomb from the Old Kingdom was unearthed a tuft of white, unspun sheep wool. It had a fibre length of 2 cm and an average fibre diameter of 34.6 microns with a quite even distribution from the thinnest fibres of 12 microns to the coarsest fibres of 110 microns (thus between type a and b in Rast-Eicher – Bender Jørgensen's 2013 classification, see Fig. 1). This signifies that by 2000 BC in Egypt, this wool had lost its natural darker pigmentation. It had also lost its kemp character and became more homogeneous, what Michael Ryder terms the hairy medium wool[29]. Another example of raw wool from a temple store of Akhenatan at Tell el Amarna is dated to the 14th century BC. These samples also had no pigmentation and the fibres were c. 6.5 cm long. The qualities range from a generalised medium wool to a hairy medium type consisting of fine and medium fibres and only a few coarse fibres. These wool samples had an average fibre diameter range from 14 microns to 74 microns with the average diameter of 29 microns and the mean diameter between 26 and 43 microns[30]. Thus, based on these two samples only, we could suggest that during the Bronze Age in Egypt, wool fibres become longer, slightly thinner and more homogenous.

In the southern Levant, rich evidence for plant-fibre textiles exists, especially in Chalcolithic contexts. Bone material shows the early use of sheep and goat, similar to the Aegean. Yet in the southern Levant, wool textiles occur only from the Middle Bronze Age, for example at Jericho or at Tall Mozan in Syria[31]. Orit Shamir suggests associating the Middle Bronze Age occurrence of wool textiles not with sheep domestication or wool developments, but with the introduction of the warp-weighted loom which we also see as a Levantine innovation from the Middle Bronze Age[32].

From central Europe, recent research has identified Bronze Age wool characteristics based on skins and textiles. Fleeces are short, less than 5 cm, and of a combination of fine light-coloured under-wool and coarser and darker fibres. Interestingly, in Hallstatt Middle Bronze Age (c. 1500–1245 BC) wool fibres in textiles are generally finer than those found on fleeces, suggesting that wool selection and sampling took place[33]. This points to another important strategy

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24 Shaw 1982/1983.

25 Cherry 1988, 29: »It is well-known that nomads, ancient or modern, have never had a ›good press‹ and that, for classical antiquity, we depend largely on unsympathetic accounts, rarely based on personal autopsy, by historians, geographers, military men and administrators, to whom pastoralists were either an irrelevant curiosity or an irritating impediment«.

26 Moulhérat – Spantidaki 2008; Spantidaki – Moulhérat 2012, 189.

27 Spantidaki – Moulhérat 2012, 189.

28 Frangipane et al. 2009, 19 f.

29 Ryder 1969, 497–500.

30 Ryder 1972; 1974, 100–110. This would correspond to fibre type b in Rast-Eicher – Bender Jørgensen's classification, see Fig. 1.

31 Shamir 2014; Rothenhäusler, in press.

32 Shamir 2014.

33 Rast-Eicher – Bender Jørgensen 2013. On the available evidence for Early Bronze Age archaeological textiles in central and northern Europe, see also Rast-Eicher – Bender Jørgensen 2015.

in animal breeding and fibre specialisation: when fibre qualities could only be controlled and genetically manipulated to a certain degree via cross-breeding, selective breeding and specialised shepherding, wool qualities could be controlled manually by sorting and gathering fleeces and tufts with specific qualities, hues, shine etc. Even with a sheep flock of highly mixed wool qualities, a skilled wool-sorter could identify and categorise a range of qualities destined for both the finest and the coarsest textiles. We have no Linear B evidence for wool-sorters as a professional occupation, neither do we have written evidence for wool categories[34], but the standardisation of wool textile types suggests a rigorous distinction between wool qualities, and this is enabled by a specialisation in herding and wool sorting.

Evolutionary Theories of Wool Fibres

Michael Ryder sets the archaeological finding of wool into an evolutionary and binary scheme of wool fibres[35]: »About 1500 BC both the primitive people of northern Europe, and the civilisations of Egypt, had generalised types (….). The wool in North Europe was naturally brown, while that in Egypt was white. Surprisingly, however, the Egyptian wool was coarser. This theme of finer wool in more primitive areas, or in earlier periods, is repeated throughout subsequent history«[36]. Thus, Ryder uses an interpretive model based on ›centre *versus* periphery‹ and ›primitive *versus* modern‹ and their different capacities of innovation, blending, and conservation. The primitive peripheries become the keepers of the finer qualities, while the core areas decrease in quality and instead obtain more uniformity and average qualities according to Ryder. A more recent study of Bronze Age archaeological textiles reaches a similar conclusion: the wool qualities in Scandinavian Bronze Age textiles are generally finer than those found in central Europe. However, the textile experts Antoinette Rast-Eicher and Lise Bender Jørgensen interpret this result as being a trace of a special ›Nordic‹ sheep type which differs genetically from central European and Near Eastern sheep types[37].

Colin Renfrew[38] presents another evolutionary model of how textile production and wool fibres evolved in the Neolithic and Bronze Age: »Much of the evidence is inferential since the products of the craft, the textiles, have not been preserved. That there was a considerable trade in woollen textiles in the Aegean Late Bronze Age seems likely enough. In Early Neolithic times, at least, flax was probably the principal fibre used. When the transition came we cannot be sure, but it may well have been at the end of the Neolithic period where there is, for the first time, plausible evidence for the warp-weighted loom. If these conclusions are sound, we must imagine a textile industry growing up in the same way as metallurgy, with the excellence of the new products creating a demand and an increase in production, which in turn led to technical innovations and further improved products. This standard positive feedback growth pattern will have operated in the same way for many developing crafts«.

There are several comments to be made regarding Renfrew's model. Firstly, it is worth noting that Renfrew sets metallurgy as a normative and formative model for textile production, although textile techniques including weaving are much earlier crafts than metallurgy. Secondly, demand is fuelled by excellence and novelty, not by need or practicalities, according to Renfrew. Thirdly, Renfrew associates the appearance of the warp-weighted loom with the appearance of wool but this equation cannot be generally confirmed: there are loom weights from 5500 BC in central

34 Nosch 2014.

35 Ryder 1969, 500: »Most of the major variations in sheep, i.e. in the horns, tail length, and the appearance of a white, woolly type of fleece seem to have taken place by the time that illustrations and records first appeared in Mesopotamia about 3000 BC, i.e. during the first half of the period since domestication. This seems to be an example of the principle that evolution along a new line at first proceeds rapidly, and then slows down. In addition, the fact that evolution progresses more rapidly in smaller populations may have been a contributory factor«.

36 Ryder 1974, 110.

37 Rast-Eicher – Bender Jørgensen 2013. This conclusion is based on finds from Norway, Sweden, and Austria.

38 Renfrew 1972, 350–354.

Europe, long before wool is attested, and the warp-weighted loom can be used for linen as well[39]. Loom types, horizontal or vertical, do not correspond to the fibre types – flax and wool. The misunderstanding of connecting the occurrence of wool with the appearance of textile tools and textile production is also found in other scholarly works[40]. It may be correct in places such as the southern Levant (see above), but it is no general rule. Indeed, plant-fibre textiles existed long before wool, and textile and basketry impressions on clay have been recovered from the Upper Palaeolithic at 27,000 BP from Dolni Vestonice and Pavlov in the Czech Republic in central Europe[41].

Finally, fibre analysis of Bronze Age textiles indicates that an increase in production does not necessarily lead to improved products. Fibre qualities in northern Europe in the 14th century BC are finer than in contemporary Egypt with its state controlled production. This, as we have seen above, made Michael Ryder suggest that wool fibres evolved into a coarser and more standardised type in the core areas and remained finer in the peripheral areas of Europe.

Bronze Age Wool Terms

Elizabeth Barber suggests that since wool has a common root in the Indo-European languages – ›wool‹ in English, ›Wolle‹ in German, *lēnos* in classical Greek, *hulana* in Hittite – it is possible that the people speaking Indo-European languages (Anatolian, Celtic, Germanic, Indo-Iranian, Balto-Slavic, Armenian, Greek and Latin) would still have lived together somewhere in west-central Asia when around 4000 BC the soft and spinnable wool appeared as a further result of the domesticated sheep[42].

However, already in Mycenaean Greek there is another term for ›wool‹, *eiros*. It is attested indirectly in Linear B through its adjective *we-we-e-a*, *werweheha* (cf. εἶρος) meaning ›woolen‹, in KN L 178 and L 870. Pierre Chantraine suggests an interpretation for the etymology of *eiros*: »quant à l'étymologie, on peut entrevoir un rapport avec la famille du grec ἀρήν, latin *vervex*, etc., mais rien n'est démontrable«[43].

This means that in Greek there is a shared Indo-European root for wool, and another term for wool perhaps related to the technical term for wether. If this were true, it would suggest that the shared Indo-European term would mean hair/kemp/fleece/wool of sheep and goat, but that with domestication and the increased wooliness of sheep, the Bronze Age people generated a new and more specialised term for the wool fibres taken from the domesticated and castrated male *Ovis*.

