Eneolitička proizvodnja tekstila

Eneolithic textile production

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Tijekom eneolitičkog razdoblja na području jugoistočne i srednje Europe došlo je do nekoliko važnih ekonomskih pomaka. Između ostalog, počeli su se koristiti sekundarni proizvodi životinjskog porijekla, kako je prvobitno predložio Andrew Sherratt (1981, 1983), i čemu su naknadno posvećene mnoge arheološke rasprave (Evershead et al. 2002; Craig 2002; Craig et al. 2002; Greenfield 2005; 2010; Vigne & Helmer 2007; Halstead & Isaakidou 2011). Sličan je razvoj razmatran i u kontekstu arheološkog proučavanja tekstila koje je usmjereno na rano korištenje vune (Good 1999; 2007; Becker et al. 2003; Rahmstorf 2005; Rast-Eicher 2005; 2013; 2014; Shishlina et al. 2003). Ipak, mnogi problemi vezani uz to interesno područje, poput nedostataka očuvanih tekstila i činjenice da većina neizravnih nalaza nije analizirana i objavljena, razlog su zašto su teme vezane uz tekstilnu proizvodnju i promjene tehnologije izrade tekstila ostale neobrađene. Posljedično, pitanja izvora sirovinskih materijala, koji su usko vezani uz promjene trendova u strategijama preživljavanja tijekom eneolitika, kao i njihova specijalizacija za tekstilnu proizvodnju, ostaju neistražena.

Neki od glavnih ciljeva arheologije tekstila uključuju proučavanje pojave novih strategija proizvodnje vlakana (McCorriston 1997; Rast-Eicher 2005; Kimbrough 2006; Grabundžija & Schoch, u tisku) i objašnjavanje, kako kulturoloških, tako i klimatskih čimbenika koji su utjecali na razvoje u tehnologiji predenja i tkanja (Nosch 2014; Andersson 2011, 2012, 2014; Barber 1991; Gleba 2008; McCorriston 1997). U najnovijim istraživanjima koja se bave širenjem inovacija primjenjuju se matematički modeli (Djurdjevac Conrad et al. 2018) te pristupi temeljeni na upotrebi agentnih sistema

Several important economic advances were introduced and spread across the area of South East and Central Europe during the Eneolithic period. Among them, the use of secondary animal products, which was originally proposed by Andrew Sherratt (1981, 1983) and later extensively discussed in diverse archaeological studies (Evershead et al. 2002; Craig 2002; Craig et al. 2002; Greenfield 2005; 2010; Vigne & Helmer 2007; Halstead & Isaakidou 2011). Similar developments have also been considered within the context of textile archaeological research that focuses on early wool exploitation (Good 1999; 2007; Becker et al. 2003; Rahmstorf 2005; Rast-Eicher 2005; 2013; 2014; Shishlina et al. 2003). However, many issues related to the particular research area, such as the lack of actual textiles and the fact that much of the indirect evidence remains unanalyzed and unpublished, has left the subject of textile production and its changing technology unexamined. Consequently, the issue of raw fibre material resources, which closely relates to the changing trends in the subsistence economies of the Eneolithic period, and their specialization for textile production, is poorly understood.

Some of the main objectives in textile archaeology include investigating the appearance of new fibre production strategies (McCorriston 1997; Rast-Eicher 2005; Kimbrough 2006; Grabundžija & Schoch, in press) and explaining both cultural and environmental factors that influenced developments in spinning and weaving technology (Nosch 2014; Andersson 2011, 2012, 2014; Barber 1991; Gleba 2008; McCorriston 1997). In the most recent research, a mathematical modeling of the spreading of innovations (Djurdjevac Conrad et al. 2018) and agent based approaches to information transfer (Park za prijenos informacija (Park et al., u postupku recenzije) kako bi se odredili prostorni i vremenski aspekti proučavanih tehnoloških trendova.