Flax: Specialisation and Intensification

The first textile fibre, and the first textile crop, is flax[44]. One of the earliest pieces of evidence for a woven linen textile is from Egypt, from Fayum c. 5000 BC[45]. Daniel Zohary and Maria Hopf conclude that »the available archaeological evidence clearly suggests that flax belongs to the first group of crops that started agriculture in the Near East […] the gradual increase in seed size and the use of linen indicate that flax cultivation was, very probably, already practiced in the Near East

39 Hoffman 1964.

40 Vandkilde 2007, 59 expresses the same common misunderstanding that weaving and spinning only appear with the appearance of wool as a secondary product. Vandkilde connects the shift towards cattle in the fifth and fourth millennia BC and sheep and goats kept for their secondary products with the occurrence of spindle whorls and loom weights in settlements: »Moreover, loom-weights and spindle-whorls begin to appear on the settlements, implying that weaving was practised. Some sites even have impressions of textiles on the surface of pots«.

41 Adovasio et al. 1996; Svoboda et al. 2009; Richter 2010; Mazare 2014.

42 Barber 1991; Chantraine 2009, 612.

43 Chantraine 2009, 309 f.

44 According to archaeobotanist Hans Helbæk, *Linum* cultivation began in the Near East around 5000–4500 BC, the so-called Halaf Period. See Helbæk 1959, 110. The plant would have been used also before domestication.

45 Caton-Thompsen – Gardener 1934. See Helbæk 1959, 103–129.

before 6000 BC«[46]. However, it is important to consider that this early evidence may attest to flax for linseed oil[47] or for fibre, or both. Hans Helbæk believed that flax was first used for its seeds and later for its fibre, observing that: »In the Near Eastern region where the seed agriculture of the Old World took its first faltering steps several wild species of the genus *Linum* are distributed and undoubtedly the first farmers knew the commonest of them in advance for its nourishing seeds. Eventually they would have discovered also that its stem was highly useful in that the best fibres after suitable treatment could be spun to string and thread which ultimately would have given rise to the art of weaving«[48].

New data on linseed sizes may shed light on the early exploitation of the flax plant. In ancient Near Eastern excavations linen seeds have a length of c. 4.0 to 4.7 mm and a width of c. 2.3 to 2.7 mm. It is significant that these sizes remain consistent for data from 5000 BC to c. 1800 BC[49]. In contrast, in central Europe flax seems to split into two kinds at an early stage, one with large seeds for linseed oil, and another with smaller seeds for textile fibre. Archaeologists and archaeobotanists Christoph Herbig and Ursula Maier examined waterlogged flax seeds from a series of 32 wetland settlements from Late Neolithic sites (dated 4000–2200 BC) in the Alpine region. Flax seeds of the early phase 4000–3700 BC are significantly larger than seeds from the following periods[50]. This difference in size cannot be explained by natural or climatic variations. The researchers conclude that two varieties of flax were cultivated in the Late Neolithic: in the early phase, a flax type with larger seeds is used for both oil and fibre production, just as in the Near East[51]. However, in the middle of the fourth millennium BC, around 3400–3300 BC, a flax type with smaller seeds appears. From that moment textile production increases, and at around 3000 BC flax cultivation and textile production become intensified and specialised. An example is the Upper Swabian Alleshausen-Grundwiesen site where the prehistoric inhabitants were constantly occupied with flax cultivation and flax-fibre processing[52], a real central European ›flax-boom‹[53]. This is concurrent with Sherratt's proposed SPR[54].

Bronze Age Greece, where few flax seeds are preserved, thus seems located between two agricultural regimes: the area of large-seeded *Linum* attested in dynastic Egypt and in the Near East, and that of the small-seeded fibre-efficient *Linum* of Neolithic Switzerland[55]. It is, therefore, tempting to wonder if the double terminology in Linear B of *SA* for flax plants[56] on the one hand and Mycenaean *ri/ri-no*, *linon* (cf. λίνον) and ›linen‹ for the linen textile products on the other hand is not only a conservation of the Minoan flax terminology but also echoes the conception of the use of this plant for two quite different purposes.

Plant Fibre Innovations and Traditions

There are other textile plants[57] which we may assume were introduced along with flax in the Aegean although there is very little archaeological or epigraphical evidence for this. It is impor-

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46 Zohary – Hopf 2000, 132. See more generally 126–132.

47 One of these few early flax finds are three flax seeds dated 5800–5600 BC from Tell es-Sawwan, middle Tigris, Iraq. See Renfrew 1969, 156. 167.

48 Helbæk 1959, 104; McCorriston 1997.

49 Helbæk 1959, 109 tab. 1.

50 Herbig – Maier 2011, 529.

51 Maier – Schlichtherle 2011, 571 f.

52 Herbig – Maier 2011, 531.

53 Herbig – Maier 2011, 532. See also Maier – Schlichtherle 2011, 571.

54 Sherratt 1981, 261–305.

55 Helbæk 1959, 105; Gavalas 2002/2003. However, the early 7th millennium evidence of cereal agriculture in the Argolid and Crete must be noted, see Perlès et al. 2013.

56 Rougemont 2007 suggests instead that *SA* designated the fibres in a more raw or retted stage, while *ri* indicates the cleaned and processed fibres ready for spinning or already spun. See also Nosch, in press.

57 André 1985.

tant to remember that textile plant fibres, such as flax (*Linum usitatissimum* L.), nettle (*Urtica dioica* L.) and hemp (*Cannabis sativa* L.) grow in quite different environmental systems. Nettle can only be cultivated with difficulty but must be gathered, preferably near nitrogen-rich soils, while flax and hemp crops can be sown annually and integrate well within the shifting regimes of cereal cultivation. Thus, a centralised authority such as the Mycenaean palaces would choose flax and hemp as primary plant fibre crops since they can be exploited systematically. However, we still know very little about these textile crops in the Bronze Age Aegean, and the few random empirical finds tend to direct and define their interpretation, perhaps excessively. An example is hemp, an annual plant used for textile fibre. Hemp resembles flax, and is processed in a similar way. Hemp is often used for rope, sacks, caulking, nets, packing, mats and sailcloth, but it can also be processed into fine fibres and clothing which can scarcely be distinguished from linen in archaeological textiles[58]. Hemp has been known since the Neolithic in central Europe and Asia, but according to several scholars it was not used in the Mediterranean area before the Early Iron Age[59]. This late date is due to the fact that the earliest findings are from the first millennium BC: in eighth-century Gordion, textiles of hemp were recovered, and a hemp shirt was found in the fifth-century kurgans from Pazyryk[60]. Yet it seems unlikely to consider hemp a first millennium BC innovation or to imagine that the Mycenaeans, who mastered the mechanical and chemical treatments of plant fibres, who had boats and naval initiatives, who organised the extensive cultivation of various crops and who were engaged in international networks, would not have known or used hemp.

Nettle is also not attested in any written sources as a fibre plant, but the situation is now different since it has probably been identified in a tiny ribbon from Late Bronze Age Crete[61]. Nettle fibres are similar to those of flax and hemp, but nettle-fibre use probably does not represent an innovation but rather the evidence of how different fibre plant species share a common highly developed fibre preparation technique.

Innovation in Textile Techniques

Spinning

Research in Neolithic and Bronze Age plant-fibre based textile products in the Alpine region demonstrates that a new spinning technology appears, perhaps as a result of the gradual introduction of wool as spinnable material. Earlier, plant fibres were spliced together and subsequently spun on a heavy spindle whorl into thread; from the Early Bronze Age, a smaller type of spindle whorl appears with the regular range of textile tools, suggesting that splicing is no longer the only spinning technique, and that fibres – wool – can be spun directly from the fleece. This central European trend may have been a forerunner of innovation, or it may have originated in the Aegean. In Greece, this technical development can predominantly be analysed on the mainland, where many spindle whorls have come to light. In the southern Aegean, with fewer finds of spindle whorls, this change is less visible in the archaeological record. However, in the Aegean, the situation is less straightforward than in central Europe. In the Aegean Neolithic spindle whorl assemblages, there are both heavy and very light spindle whorls, whereas spindle whorls in the Early Bronze Age I–II assemblages are often heavier, more standardised, with fewer small and

58 Barber 1991, 15.
59 Barber 1991, 18.
60 Barber 1991, 18.
61 Spantidaki – Moulhérat 2012, 189.

light specimens than in the Neolithic[62]. Thus, based on the study of spinning tools, there is no linear evolution towards finer threads in the Aegean[63].