Složenost proučavanja razmjera proizvodnje novih izvora vlakana uglavnom se oslanja na *proxy* indikatore i integraciju različitih istraživačkih polja. Inkorporiranje modela klimatskih promjena (Grabundžija & Russo 2016) i istraživanje razvoja vegetacije (Schumacher et al. 2015; 2016) od ključne su važnosti za određivanje okolišnih faktora koji su mogli utjecati na uzorke iskorištavanja različitih sirovinskih materijala. Kao što je vidljivo iz uzorka eneolitičkih tekstilnih alatki diljem jugoistočne i središnje Europe, glavni se klimatski trendovi preklapaju s promjenama u morfologiji pršljenova za predenje (Grabundžija & Russo 2016). Čini se da su oba skupa podataka usklađena sa zabilježenim tendencijama u strategijama preživljavanja (Hoekman-Sites & Giblin 2012; Gyucha & Duffy 2013). Tekstilni zanati među najstarijim su tehnologijama, a znatna količina tekstilnih proizvoda bila je neophodna u svakodnevnom životu. Proizvodnja je ovisila o dostupnosti sirovina, stoga je uvođenje novih vrsta vlakana moglo biti od ključne važnosti za ekonomiju tijekom proučavanog razdoblja.

Alatke za proizvodnju tekstila ovise o nekoliko faktora, kao što su primijenjene tehnike, korišteni materijali i željeni krajnji proizvodi. Većinu njih moguće je sagledati kroz analizu morfoloških karakteristika tekstilnih alatki, a koje su, dokazano, osjetljive na kulturnu atribuciju (Grabundžija 2018).

Izravni i neizravni dokazi

Najstarija dosad poznata vunena tkanina datirana je u vrijeme između 3700. i 3200. god. kal. pr. Kr. (Shishlina et al. 2003), a pronađena je na sjevernom Kavkazu u središnjoj Aziji i pripisana kulturi Majkop. Osim toga, na predenom platnu s lokaliteta Lagozza di Besnate u gradu Varese pronađeno je nekoliko pojedinačnih vunenih niti (Bazzanella et al. 2003: 184) datiranih u kasni neolitik (Baioni 2003: 183), otprilike u vrijeme između 3800. i 2800. god. kal. pr. Kr. (Skeates 1994: 222-223), a oba nalaza sugeriraju da je u europskim kontekstima moguće očekivati prvu pojavu vune jednako rano kao i na Bliskom Istoku. Činjenicu da je vuna prepoznata u 4. tisućljeću pr. Kr. (Good 1999; Shishlina et al. 2003) treba uzeti kao referentnu točku za buduća istraživanja, odnosno kao *terminus ante quem* za pojavu vunastih ovaca (Becker et al. 2016: 113).

et al., in review) are being applied for determining spatio-temporal aspects of the investigated technological trends.

The complexity of investigating the expanse of new fibre material production relies mainly on proxy indicators and the integration of different research fields. Incorporation of climate change modeling (Grabundžija & Russo 2016) and investigation of vegetation developments (Schumacher et al. 2015; 2016) is considered crucial for determining possible environmental factors that might have influenced different raw material exploitation patterns. As observed on the Eneolithic textile tool samples across South East and Central Europe, the main climate trends are shown to be concurrent with changes in spindle whorl morphology (Grabundžija & Russo 2016). Both sets of data appear to be in accord with the outlined tendencies in subsistence strategies (Hoekman-Sites & Giblin 2012; Gyucha & Duffy 2013). Textile crafting is one of the oldest technologies and the variety of its products was indispensable in everyday life. It relied on raw material availability, so the introduction of new fibre options might have had a fundamental impact on ancient economies during this period.

Textile tools depend on several factors, such as applied techniques, used materials and desired end products. Most of them can be investigated through the analysis of morphological traits of textile tools, which have proven to be culture sensitive (Grabundžija 2018).