Weaving

There are different technical terms for weaving: Gr. *plekein*, ›to plait‹, and Gr. *hyphainein*, ›to weave‹. The word for ›loom‹, Gr. *histos*, is found in Mycenaean Greek in the occupational designations *i-te-ja-o*, *histeiāhōn* (genitive feminine plural) ›of the female weavers‹. This is based on the root **sta-* in *histamai*, a stable, standing device[64]. The loom is called *histos* in first millennium BC Greek, and most probably also in the Late Bronze Age[65]. Loom weights are called *agnuthes*, a term without Greek etymology, or they are called ›stones‹, *lāes*[66]. This terminology may mirror the usage of stones as weights in the warp-weighted loom, especially in Mycenaean MBA–LBA Greece where clay loom weights are rarely found. While many elements of the loom are clearly Greek, it is significant that the terms for those devices for changing the shed are not Greek: the heddles (*mitos*) are of Semitic origin, the heddle bar (*kanōn*) and the shed bar (*kairos*) are of non-Indo-European roots[67]. This raises the question of twill which was long considered an Iron Age invention. However, this is questioned by the Chalcolithic twill textile fragment found in Alishar, Anatolia[68], as well as a 2/2 twill from the Hallstatt Middle Bronze Age[69]. Furthermore, Agnete Wisti Lassen suggests interpreting some second millennium iconographical motifs as depicting twills with a pattern that is distinctly different from that of tabbies[70]. No Linear B term suggests the existence of twill.

Heddle Innovation and the Mechanisation of the Loom

In a passage of the Iliad (Hom. Il. 23, 759–763) a foot-race between Ajax and Ulysses is described, and Ulysses is right behind Ajax, as close as a girl pulls the heddle bar (*kanōn*) to her breast:

ἔκφερ᾽ Ὀϊλιάδης· ἐπὶ δ᾽ ὄρνυτο δῖος Ὀδυσσεὺς
ἄγχι μάλ᾽, ὡς ὅτε τίς τε γυναικὸς εὐζώνοιο
στήθεός ἐστι κανών, ὅν τ᾽ εὖ μάλα χερσὶ τανύσσῃ
πηνίον ἐξέλκουσα παρὲκ μίτον, ἀγχόθι δ᾽ἴσχει
στήθεος· ὣς Ὀδυσσεὺς θέεν ἐγγύθεν, αὐτὰρ ὄπισθεν
ἴχνια τύπτε πόδεσσι πάρος κόνιν ἀμφιχυθῆναι[71].

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62 Also Carrington Smith 1977, 260 observed the increasing sizes in the EBA (but I believe that her explanation, the arrival of flax, is incorrect): »The most notable difference between Neolithic whorls and Early Bronze Age whorls lies not so much in their forms, as in their sizes. There must have been a reason why larger, heavier whorls became popular in the Early Bronze Age, and that reason may well have been supplied by the arrival of flax in Greece«. This pattern is also observed in Tiryns, see Siennicka 2012. However, in Late Neolithic/Early Bronze Age Thassos, Vakirtzi et al. 2014 see a development towards a more diversified yarn production in the Early Bronze Age.

63 Joanne Cutler and Malgorzata Siennicka are currently exploring these issues and I thank them for providing me with valuable information. See Siennicka 2012; Cutler et al. 2014; Cutler, in press; Siennicka, in press.

64 See Del Freo et al. 2010.

65 Del Freo et al. 2010.

66 Del Freo et al. 2010, 358.

67 Barber 1991, 7. 281: »The terms for the mechanization of the weaving process are also without Indo-European etymologies«. Cf. Harlizius-Klück 2004; Del Freo et al. 2010, 359.

68 Barber 1991, 167.

69 Grömer 2012, 32.

70 Wisti Lassen 2013, 84.

71 The translation within the Loeb series is by A. T. Murray (1924), and here I have underlined some of the problematic translations of textile terms: »Then speedily the son of Oïleus forged to the front, and close after him sped

The passage refers to the *kanōn* and the image compares the extreme proximity between the two heroes and between a girl's body and the loom. From a textile perspective, the passage sheds light on a pivotal innovation of weaving: the heddles (*mitos*) and the heddle bar (*kanōn*). Heddles are loops of thread attaching some of the warp threads to the heddle bar. When the heddle bar is pulled forward or back, the heddles follow and consequently pull out some warp threads and separate them from other warp threads, thus creating a shed.

In his monograph, *The Book of Looms*, Eric Broudy discusses the innovative character of heddles (Fig. 2) and rates it as a significant invention, »a major technological advance«[72]. Weaving can simply be done by inserting the weft manually; or the natural shed is fixed on the loom while the countershed is created manually. However, with the innovation of heddles fixed to the heddle bar, weaving proceeds in the natural shed, with the heddles being pulled to create the countershed[73]. Once the heddles and the heddle bar had been invented, it would have been quite obvious to think of the addition of a second and a third heddle bar with other warp threads attached to their heddles, and this would open up for the possibility for the operationalisation of twills.

Fig. 2: Heddles (Photo by and courtesy of the Danish National Research Foundation's Centre for Textile Research)

Tapestry Weave as a Bronze Age Innovation

Tapestry weave is conceptually very different to a shed controlled weave, in the technical freedom it offers: a tightly fixed warp, on a small or large frame, which forms the warp system into which closed blocks of wefts are inserted to form shapes of distinct colour and shape. Such large verti-

goodly Odysseus; close as is the weaving-rod to the breast of a fair-girdled woman, when she deftly draweth it in her hands, pulling the spool past the warp, and holdeth the rod high to her breast; even so close behind ran Odysseus, and his feet trod in the footsteps of Aias or ever the dust had settled therein«. The translation of *kanōn* as weaving-rod should be changed to heddle bar since it is the heddle bar which is pulled to the breast by the weaver while weaving. The spool, *pēnion*, is also sometimes (and perhaps better) translated ›shuttle‹ but both terms have problematic modern industrial connotations in English. The tool is the instrument with which the weft is inserted into the weave and also the place where weft yarn is accommodated.

72 Broudy 1979, 26: »Aside from robes and tapestries the Greek loom was used to weave dresses, clocks, mantles, curtains, and even rugs. Was it a ›true‹ loom with heddles? The question has been much disputed, but the current answer appears to be yes. Before the invention of the heddle a shed rod presumably kept one shed open, while the weft for the countershed had to be darned in by hand. The heddle enabled the second shed to be formed mechanically. A minor technological advance, some would think: why all the fuss? The fuss is because the heddle was not a minor but a major technological advance that overcame the greatest problem of textile production – its tediously slow pace«.

73 Broudy 1979.

cal looms are attested in images from Egypt from the 18th dynasty[74], but the warp-weighted loom could also be used for tapestry weave[75].

Joanna Smith has made significant contributions to the interpretation of tapestry weaving in the Aegean and ancient Near East[76]. The innovative nature and technical advantage of tapestry is the possibility of making non-repeating forms and designs. The most powerful designs are made by using threads of different colours, generally threads of wool, since wool dyes better and brighter than plant fibres. It would be technically adequate to use a strong linen warp and insert dyed wool weft blocks. Thus a combination of both fibres would be a technically satisfactory solution. However, Joanna Smith rightly observes that the few Bronze Age archaeological remains of tapestry are entirely in linen[77].

An important issue to raise and a methodological challenge in the discussion of tapestry in the Bronze Age is that the archaeological textile evidence stems primarily from 18th-dynasty contexts in Egypt, while images and texts mentioning tapestry primarily originate from the ancient Near East[78].

The largest assemblage of Bronze Age tapestry pieces comes from the tomb of Tutankhamen with motifs, such as lotus flowers, geometric patterns, a falcon and hieroglyphs[79]. Most of the pieces belong to a wardrobe, such as tunics and gloves. They appear to belong to an Egyptian design tradition and are all made of dyed linen thread[80]. The earliest evidence for tapestry weave in Egypt is on a piece with the in-woven *ka*-name of Thutmosis III which was found in the tomb of Thutmosis IV, his grandson. Another fragment, probably from the 18th dynasty from the Valley of Kings, depicts captives and a lower edge composed of geometric patterns[81]. The captives seem to have been placed in three registers and Smith estimates the original height to have been

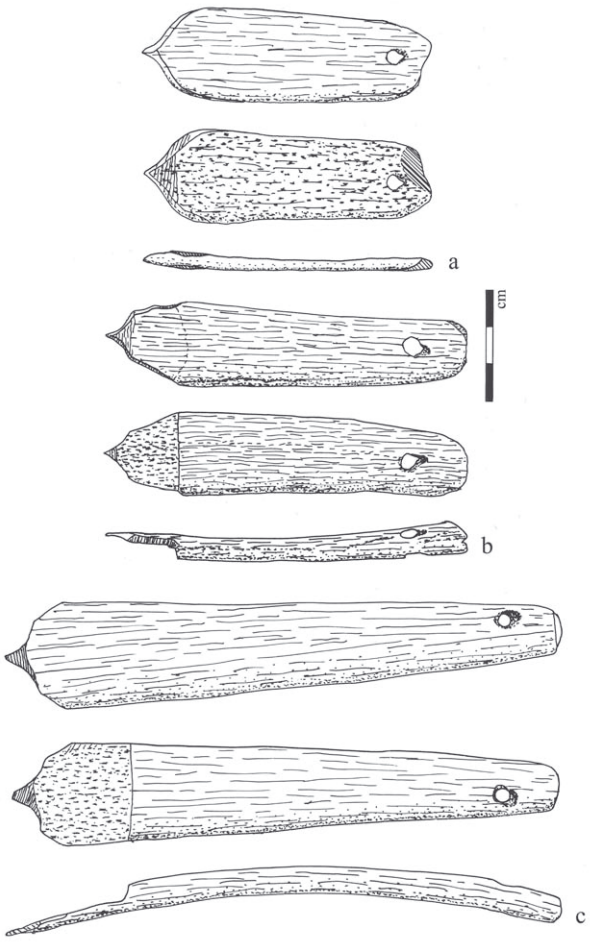

Fig. 3: Pin beaters (after Smith 2012, courtesy of author)

74 Kemp – Vogelsang-Eastwood 2001.
75 Barber 1991; Smith 2012, 241; 2013, 163.
76 Smith 2001; 2012; 2013; Wisti Lassen 2010, 278–281.
77 This may probably be explained as a combination of the preservation situations (plant fibres survive better in the arid areas) and the fact that the practical considerations concerning the persistence of dyes are most pertinent regarding clothing but less pertinent for a decorative piece to be hung on the wall. Indeed, the colours of tapestries could even be enhanced with paint. See Smith 2013, 159.
78 Smith 2013, 160: »The evidence for tapestries and tapestry weaving begins in the 19th century BC and can be traced first in Syria (including the Lebanon) and northern Mesopotamia, then in Egypt by the 18th dynasty, and eventually in the southern Levant, Cyprus, Cilicia, and the Aegean«.
79 Smith 2013, 173 f.
80 Smith 2013, 162: »Because of the use of colored linen thread in all examples of tapestry found in Egypt, the many designs incorporating Egyptian hieroglyphs, and the typically Egyptian forms of attire made with tapestry woven cloth, it seems that most of the tapestries in Egypt were made there rather than imported«.
81 Smith 2013, 174 f.

c. 80 cm. She interprets this tapestry as a throw cover for a throne or a stool: »Its use as a furniture cover for a stool would have been in keeping with the traditional depiction of the pharaoh trotting the enemies of Egypt« writes Smith[82]. Thus, in this early evidence for tapestry, the technology is already well advanced and explores the full potential of imagery.

Tapestry scenes can be woven in separate rectangular panels and then stitched together into, for example, long procession scenes. Smith makes an attractive comparison of the rectangular tapestry woven panels, and the rectangular scenes in Old Babylonian and Old Syrian cylinder seals also depicting investiture, rulers, gardens and divinities[83].

The Akkadian textile term *mardatum* is by many considered the technical term for tapestry[84]. It is attested in an Old Assyrian private document from Kanish[85] and also at Mari[86]. In Ugaritic it appears as *mrdt*[87].

Joanna Smith has also identified specialised tapestry weaving tools i.e. pointed and sometimes pierced bone beaters (Fig. 3) made from cattle ribs[88]. Such tools have come to light in excavations in Egypt, the Levant and Cyprus. It seems to be a practical and handy tool for several types of textile activities, and its use especially in tapestry weaving seems very attractive. Smith writes concerning Cyprus that »well preserved contexts from the 13th through the 11th centuries BC at Kition on Cyprus demonstrate clearly that tapestry weaving came to be the product of specialised weavers working in a large workshop possibly for a central authority as well as weavers who worked in a household context, also possibly for a central authority«[89].

The Spread of Tapestry Weave Techniques: Theories of the Diffusion of Textile Innovations

The Annals of Thutmosis III describe Egyptian raids in Lebanon and Megiddo in the 18th dynasty, and the war booty includes clothing[90], suggesting an efficient method to spread textile innovations. The hypothesis according to which (violent) encounters of peoples are a means of the diffusion of textile technologies was argued by Elizabeth Riefstahl in 1944. She believed that the Syrian captives in Egypt during Thutmosis III's reign transmitted the tapestry technique to Egypt[91]. In addition, she introduced the concept of a receptive environment as a pertinent platform for innovations, termed the »relative unconventionality« of the New Kingdom[92].

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82 Smith 2013, 175.

83 Smith 2013, 171: »It is tempting thus to see the register structure of Old Syrian seals as reflective of sectional tapestry design. Some motifs found in the registers of seal designs, such as the guilloche, could be shorthand for the borders associated with larger textile designs or even a general reference to a larger scale figural textile«.

84 Smith 2012, 242.

85 Veenhof 1972, 160. 179; Michel – Veenhof 2010, 235 f.; Wisti Lassen 2010, 279.

86 Durand 2009, 61–65 (›tissu brodé‹). 65 f. (*massitâtum* as ›tapisserie‹). See further references in Smith 2012, 242. At Nuzi, there are *mardatuhuli*, who are mardatum-makers in 15th-century sources, and at Alalah there are families of such *mardatuhuli* suggesting that knowledge and skill is transferred from generation to generation in certain families, see Smith 2013, 161 n. 19.

87 Vita 2010, 330 f.; Smith 2013, 166 n. 66; 172 n. 120. I am not convinced of the association between tapestry and Mycenaean *pa-we-a*, *pharweha*, as suggested by Smith 2012, 243 f. *Pa-we-a* are produced in great quantities and seem to be a rather standardised textile of either wool or linen.

88 Smith 2001; 2013, 163–166.

89 Joanna Smith combines this information with pottery styles and concludes that »Cypriot tapestry and cord-making both point to a technology that centred on geometric and figural designs arranged in horizontal bands«. See Smith 2013, 175–178.

90 Smith 2013, 161 n. 14.

91 Riefstahl 1944.

92 Riefstahl 1944, 31: »It seems possible that the art of weaving in patterns may have been an importation during the New Kingdom. While patterned cloths from abroad must have found their way to Egypt at an earlier period, and simple woven or embroidered patterns may (…) have been produced in Egypt, perhaps chiefly for uses other than clothing, it may be that the relative unconventionality of the New Kingdom succeeded in breaking down, or partially breaking down, the custom of wearing white garments«.

In reality, tapestry weave in its essence is so simple that it could have been invented in many places simultaneously. Yet the archaeological and iconographical evidence reveals high skill and complexity, with craftspeople mastering this technique at a very high level. The extensive know-how and skill, the ability to incorporate tapestry into patterned weave or to combine tapestry weave and other weaving and braiding techniques requires expertise and creativity. It seems that this quite simple technique was taken to a very high level of complexity. Thus, the transmission of tapestry weave is essentially not so much about the transmission of a technical innovation but more about how some craftspeople and environments could master this technique, combine it with others and raise it to an art form.

Derivative Innovations Associated with the Exploitation of Wool

A derivative innovation is a secondary product or service derived from an innovation[93]. These innovations are slight modifications of the main product. Wool's many natural hues and its capacity to absorb dyes generated derivative innovations in the cultivation and extraction of plant dyes, in the mineral exploitation of alum stone, and in the faunal extraction of murex for purple dye.

Plant Dyes

Archaeological textiles from the end of the second millennium in central Europe testify to a wide use of dyes[94], and in the Aegean iconography and Linear B inscriptions attest to the extensive use of dye plants. The widely available, although not entirely colourfast sources of dyestuff, are the various plants yielding dyes[95]. Plants for large-scale textile dyeing in the Bronze Age are, for example, madder (*Rubia tinctoria*, red dye)[96], woad (fermented *Isatis tinctoria* providing blue colour), saffron (*Crocus*), safflower (*Carthamus tinctoriu*s), and weld (*Reseda luteola*) providing yellow dyes. From Minoan and Mycenaean frescoes we know that red, orange, blue and yellow were used in clothing. Henna, madder, and alkanet are all efficient providers of red dyestuffs, and the various terms used to designate red (*po-ni-ki-jo*, *phoinikion* (cf. φοῖνιξ), *e-ru-ta-ra*, *eruthrā* (cf. ἐρυθρός) suggest that different sources provided the red colour[97]. The intensive exploitation of safflower fields at Mycenae (the Ge series) and recordings of saffron (CROCus logogram) demonstrate the stable supply of yellow dyestuff[98]. This use of saffron as dye is also suggested by the Minoan frescoes in which we see yellow garments and the saffron-gatherers from Thera and Knossos.