Direct and Indirect Evidence

So far, the oldest woolen textile, dated between 3700-3200 cal. BC (Shishlina et al. 2003), which was found at North Caucasus in Central Asia is attributed to the Majkop culture. Additionally, a few stray wool fibres on a twined cloth from Lagozza di Besnate, Varese (Bazzanella et al. 2003: 184) that was dated to the recent Neolithic (Baioni 2003: 183), roughly between 3800-2800 cal. BC (Skeates 1994: 222–223), propose that first wool can be expected in European contexts just as early as in the Near East. The fact that wool has been identified in the 4th millennium BC (Good 1999; Shishlina et al. 2003) should be taken as a reference point for further investigation, marking a *terminus ante quem* for the appearance of woolly sheep (Becker et al. 2016: 113).

Due to the rareness of direct evidence, a great deal of research in the frame of textile archaeology re-

Zbog rijetke pojave izravnih dokaza, a s ciljem proučavanja vlakana znatan dio istraživanja u okvirima arheologije tekstila odnosi se na različite izvore podataka. Studije tekstilnih vlakana koje se bave pretpovijesnom proizvodnjom na Bliskom Istoku dodatne podatke mogu crpiti iz pisanih izvora, uključujući i prijeko potrebne podatke o ranim izvorima sirovina. Preciznije, proizvodnja vune spominje se već u 3. tisućljeću pr. Kr. u zapisima na klinastom pismu (Völling 2012), a u nekima se od njih čak opisuju tehnike korištene u proizvodnji tekstila (Waetzoldt 1972; 2007; 2010; 2013; Steinkeller 1980). O detaljima tekstilne proizvodnje, prvenstveno predenju, tkanju i bojenju, već je raspravljano u nekoliko studija koje se bave tekstovima s lokaliteta Ur III (Andersson Strand & Cybulska 2012; Firth & Nosch 2012; Firth 2013). Nažalost, takav pristup nije moguće primijeniti u kontekstu pretpovijesne Europe, gdje se studije tekstila oslanjaju na sporadične konkretne ostatke i analizu znatno brojnijih tekstilnih alatki.

sorts to different sources of information for the purpose of investigating fibre materials. Textile fibre studies that focus on the prehistoric Near Eastern productions are able to derive additional data from written sources, which include indispensable information on the early raw materials. Specifically, wool production is mentioned already in the late 3rd millennium BC cuneiform scripts (Völling 2012), some of which are even describing employed textile production techniques (Waetzoldt 1972; 2007; 2010; 2013; Steinkeller 1980). Specifics of textile production, in particular spinning, weaving and dyeing, are addressed in several studies based on Ur III texts (Andersson Strand & Cybulska 2012; Firth & Nosch 2012; Firth,2013). Unfortunately, this kind of approach is not possible in the context of prehistoric Europe, where textile studies rely on scarce actual remains and the analysis of more numerous textile tools.

Ostaci tekstila

Očuvanje tekstila u arheološkim kontekstima uglavnom ovisi o uvjetima tla i mikrobima. Izuzetno se rijetko pojavljuju u pretpovijesnim slojevima, što je ujedno i glavni razlog zbog kojeg arheolozi često zaborave i previde njihovo postojanje. PH vrijednosti tla različito utječu na očuvanje vlakana životinjskog i biljnog porijekla. Neutralna tla (pH=7) pogoduju životinjskim vlaknima koja se većinski sastoje od bjelančevina, što znači da se raspadaju u alkalnim uvjetima, za razliku od biljnih vlakana, koja se, zbog svog celuloznog sastava, raspadaju u kiselom, a ostaju bolje očuvana u alkalnom okruženju (Cybulska & Maik 2007).

Očuvanje obje vrste vlakana, biljnih i životinjskih, u istom kontekstu je neuobičajena pojava, iako je moguća pod posebnim okolnostima kada su aktivnosti mikroba smanjene zbog suše (Good 1999), smrzavanja (Winiger 1995) ili visoke koncentracije soli (Bichler et al. 2005).