Alum as a Mordant

Alum (potassium aluminium sulphate) and alum stone is a mineral available in several parts of Greece, especially on the island of Melos[99]. It has astringent properties but is primarily an excellent mordant to fix dyes to wool fibres. Some plant dyes such as madder only become really potent when used with alum. It is known in the Linear B records as *tu-ru-pte-ri-ja*, *struptēriā* (cf. στρυπτηρία), and seems to be a traded commodity both at Pylos (PY An 35, Un 443) and at Tiryns (TI X 6). At Ugarit it is termed ›stone for colouring‹, *abn srp*[100]. Saffron and safflower can dye

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93 See http://www.innovarsity.com/coach/glossary.html (last accessed 11 March 2014).
94 See Hofmann-de Keijzer 2010, 143–162.
95 Cardon 1990; Roth et al. 1992.
96 Schweppe 1986, 26 notes that it takes about three years before the madder plant has accumulated sufficient dye in its roots for dyeing purposes.
97 Melena 1976, 195 f.; Murray – Warren 1976; Foster 1977; Nosch 2004.
98 Killen 1983, 216.
99 Firth 2007, 130–138; Michailidou 2008, 203 f.
100 See van Soldt 1990, 352; Michailidou 2008, 203.

yellow and red directly on linen without a mordant (direct dye), but the commonest dye method is to employ mordants as with madder or safflower on wool (mordant dyes)[101]. Depending on the shades to be dyed, between 15% and 25% of the clean wool's weight must be added in alum.

Purple

Purple dye seems to represent a real Bronze Age textile innovation. Brendan Burke sees in murex one of the keys for the Minoans to enter the international trade networks in the beginning of the second millennium BC[102]. Murex is found in Neolithic excavations, but from around 2000 BC the amount of murex shells increases, especially in Crete, and Brendan Burke suggests that this is a true Minoan innovation which subsequently spread around the Mediterranean. By the end of the Late Bronze Age, Linear B tablet KN X 976 records *po-pu-re-jọ*[, *porphureyoi* (cf. πορφύρα) probably ›royal‹ (*wa-na-ka-te-ro*, *wanakteros* [cf. ἄναξ]) purple dyers[103]. Murex yields an intense and extremely colourfast dye on wool textiles in particular.

Innovations in Clothing: From Skin and Fur to Felt and Textiles

It is crucial to note that also before the development of the wool fleece, sheep and goats provided skins and fur for clothing. But for skin clothing, animals had to be slaughtered. The Iceman, commonly referred to as ›Ötzi‹, who lived in the Alps around 3300 BC, was found wearing such clothing made of well-worked, soft skins and a cape of plaited plant fibres[104].

Felt is not attested archaeologically, but according to Michael Ryder it can be made from the non-fleeced sheep and therefore was the first form of wool textile[105]. However, the absence of felt on the Iceman led Ryder to conclude that felt is an Asian invention[106].

Bronze Age clothing in the Aegean, the ancient Near East and in Europe, shares some essential features and conditions: Bronze Age textiles are primarily woven in tabby technique; the costume consists of both plant fibre and animal fibre, and it contains costume elements of skin and fur[107]; further, costume is to a large degree gendered, women wear long skirts with rich woven decorations in Bronze Age (ritual?) art (Fig. 4); it combines tailored and fitted costume elements with draped and wrapped elements which are fixed with pins and fibulae. This is the technological framework of clothing in the Bronze Age, within which changes and innovations seem to take place. This wide range of clothing possibilities and choices seems to suggest that at the end of the second millennium BC costume traditions stem from many sources and incorporate technologies and inspiration from several of them. The innovations are difficult to pin-point and seem rather to consist of new combinations of different schemes.

In the Aegean, iconography suggests fitted female bodices and wide, decorated dresses (as seen in Minoan Akrotiri frescoes, the Knossos and Mycenae frescoes, Mycenae ivories and images on sealings), while the simple rectangular shape of textile logograms in the Linear A and B tablets rather suggests a clothing practice of draping and wrapping. Frescoes and images on seal stones emphasise the gendered nature of clothing. Ritual costumes for women are depicted on the

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101 See Schweppe 1986, 12: Safflower contains two dyes. Safflower yellow dissolves in cold water and dyes wool on an alum mordant to a golden yellow, and red dye carthamin, which dyes silk, cotton and linen directly without a mordant.

102 Burke 1999, 75–82; Militello 2007. See also Thureau-Dangin 1934 and van Soldt 1990 on purple dyes in Ugarit. Cf. Landenius Enegren – Meo, in press.

103 Carlier 1984, 52; Palaima 1991, 291; Nosch 2004.

104 Groenman-van Waateringe 1992; Spindler et al. 1995; Winiger 1995; Schlumbaum et al. 2010.

105 Ryder 1993, 309.

106 Ryder 1993, 310.

107 Harris 2012, 86–88.

Hagia Triada sarcophagus[108]. This may testify to two different ritual dress traditions in Aegean art, one Minoan and one Mycenaean. Some depicted women seem to wear skirts made of hides, while other women are dressed in long robes with a vertical band. The visual depiction of Mycenaean female priestly attire, apart from the long robe, also includes an elaborate headdress, a polos[109]. Brendan Burke has convincingly argued that the painted sarcophagus is »a hybrid of Minoan and Mycenaean elements«[110] and Tina Boloti confirms this hybrid nature in her assessment of the Aegean female garments painted on the sarcophagus[111].

Contemporary to the Late Bronze Age Aegean is Middle Bronze Age central Europe (1600–1250 BC) and the Scandinavian Early Bronze Age (1800–1100 BC). Susanna Harris compares synchronically 14th-century BC cloth cultures across Egypt, the Aegean, central Europe, and Scandinavia, with a focus on the choice of materials, e.g. plant fibre, wool, and skin. Through the narrow chronological window of the 14th century she finds comparable and common elements in these diverse cloth cultures[112]. There is in Harris' primarily archaeological approach a notable vertical, or North–South, European dimension and focus emphasising the universality and commonality in the European Bronze Ages[113]. She concludes that these different cloth cultures »have their roots in the interconnected Bronze Age world«[114]. This stands in contrast to the philological approaches emphasising the ancient Near Eastern and Mediterranean horizontal, or East–West, connections and attempting to break down disciplinary and academic boundaries between Indo-European and Semitic textile terms[115]. These two clothing paradigms each draw on their own sets of data from archaeology and written sources respectively and only meet partly.

Another parameter of innovations is how to wear a fabric: draping and wrapping clothing practice in particular provides the wearer with a rich range of possible costume types, since textiles can be draped and fixed in multiple ways, according to the wearers' needs, gender, taste and culture. Karina Grömer, Helga Rösel-Mautendorfer and Lise Bender Jørgensen, based on a female Middle Bronze Age grave in Austria with only ›functional‹ jewellery, such as two long bronze pins, spiked pendants and a bronze girdle more than 1 m long and 9 cm wide, suggest the existence of several draped costume types which could be held by these accessories[116]. In central Europe, Hallstatt remains of hems and seams demonstrate how textiles are cut and sewn, but other contemporary finds from central Europe of fibulae, pins, buttons and belts also provide evidence of draping and wrapping costumes[117]. In 14th-century BC southern Scandinavian oak coffin graves, the Egtved Girl's costume from Denmark is a combination of a corded skirt and a woven tight-fitting blouse, but this costume has recently been shown not to originate in Denmark, but possibly came from the Schwarzwald area[118]; the Borum Eshøj woman also wears a woven, tight-fitting blouse but her so-called skirt could not have been worn as such because it is more

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108 Long 1974; Militello 1998. Burke 2005 has demonstrated how the Hagia Triada sarcophagus and its clothing is a display of the emerging Mycenaean ideology in Crete.

109 Boloti 2014. A long robe with diagonal bands is coined a ›Syrian‹ robe by Marinatos 1993, 127 f. and defined as a typical dress of Aegean priests. See Sapouna-Sakellaraki 1971; Trnka 2007; Tzachili 2007.

110 Burke 2005, 419.

111 Boloti 2014, 152: »On one hand, the indubitably Minoan hide-skirt, a peculiar type of ritual garment, used in Crete, in all probability from MM II onwards and on the other hand the long robe with vertical band, which, in combination with polos, emerges as its Mycenaean counterpart. It is important to stress here that the latter appears in Crete after LM II, a period characterised by the Mycenaean presence on the island, with the earliest examples attested in the aforementioned Knossian Procession fresco«. See also Trnka 2007.

112 Harris 2012, 61–97.

113 Harris 2012, 61–97. Harris follows paths laid out by Harding 2000; Kristiansen – Larsson 2005.

114 Harris 2012, 88.

115 Michel – Nosch 2010.

116 Grömer et al. 2013, 218–241.

117 Grömer et al. 2013, 226 f.

118 Frei et al. 2015.

1–9 Mittelbronzezeitliches Urnenfeld von Cîrna [253], Tonstatuetten. – 10 Kličevac [310]. – 11 Dupljaja [308].
(Nach V. Dumitrescu, F. Milleker/J. Petrović, M. Hoernes).
M. etwa 1:5

Fig. 4: Various female Bronze Age clay figurines from Romania and former Yugoslavia
(after Müller-Karpe 1980, pl. 326)

a b

Fig. 5 a. b: The Borum Eshøj female dress, dated 14th century BC (a. Photo by Roberto Fortuna, courtesy of the National Museum of Denmark; b. Drawing from Boye 1896)

than 120 cm long and would have been over-folded or worn in a different way (Fig. 5 a. b), perhaps falling from the shoulders like a peplos[119].

Thus a rich blend of technologies and material overlaps in Bronze Age clothing, and innovations appear to consist of new combinations of known fittings, techniques and practices. Furthermore, in the scholarly literature on Bronze Age clothing, elements of continuity and tradition dominate in the interpretations, and it is rare that authors identify clothing innovations. One of the few examples is the invention of the peplos as a result of a tubular woven textile stemming from central Europe and woven on a two-beam loom, a theory proposed by textile scholar Inga Hägg[120]. Hägg finds evidence for this tubular textile form used as a female garment, folded over and pinned on the shoulders, in second-millennium central Europe, and suggests that this garment type travelled south to Greece at the end of the Bronze Age and became an iconic female costume in the first millennium BC, especially in early classical Greece. Hägg thus connects the so-called Doric migration to the so-called Doric peplos[121].

[119] I thank Ulla Mannering for explaining this to me. Also the Skrydstrup woman's ›skirt‹ is too long to be worn as a skirt.

[120] Hägg 1996, 143. Hägg's theory is discussed in Grömer et al. 2013, 233–235.

[121] The same type of garment is found in an Iron Age bog find in Denmark. For the Huldremose ›peplos‹ dated second to first century BC, see Mannering et al. 2010, 266.

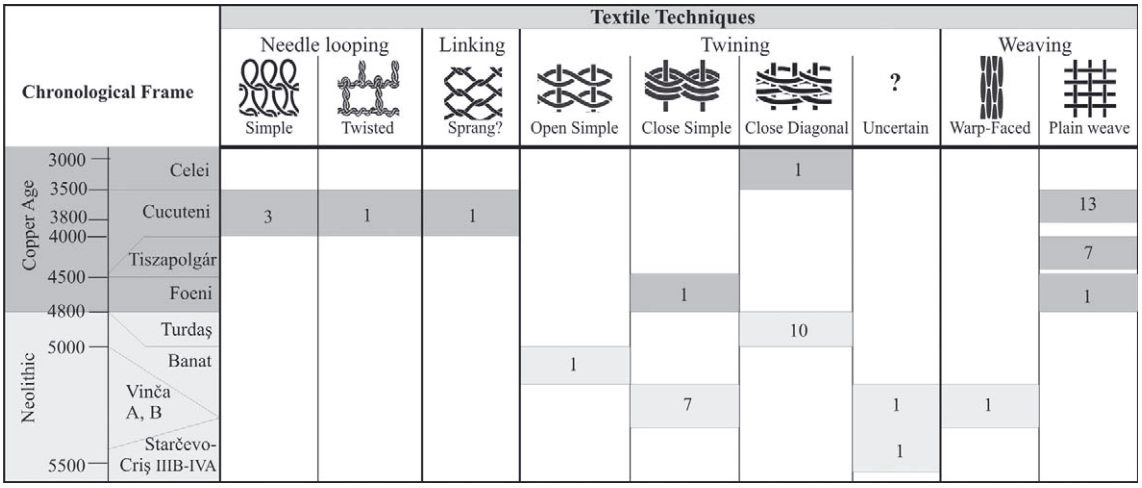

Fig. 6: Illustration of textile techniques attested in Romania in the Neolithic and Copper Age (after Mazare 2014)

Here, I would like to raise awareness of a significant tradition in textile technology which actually comes from a cross-craft movement[122] from skin technology to textile technology. Nancy Thomas views craftsmanship explicitly from the perspective of the tools, and not from the finished products or from their uses. This craft-driven perspective highlights a cross-craft link in the use of needles. The transition from skin to textiles still continues today, but only as a seasonal transition, and the two clothing traditions – skin and textile clothing – co-exist side by side. Skin technology requires high skills in stitching, a technique which was for millennia only partly adopted in association with weaving. In Linear B we still see that the root **rap-* is used for stitching both in leather and in textiles, despite the fact that these are quite different occupations and technologies. We see stitching as a shared occupational term (*ra-pi-ti-ra*$_2$, *raptriai* [cf. ῥάπτω] on PY Ab 555, *ra-pte-re*, *raptēres*, attested on numerous tablets from Pylos and Knossos[123]). The adjective *ra-pte-ri-ja*, *raptēriai*, describes stitched reins as part of leather equipment for horses and chariots in PY Ub 1315 but the participle *e-ra-pe-me-na*, *errapmenā*, refers to textiles.

KN L(2) 647 + 2012 + 5943 + 5974 (103)

.A] ‘nu-wa-ja , *pe* TELA[1][’] TELA[1] 17 TUN+*KI* 3

.B]ra , / e-ni-qe e-ra-pe-me-na ‘nu-wa-ja’ TELA[1][ ]-ra$_2$ TELA[1]

lat. *inf*.

] ⟦ę-ṛị-[ ] ṬẸḶẠ 1 ⟧

Furthermore, in the Linear B archives there are occupational titles, such as *ra-pte*, *raptēr*, ›male sewer‹ and *ra-pi-ti-ra*$_2$, *raptriai* ›female sewers‹. The women seem to deal with textiles; the male *ra-pte-re* are land holders and occur in great numbers but never in textile contexts, and it seems possible that they work with leather. The use of stitching in association with weaving is only one of many different textile techniques that demonstrate the cross-craft of the needle; other techniques include looping and needle binding (Fig. 6), which are both attested archaeologically in fourth-millennium BC Europe[124].

122 Thomas 2012, 755–763.

123 PY An 172, 207, 298, 424, Ea 28, 29, 56, 325, 460, 754; KN Fh 1056, V 159.

124 Mazare 2014.

Sails as a Bronze Age Textile Innovation

From a chronological perspective we can be quite certain that looms and weaving existed long before sails on ships, as it was only in the Bronze Age that sails begin to appear[125]. This innovation is attested at the earliest in the late fourth millennium[126]. The sail in first millennium Greek is called *histion*, which derives from the Bronze Age term ***histos*, the ›loom‹[127], and a mast with a sail is indeed a wooden construction upon which is a textile. It is not unlikely that Mycenaean sails were called ***i-ti-ja*, *histia*, given that nothing fundamental changes in either textile technology or sail technology between the introduction of sails and the Late Bronze Age. Ships with masts and sails are illustrated in the Akrotiri frescoes. A drawing on a Late Helladic Asine stirrup jar (Fig. 7) features a boat, and the grid pattern on the sail suggests that it is made of textile and not of skin[128].

Fig. 7: Illustration of Bronze Age boat with a sail from Asine (after Frödin – Persson 1938)

Pierre Chantraine inserts the Greek maritime vocabulary into a historical and technological reconstruction. He assumes that the Greek migrations into the Aegean, probably in the third millennium BC, came with only a basic terminology for the boat. It was effectively through the encounter with non-Greek maritime praxis that the Greeks adopted the innovations of the mast (with the sail) and the keel, and introduced their own appropriate technical terms for the mast and keel[129].

Traditions and Innovations in Mycenaean Textile Terminologies

Loanwords in Mycenaean, especially Semitic loans, are rather rare in the Linear B archives and belong primarily to the field of commercial exchange, to names of plants such as spices[130], metals, precious materials[131] and textiles. Thus Mycenaean Greek has »a small nucleus of terms with a Semitic etymology«, which belong to the field of »special terminology« and shed light on contacts and exchanges between Mycenaean Greeks and their immediate or more distant neighbours. Valentina Gasbarra classifies these terms as a special class of loanwords, so called ›Wanderwörter‹. »The textile loanwords in the Mycenaean archives point primarily to extensive commercial rela-

125 Casson 1971; Zagal-Mach Wolfe 2013.

126 Casson 1973; Cervicek 1974, fig. 156; Basch 1977, 1–10; Gertwagen 2014, 155: »The introduction of ships with sails, also equipped with long oars, first in the south-Eastern Mediterranean, marks a major nautical revolution. Harnessing wind power, in contrast to muscle power, gave them a dramatic advantage over both long boats and overland alternatives in terms of speed and capacity«. See also Darnell 2006.

127 On the Linear B occupational designations *i-tę-wę*, *histēwei* or *histēwes*, and *i-te-ja-o*, *histeiāhōn*, see above.

128 Frödin – Persson 1938, 300 fig. 207, 2.

129 Chantraine 1928, 24: »Dans ces notes rapides se dégage pourtant en ses traits les plus apparents la physionomie du vocabulaire maritime grec. Les envahisseurs indo-européens, venus du nord, ont rencontré la civilisation égéenne essentiellement maritime: mis en contact avec la mer et une navigation organisée ils en ont profité pour tenter des aventures nouvelles. Tout n'était pas neuf pour eux dans cette technique. Les indo-européens possédaient le nom du bateau (ναῦς) sans doute aussi celui de la poupe et de la proue (πρυμνή, πρῷρα). Ils savaient ramer ἐρέτης ›rameur‹, peut-être σκαλμός ›tolet‹). Mais le nom du mât (ἱστός) et celui de la quille (τροπίς) semblent des innovations helléniques«.