Tkanine se obično kratko koriste, što znači da su pogodne za radiokarbonsko datiranje, osobito nakon što je razvijena metoda masene spektrometrije akceleratorom (AMS) koja je omogućila datiranje manjih uzoraka. U skladu s tim, u sklopu nekolicine projekata je provedeno sustavno radiokarbonsko datiranje arheoloških tekstila, čime je uspostavljen čvrsti kronološki okvir za važne tekstilne zbirke i, što je još važnije, na temelju čega

Textile Remains

Preservation of textiles in archaeological contexts mainly depends on soil conditions and microbial activity. Their appearance in prehistoric deposits is exceptionally rare, which is the main reason why their overall presence often tends to be forgotten and overlooked by archaeologists. The soil's pH-value influences the conservation of animal and vegetal fibres differently. Neutral soils (pH=7) favour animal fibres that are protein-based, which causes them to decay in alkaline conditions, while vegetal fibres dissolve in acidic milieu and are better preserved in alkaline environment, mainly due to their cellulose composition (Cybulska & Maik 2007).

The preservation of both types of fibres, vegetal and animal, in the same context is extraordinary, whereas it occurs in special circumstances of reduced microbial activity due to desiccation (Good 1999), permafrost (Winiger 1995) or high salt concentration (Bichler et al. 2005).

Textiles usually have a relatively short period of use, which makes them suitable for radiocarbon dating, especially after the development of accelerator mass spectrometry (AMS) that enabled dating of smaller samples. Accordingly, several projects have carried out systematic radiocarbon dating of archaeological textiles, which established a solid chronological framework for important textile collections, and more importantly, resulted in an on-je Rheinische Friedrich-Wilhelms-Universität u Bonnu osnovao elektroničku bazu podataka datiranih tekstila (http://textile-dates.info).

Glavna analiza vlakana uključuje njihovo prepoznavanje, mjerenje i procjenu kvalitete, dok se dodatne izmjere mogu koristiti pri određivanju načina njihove obrade, primjerice za utvrđivanje jesu li vlakna prethodno namakana, te da li su spajana uplitanjem ili predenjem (Leuzinger & Rast-Eicher 2011). Sastav vunenih vlakana može ukazivati na vrstu ovce od koje potječe sirovina (i.e. primitivne dlakave ovce ili razvijenije vrste), na to je li vuna trgana ili čupana, je li odvajana i čak je li češljana. Ovaj se proces izvodi kombiniranjem svjetlosnog i skenirajućeg elektronskog mikroskopa (SEM) koji se koriste za proučavanje pigmentacije i strukture, te za inspekciju ljuski i srži vlakana, kao i za utvrđivanje prisutnosti bojila, iako se, u slučaju da nije moguće uzeti uzorke, kao zamjena može koristiti digitalni video mikroskop, npr. *Optilia Flexia* (Gleba 2012).

Na području jugoistočne i središnje Europe pronađeno je samo nekoliko ostataka tekstila, a većina ih je otkrivena u močvarama Ljubljanskog barja. Nažalost, količina dostupnih podataka o ovim uzorcima izuzetno je mala.

Komadići niti i užadi iz Dežmanovih istraživanja čuvaju se u Nacionalnom muzeju u Ljubljani. Druge niti i užad, kao i sitni komadići tkanog tekstila, čuvaju se u Blatnoj Brezovici. Kemijske analize su pokazale da su nalazi izrađeni od lana ili konoplje (Greif 1997: 41). Ipak, za razliku od lana (*Linum usitatissimum*), korištenje konoplje (*Cannabis sativa*) za proizvodnju tekstila iz razdoblja prije željeznog doba u Europi nije dovoljno poznato (Barber 1991: 15). Solidna količina nalaza iz Ljubljanskog barja, većina kojih, nažalost, nije u potpunosti objavljena, uključuje različite tekstilne proizvode (predivo, užad i tkana platna). Svi su ovi nalazi, prema dostupnim podacima, biljnog porijekla, iako za većinu njih nisu poznati tehnološki parametri poput debljine i smjera predenja niti, tehnika tkanja i slično.