130 Cumin: Myc. *ku-mi-no*/*-na*, *kumīnon/a* (cf. κύμινον), to be compared with Akk. *kamunū*(*m*), Ugar. *kmn* and Hebr. *kammon*. Sesame: Myc. *sa-sa-ma*, *sāsama* (cf. σήσαμον), to be compared with Akk. *šamaššammū*(*m*) and Ugar. and Phoen. *ššmn*. Cyperus (?): Myc. *ku-pa-ro*, *kupairos* (cf. κύπαιρος), perhaps in Hebr. *koper*.

131 Gold: Myc. *ku-ru-so*, *khrūsos* (cf. χρυσός), Akk. *ḫurāṣu*(*m*), Ugar. *ḫrṣ*, Phoen. *ḥrṣ* and Hebr. *ḥārūṣ*. Lapis-lazuli: Myc. *ku-wa-no*, *kuwanos* (cf. κύανος). Ivory: Myc. *e-re-pa*, *elephas* (cf. ἐλέφας).

tions with the Semitic East, but also to the high level of lexical (and, consequently, social and cultural) permeability between the Semitic and the Greek world«, writes Gasbarra[132].

In Mycenaean Greek, the bulk of textile terms are transparently Greek. A minority is foreign – pre-Greek or unidentified – or a loan word from Semitic languages. The Linear B textile term *tu-na-no* seems to be a loan word from an unidentified, non-Greek language. Another such example is the word for spindle whorl, which is not attested in Linear B, but the classical Greek term *spondulos*, ›spindle whorl‹, suggests a pre-Greek origin[133].

In the Knossos Linear B archives[134], the textile term and Semitic loanword *ki-to*, *khitōn* (cf. χιτών), is attested. It occurs several times, in the nominative singular *ki-to*, *khitōn* (KN Lc(1) 536 and L 693), nominative plural *ki-to-ne*, *khitōnes* (KN L 771), accusative singular *ki-to-na*, *khitōna* (KN Ld(2) 785) and in the instrumental form *ki-to-pi*[, *khitōmphi* (KN Ld(2) 787). As Gasbarra concludes: »The term represents a good degree of adaptation into the Mycenaean lexicon, making a derivative and internally transparent adjective through the insertion of Greek affixes, like *e-pi-ki-to-ni-ja*[135], Gr. ἐπιχιτωνία, an adjective that specifies a cloth which is ›worn over the *ki-to*‹«.

It is worth noting that we can follow this common Greek and Semitic clothing term and what it represents in various cultures of the Bronze Age. The Greek word for a long, unisex tunic, *khitōn*, Gr. χιτών is probably loaned from the Akk. *kitû*(*m*), which can be compared with Ugar. and Phoen. *ktn*, Hebr. *kutonet*[136]. The Akkadian term for linen is *kitûmbut* while the Old Assyrian *kutânum* denotes a wool fabric. In modern languages, we find the Arab *el qutun*, which gave Spanish *algodón* and English *cotton*. Thus, despite a common root, the meaning has changed significantly over the millennia. This may perhaps suggest that the garment type *khitōn* came into the Greek-speaking areas through trade networks which were familiar with the adoption of foreign terms for new and exotic goods.

Another essential aspect of tradition and innovations in textile terminologies is that some Semitic textile terms for very fine fabrics are well-attested in the Bronze Age palace cultures around the Aegean, but not in Linear B (which could certainly be a coincidence of preservation). But they do appear in first millennium Greek. This can be observed for βύσσος, ›byssos‹ which is attested in Akkadian *būṣu*; in Ugaritic and Phoenician *bṣ*; and in Hebrew. *būṣ*; another example is σινδών, ›fine woven cloth, fine linen garment‹ attested in Akkadian *sadinnu*; and in Hebrew *sadīn*[137].

Tradition and Innovation in the Administration of Textile Production

Here it is also relevant to examine the continuities and breaks between the Minoan and Mycenaean recording traditions. While about ¾ of the syllabary is parallel in Linear A and Linear B, this is not the case for logograms. Ilse Schoep concludes that c. 80% of the some 180 Linear A logograms did not continue into Linear B[138]. As John Bennet phrases it, »the creators and early users of Linear B devised a new logographic repertoire«[139]. Mycenaean scribes use textile logograms extensively, but they are not part of this newly created logogrammatic repertoire. Rather, the creators and early users chose to continue to use the Minoan logographic repertoire of how to record wool and textiles. Furthermore, when recording textiles Mycenaean scribes also maintained the Minoan Linear A tradition

132 Gasbarra 2014, 160.

133 Barber 1991; Del Freo et al. 2010.

134 The term is only attested in the Knossos archives; this could, however, be due to the preservation situation and is not necessarily explained by a stronger terminological proximity to Semitic textile terms.

135 In KN L 693 and, probably, in KN L 7514.

136 Ellenbogen 1962, 96; von Soden 1965–1981; Masson 1967, 29; Beekes 2010, s.v.; Vita 2010, 330; Gasbarra 2014, 162.

137 Gasbarra 2014, 162.

138 Schoep 2002. See also Duhoux 1985 and Palaima 1988.

139 Bennet 2008, 15.

of extensive use of ligatures; and even when they eventually did create new textile logograms, they maintained these Minoan traditions of the rectangular textiles (such as in **164*) or the tradition of ligatures (such as **146+WE* and **166+WE*, and TUNica+*RI*, TUNica+*KI*).

A different graphical tradition was used for rendering wool by both Minoan and Mycenaean scribes. The logogram **145*/LANA for wool was a composition of two merged syllabograms in Linear A (*ma-* and *ru-/lu-* in Linear B), but to the Mycenaean scribes it had lost its monogrammatic character and become stylised into a logogram[140]. Vasilis Petrakis' examination of monograms leads him to conclude that they are a rather recent invention in the Bronze Age graphical traditions, and again it is worth noting that monograms are not common in the textile realm[141]. Interestingly, in Linear B, the other major textile fibre, flax, is rendered by a logogram, *SA*, corresponding to the syllable *sa-*. In the landholding records of flax cultivation, *SA* functions as a logogram and its syllabic character suggests that it is probably the abbreviation of a pre-Greek name for flax. We do not have such a *SA* textile crop attested in Linear A, but it is likely that Minoan scribes would also have used this syllable to express a logogram for the flax plant. Thus in Linear B there is no conventional logogram for any textile fibre; moreover, the multitude of logograms which exist were invented for the various types of textiles by Minoan scribes, and the Mycenaean scribes continued using them. This would suggest that textile technologies and textile types did not change very much between the two administrations.

Discussion

Innovations shape our perceptions of the chronology of the past. We divide the past into Stone Age, Bronze Age and Iron Age according to metallurgical innovations; the invention of writing sets the boundaries between prehistory, proto-history and history. However, if we were to use textile fibres as our chronological frame of reference, we would have the Plant Fibre Age from the Palaeolithic to the Neolithic, then the Animal Fibre Age since the fourth millennium BC, the Cotton Fibre Age from the Early Modern, and the Man-Made or Synthetic Fibre Age since the 20th century. In terms of significant textile tool innovations, the chronology would begin with the invention of weaving, then of the warp-weighted loom and the horizontal loom in a distant past, then the treadle loom at the turn of the second millennium AD, the Jacquard loom in the 18th century, and the electronic looms of today.

Junius Bird, Curator Emeritus of the American Museum of Natural History, highlights the significance of textiles and especially the innovation of heddles in the Bronze Age: »In view of the importance of textiles in the lives of the majority of mankind, it is curious that the invention of the heddles is not recognised as one worthy to be ranked with, for instance, the discovery of methods for making fire. Both have played major roles in enabling man to utilise environments which otherwise would have been difficult or very discouraging. Both have an antiquity which, though by no means comparable, still remains a mystery, and both seem to have developed long after man was familiar with fire and textiles«[142].

The major innovations in textile technology occurred in the Neolithic and the Early Bronze Age: the domestication of sheep and goats and the gradual development of fleeces with more wool and less kemp and hair gave a new animal fibre type to societies which had previously only used skin clothing and plant-fibre textiles. Despite the fact that sheep bones become increasingly important in the archaeological record of the Neolithic and Early Bronze Age, the earliest wool textile found thus far in the area is from 3000–2900 BC in Anatolia, and wool only occurs from the Middle Bronze Age in the southern Levant. It is not before the Late Bronze Age that wool tex-

[140] I thank John Killen for pointing this out to me, *per litteras* 8 January 2013.
[141] Petrakis 2012 rejects **145*/LANA as of monographic nature.
[142] Cited in Broudy 1979, 26. The text does not inform us about the source of the quote by Junius Bird.

tiles become more common finds in the Eastern Mediterranean area[143]. This new animal fibre also gave rise to a series of derived innovations. It engendered a new spinning technique as is attested in central European Neolithic and Early Bronze Age settlements. The capacity of wool to absorb dyes and fix them permanently provided new possibilities for developing dyes and dye technologies based on the cultivation and extraction of dye plants, and this required wider exploitation of alum as a textile mordant. Murex gave rise to a new Minoan luxury product, and wool fibre scales have the capacity to entangle, and therefore this animal fibre can be fulled and transformed into felt. The two new technical terms relating to integral parts of wool treatment, *ka-na-pe-u*, *knapheus* (cf. γναφεύς), ›fuller‹ and *tu-ru-pte-ri-ja*, *struptēriā* (cf. στρυπτηρία), ›alum‹, both have no Greek etymology and may have derived from languages outside the Greek area[144]. However, by the end of the Bronze Age, they are clearly integrated in Mycenaean Greek as technical terms in the administration of the palace textile industry[145]. Thus we can imagine that in the Neolithic or Early Bronze Age, an entirely new wool-related vocabulary came into Greek.