Arheobotanički podaci iz močvara (Greif 1997: 29, Sl. 4, 5) potvrđuju prisustvo nekoliko divljih i kultiviranih vrsta koje su mogle biti korištene u proizvodnji tekstila, prostirki i košara, uključujući rogoz (*Typha angustfollia*) i lipu (*Tilia sp.*). Lan je tek nedavno uvršten na popis zbog korištenja prikladne arheobotaničke metode uzorkovanja i proučavanja (Tolar & Veluščček 2009). Prisutnost lana zabilježena je na lokalitetu Stare Gmajne, jednom

line database of dated textiles established by the Rheinische Friedrich-Wilhelms-Universität in Bonn (http://textile-dates.info).

The main fibre analysis includes the identification of fibres, measurement and assessment of fibre quality, while further measurements of fibres can be used for determining how they were processed, e.g. whether the plant fibres were retted or not, or whether they have been spliced or spun (Leuzinger & Rast-Eicher 2011). The composition of wool fibres can indicate the type of sheep they derive from (i.e. primitive hairy sheep or more developed ones), whether the wool was shorn or plucked, if it had been sorted or even if it had been combed. This is done by a combination of light microscopy and scanning electron microscopes (SEM), used for investigating pigmentation, scales, fibre surface, medulla and indications of dye, although if it is not possible to take samples, a digital video microscope, i. e. *Optilia Flexia* may be used as an alternative (Gleba 2012).

Only a few textile remains have been found within the scope of South East and southern Central Europe. The great majority of them were recovered at Ljubljansko Barje moors, however, the existing data on these particular examples are very scarce.

Pieces of threads and cord from Dežman's excavations are kept in the National museum in Ljubljana. Other threads and cords, as well as tiny pieces of woven textiles are found at Blatna Brezovica. According to chemical analyses, they are made of either flax or hemp (Greif 1997: 41). But, in contrast to the use of flax (*Linum usitatissimum*), the textile use of hemp (*Cannabis sativa*) in Europe is so far not sufficiently attested prior to the Iron Age (Barber 1991: 15). The fair amount of evidence from Ljubljansko barje, most of which is unfortunately insufficiently published, includes textile products of different character (yarn, cords and woven fabrics). These are all, according to the available data, of plant origin, although, for most of the finds nothing is known about technological parameters, like thickness and spin direction of the thread, weaving techniques, etc.

Archaeobotanical data from the moors (Greif 1997: 29, Fig. 4, 5) attested the presence of a few wild and cultivated species that might have been used for textile, mat and basketry products, including marshy grass (*Typha angustfollia*) and lime-tree (*Tilia sp.*). Flax was only recently added to the list, due to the use of an appropriate archaeobotanical method of sampling and examination (Tolar & Veluščček 2009).

od močvarnih nalazišta gdje je pronađeno i predivo pripremljeno za tkanje ili izradu užeta (Pajagič-Bregar et al. 2009: 310). Provedena analiza vlakana temeljena je na slikama dobivenim SEM-om, a rezultati sugeriraju da je ova visoko-kvalitetna pređa, datirana u kraj 4. tisućljeća pr. Kr., vjerojatno ispredena od vlakana dobivenih iz plodova i stabljika biljaka iz porodice trava (*Poaceae*) (Pajagič-Bregar et al. 2009: 318).

Još jedan važan dokaz iz regije jest tehnološki potpuna tkanina pronađena u brončanodobnom grobnom humku na lokalitetu Pustopolje u Bosni i Hercegovini, datirana u sredinu 2. tisućljeća pr. Kr. (Marić Baković & Car 2014: 42). Vuneni plašt iz Pustopolja na Kupresu sada se sastoji od gotovo 600 ulomaka, a, s obzirom na to da su očuvana sva četiri ruba, bilo je moguće odrediti njegovu izvornu veličinu, oblik i, najvažnije, način na koji je izrađen (Hoffmann 1964). Srećom, sam nalaz još je organski, što znači da se sastoji od vune i nije mineraliziran, čime su omogućene znanstvene analize vlakana i bojila. Sama tkanina jednostavno je istkana vuna, očuvana s početnim i završnim krajevima, kao i bočnim rubovima (Bender Jørgensen & Grömer, 2012: Sl. 4). Dokazano je da je plašt kvalitetno napravljen; ujednačenost vune i tkanine pokazuju da su brončanodobni proizvođači s prostora Balkana bili vješti majstori sposobni proizvesti kvalitetnu tkaninu, vjerojatno korištenjem ručnog, visećeg vretena i tkalačkog stana s nategnutom osnovom (Bender Jørgensen & Grömer 2012: 52). Tehnološka analiza strukture tekstila omogućila je identifikaciju početnog ruba: "*vrsta poprečnog ruba kakvu se obično povezuje s korištenjem tkalačkog stana s nategnutom osnovom*" (Bender Jørgensen & Grömer 2012: 61).

Dr. Antoinette Rast-Eicher provela je analizu vlakana na uzorcima iz Pustopolja korištenjem svjetlosnog i SEM mikroskopa te je, na temelju kombinacije vrlo finih i vrlo grubih vlakana, ustanovila da je korištena '"tipična" neodvajana brončanodobna vuna (Bender Jørgensen & Grömer 2012: 56).

Analogije za tekstil iz Pustopolja mogu se naći među brončanodobnim vunenim nalazima iz rudnika bakra i soli na lokalitetima Mitterberg i Hallstatt koji su datirani u vrijeme između 1600. i 1200. god. pr. Kr. (Grömer 2006). Ovi nalazi ukazuju na „potpuno razvijenu kulturu korištenja vune i, iako su jednostavne vunene tkanine izrađivane od samo jednog prediva, dokazuju pojavu određene novine - boje (Bender Jørgensen & Grömer 2012: 50).

The presence of flax was recorded at Stare Gmajne, one of the moor sites that also yielded a preserved example of a spun yarn, wound into a ball and prepared for weaving, or rope making (Pajagič-Bregar et al. 2009: 310). The performed fibre analysis was based on the SEM images, results of which suggest that this high-quality yarn, dated to the end of the 4th millennium BC was most probably spun from fibres found in fruits and stems of plants belonging to the family of grasses (*Poaceae*) (Pajagič-Bregar et al. 2009: 318).

Another important piece of evidence from the region is a technically complete textile, found in a Bronze Age burial mound at Pustopolje in Bosnia-Herzegovina, dated to the middle of the 2nd millennium BC (Marić Baković & Car 2014: 42). The woolen cape from Pustopolje, Kupres now consists of almost 600 fragments, but as all four edges are preserved it was possible to establish its original size and design, and most importantly, how it was made (Hoffmann 1964). Fortunately, the find itself is still organic, meaning it consists of wool rather than being mineralized, which enabled the scientific analyses of fibres and dyestuffs. The textile itself is a wool tabby- complete with starting and finishing borders as well as salvages (Bender Jørgensen & Grömer 2012: Fig. 4). It is proven to be well made; the evenness of yarns and fabric shows that Bronze Age manufacturers from the Balkans were skilled craftsmen, able to produce high-quality fabric, most likely using drop spindles and the warp-weighted loom (Bender Jørgensen & Grömer 2012: 52). Technical analysis of the textile structure made it possible to identify the starting border, "*a type of transverse border that is usually associated with the warp-weighted loom*" (Bender Jørgensen & Grömer 2012: 61).

Samples of the Pustopolje textile have been subjected to fibre analysis by Dr. Antoinette Rast-Eicher, who used the Light microscopy and SEM to determine that, based on a combination of very fine and very coarse fibres (kemp), a 'typical' unsorted Bronze Age wool was used (Bender Jørgensen & Grömer 2012: 56).

Analogies for the textile recovered at Pustopolje can be found among Bronze Age woolen finds from the copper and salt mines at Mitterberg and Hallstatt, both dated between 1600 and 1200 BC (Grömer 2006). These finds suggest "*a fully developed wool textile culture*", and even though the woolen tabbies are made of single yarn and are coarser than the Early Bronze Age linens, they offer a particular novelty- color (Bender Jørgensen & Grömer 2012: 50).