During the Bronze Age, no fundamental changes in textile fibre or technology occur, but significant innovations do appear. First of all, the systematic search for better quality and larger quantities of animal fibres can be seen in the sheep-breeding strategies. Pivotal innovations and changes are seen in the administrative and strategic framework of palace textile production, and these strategies must have modified textile production in the Late Bronze Age much more than inventions or new fibres. The primary and most significant change in the Bronze Age is clearly how the widespread household production of textiles is transformed in some areas into a palace-organised production of standardised types with a clear division of labour. Here we can concur with Renfrew: »The whole craft of textile production was clearly transformed by Late Bronze Age times from a local household concern to a commercially exploited industry«[146]. The same transformation is apparent in all Mycenaean palaces in terms of centralised administration, intensification and standardisation, and similar features appear in Knossos, Pylos, Boeotia[147] and Mycenae[148]. However, in many scholarly works, textile production is still perceived as a domestic occupation and not part of Bronze Age economy and trade, nor a significant part of agriculture. An example is the influential *Handbuch der Vorgeschichte 4. Bronzezeit* by Hermann Müller-Karpe. Here, textile manufacture is neither part of ›Landwirtschaft‹ nor of ›Handwerk‹ nor ›Rohstoffbeschaffung und Handel‹, but is briefly treated in the chapter ›Hauswirtschaft‹[149].

In scholarship, the extent of the textile craft is often neglected, and generally there is uncertainty as to how much importance to attribute to textile production in the assessment of the economy of an archaeological site. One of the sites in Crete that has been at the centre of the discussion of industrial versus domestic textile production in the Bronze Age Aegean is the Early Minoan II site Myrtos/Fournou Korifi[150], a small settlement where many spindle whorls and loom weights came to light. In addition, the archaeological bone material was 90% ovicaprid[151]. This led the excavator to visualize »a textile town, 4500 years ago«[152]. Later analyses have challenged his view with a more ›primitivist‹ approach and questioned both the town and its textile profile[153]. Finally,

143 Frangipane et al. 2009; Shamir 2014; Andersson Strand – Nosch 2015.
144 Barber 1991, 227.
145 Morpurgo 1979, 90 f.
146 Renfrew 1972, 351.
147 Nosch 2001; 2009; Del Freo – Rougemont 2012.
148 On the Argolis textile production in the Linear B archives, see Varias Garcia 2012.
149 Müller-Karpe 1980, 431–433.
150 Warren 1972, 262 f.; Watrous 1977; Cherry 1988, 9 f.; Burke 1997, 416 f.; Smith 2013, 176 f.
151 Jarman 1972.
152 Warren 1968.
153 Warren 1972, 262 f. See p. 263: »It also remains unknown whether textiles were produced at Myrtos for home use only, or were exported. We may feel that the latter is possible, in view of the number of finds connected with textile manufacture in so small a settlement«. See also with more reservations p. 263 note 5: »But with 8000 spindle whorls from the old excavations at Troy (…) the Myrtos evidence should not be pressed overmuch«.

Vance Watrous depopulates the site when he suggests that Myrtos is in fact only settled during the winter, and that the inhabitants practise farming only on a seasonal basis, spending the summer upland following transhumance patterns[154].

Another related example of uncertainty is how to define textile production: specialised, professional, itinerant, attached, or domestic? For example, Joanna Smith identified a large non-household textile workshop in Cyprus at Kition, Area II, in an area with cult activities, rituals and metallurgy[155]. The workshop area was in use for three centuries and measures at least 225 m^2. It contains bone textile tools, clusters of loom weights and even a preserved row of loom weights with a width of 80 cm. Moreover, permanent installations of textile production, such as vats for fibre treatment, fulling and dyeing were also uncovered. The workshop is located near the harbour and in close association with two small temples which suggests a shared productive structure or joint exploitations of the natural resources[156].

A significant overall trend in Mycenaean textile production is the intensification and extensive collection of textile crops, such as flax and dye plants (*po-ni-ki-jo*, *phoinikion*, probably madder; and *ka-na-ko*, *knākos*, safflower). Another trend is the standardisation of textile types. A constant terminological innovation throughout the Bronze Age must have been the introduction into Mycenaean Greek of foreign textile terms, such as words for new textile tool types, new weaving techniques, or for new clothing items such as *ki-to*, *khitōn*, from an ancient Semitic root. Mycenaean textile terminology is formed by some Greek names (*te-pa* cf. τάπης), and some textile names without an identified etymology (*tu-na-no*), perhaps an inheritance from Minoan. Generally, many of these textile terms seem to disappear in the first millennium BC, with *ki-to*, *khitōn*, *we-a$_2$-no*, *wehanos* (cf. ἑανός), and *pa-we-a*, *pharweha* (cf. φᾶρος), as the only notable exceptions. In the first millennium BC a wide range of different – perhaps new? – clothing terms also appear: *peplos*, *chlaina*, *chlamys*, *exōmis* and *himation*.

As demonstrated above, the technology of stitching comes from leather and skin technology. Textiles are woven into shape, and not cut: stitching only seems to appear gradually in textile technology. This amalgamation or cross-crafting of a skill from one medium to another may still be visible in the Mycenaean vocabulary of Linear B, where the same term designates women and children of the textile industry, and also the sewing of leather, and men with the occupation *ra-pte-re*, *raptēres*. Cross-craft movements are an essential element in innovation and should be investigated in other fields as well. Another example is tapestry weaving, which through processes of cross-craft processes may draw from – and inspire – painting, wood and metal inlay work and carvings of sealstones.

The evident specialisation in terms of commodities and terminologies in the Mycenaean economy and administration could open a debate regarding the extent to which crop specialisation as a palace innovation was a destabilising factor or even damaging to the palace economy. In particular, intensified flax cultivation is detrimental to the soil: sheep breeding on a large scale transforms landscape morphology fundamentally and can engender erosion. Extensive and large scale textile cropping and breeding thus heavily deplete natural resources. If the palaces encouraged such specialisation into a few textile crops throughout the kingdoms, it would have required alternative systems to ensure food supply and other subsistence crops. Indeed, it seems in the Linear B tablets that the intensive production of a few commodities was a prominent feature of the palaces' own estates; however, Cynthia Shelmerdine and Paul Halstead argue that outside the palace estates, villages and farmers lived off a much broader based agricultural economy[157]. Therefore, the collapse of the palaces would not have heavily influenced the agrarian economy, but may have led to shortcomings in high quality products, such as fine linen fabrics, linseed

154 Watrous 1977.
155 Smith 2002; 2009; 2013, 176 f.; Tzachili – Smith 2012.
156 Smith 2002; 2009, 103.
157 Shelmerdine 2001, 359 f.; Halstead 2007.

oil and dye stuff[158]. The Mycenaean palace economies are another example of the adaptation of specialised herding strategies in a highly specific environment, and the Linear B texts highlight and perhaps overemphasise the specialisation, but which may well rest upon a more sustainable model of mixed farming.

Bronze Age innovations may, however, have promoted other less fortunate developments. The intensification of sheep breeding and the accumulation of animals would provoke the rapid spread of animal diseases, some of which could even be transferred to humans. The sheep disease anthrax is caused by the bacterium *Bacillus antracis*, and it is likely that it already existed as a problem in the Bronze Age. The name derives from Greek ἄνθραξ, denoting ›charcoal‹ in Greek, probably because of the dark skin lesions caused by cutaneous anthrax infection[159]. Likewise, intense flax processing produces a dust which is damaging to the health of textile workers. Exposure can cause the medical condition of *byssinosis*, also called ›brown lungs disease‹, and the cause is bacterial endotoxin in the plant-fibre dust.

Thus in the Wool Age, textile technology becomes larger, more complex, more organised and more entangled with societies and trade. This may have constituted the basis for a later development in Greek language and literature of textile metaphorical innovations: fate is spun into a thread, plots are woven, and the sky and universe is a huge fabric[160]. Also in mythology, textiles and threads are often carriers of narratives: Ariadne's thread, Theseus' black sails and Jason's golden fleece. Not only in Greek but also in other Indo-European languages, textiles generate a vast array of shared metaphors that permeate and innovate our languages. Some of these textile expressions persist to this day, probably reflecting the long traditions of textiles in human history.

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