Alatke za proizvodnju tekstila

Za razliku od konkretnih ostataka tekstila, alatke za njegovu proizvodnju čest su nalaz u pretpovijesnim kontekstima jugoistočne i srednje Europe. Posebno je to slučaj s pršljenovima koji postaju brojniji tijekom razdoblja eneolitika (Sl. 1). Knjiga Elizabeth Barber, "Prehistoric Textiles" (Barber 1991), znatno je promijenila shvaćanje tekstila u arheologiji jer je ukazala na postojanje alatki i potencijal da se kroz njih osvrne na pitanja sirovinskih materijala, tehnika i krajnjih proizvoda.

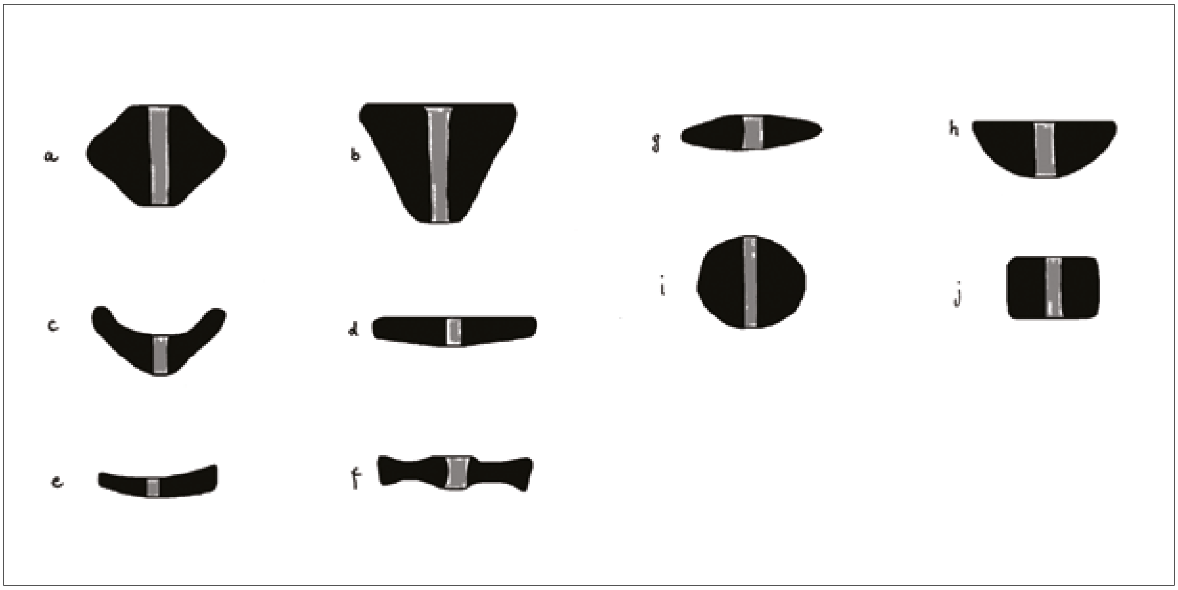
Tijekom prošlog desetljeća tekstilne su se alatke našle u središtu studija kojima se nastoji objasniti tehnološki razvoj povezan sa specijalizacijom zanata (Andersson Strand 2011), povećanjem proizvodnje (McCorriston 1997) i uvođenjem novih sirovina (Kimbrough 2006). Kako bi se rasvijetlila izvorna upotreba i funkcija tekstilnih alatki s obzirom na različita vlakna, studije tekstila često se služe kombinacijom dvaju metoda. Prva se odnosi na tehnološku analizu tekstilnih alatki (i.e. Belanova-Štolcova & Gromer 2010), a druga, koja je nadopunjava, se temelji na rezultatima eksperimentalne arheologije (Andersson Strand 2010) koji pružaju analogije potrebne za određivanje parametara funkcionalnosti alatki.

Textile Tools

Unlike actual textile remains, textile tools are well represented in the prehistoric contexts across South East and Central Europe. This especially holds true for spindle whorls, which become numerous during the course of the Eneolithic period (Fig. 1). Elizabeth Barber's book "Prehistoric Textiles" (Barber 1991), immensely changed the perception of textiles in archaeology, since it raised the awareness of tools and their potential for addressing issues of raw fibre materials, techniques and final products.

During the past decade textile tools have become the main focus of studies explaining technological developments connected to craft specialization (Andersson Strand 2011), intensified production (McCorriston 1997) and introduction of new raw materials (Kimbrough 2006). In order to elucidate the original use and function of textile tools in connection to different fibres, textile studies often combine two main methods. The first includes a technical analysis of textile tools (i.e. Belanová-Štolcová & Grömer 2010) and the second, which complements it, is based on the results of experimental archaeology (Andersson Strand 2010) that provides analogies necessary for a determining tool's functional parameters.

Slika / Figure 1. Najčešći tipovi eneolitičkih pršljenova: (a) bikonični, (b) konični, (c) konkavni konični, (d) diskoidni, (e) različiti oblici ulomaka keramike, (f) diskoidni u obliku kotača, (g) lećasti, (h) konveksni, (i) okrugli i (j) cilindrični / Most common Eneolithic spindle whorl types: (a) biconical, (b) conical, (c) concave conical, (d) discoid, (e) various forms of ceramic fragments, (f) wheel-like discoid, (g) lenticular, (h) convex, (i) spherical and (j) cylindrical (crtež / drawing: A. Grabundžija).



Izuzev pionirskih studija tekstilnih tradicija u Rumunjskoj (Mazăre 2014) i Bugarskoj (Petrova 2011), koje su u obzir uzele samo arheološke nalaze iz ograničenih zemljopisnih cjelina, dijagnostički nalazi sa širokog prostora jugoistočne i srednje Europe tek su odnedavno postali predmetom sustavnih istraživanja (Grabundžija & Schoch, u tisku). Iako je Mazareina studija (2014) tekstilnih alatki iz Transilvanije obuhvatila dugo razdoblje između otprilike 6000. i 3500. god. pr. Kr., u njoj eneolitička proizvodnja tekstila nije dovoljno istražena i obuhvaćena. Nažalost, 'prijelazna' stoljeća druge polovice 4. i prve polovice 3. tisućljeća pr. Kr., koja nisu zahvaćena spomenutom studijom, najzanimljivije su razdoblje za proučavanje iskorištavanja novih izvora vlakana. Prvo, zbog onoga što Sherratt predlaže u svom SPR modelu (Sherratt 1981; 1983) po pitanju izvora životinjskih vlakana, i, drugo, zbog onoga što o uzgoju lana govore nove studije botaničkih ostataka (Brombacher & Jacomet 1997; Jacomet 2009; Herbig & Maier 2011; Harris 2014).

S druge strane, studija koju je Petrova (2011) provela na tekstilnim alatkama iz Bugarske uglavnom se bavi kasnijim kontekstima i primarno se osvrće na uzorke alatki iz brončanog i željeznog doba. Takav pristup ni u ovom slučaju nije omogućio detaljnije proučavanje velikih napredaka u strategijama pribavljanja vlakana kakve bi se moglo očekivati u razdoblju eneolitika. Uzgredno, nedostatak oba navedena istraživanja jest to što je zbog usmjerenosti na pojedinačna razdoblja i ograničene prostore ostalo malo mjesta za usporedbe rezultata na međuregionalnoj razini.

Ipak, napravljena je još jedna studija tekstilnih alatki koja je uključila znatan broj eneolitičkih nalazišta u Poljskoj (Chmielewski 2009), i koja može poslužiti kao referenca za tehnološke promjene uočene na uzorku alatki iz jugoistočne i srednje Europe (Grabundžija & Russo 2016; Grabundžija & Schoch, u tisku). Chmielewskijevo opsežno istraživanje proizvodnje tekstila uključilo je ne samo tehnološke aspekte predenja i tkanja, već i zooarheološke i arheobotaničke podatke važne za istraživanje tekstilnih vlakana. Nadalje, njegova i Gardyńskijeva funkcionalna analiza pršljenova temeljena na izračunima momenta inercije (Chmielewski & Gardyński 2010) znatno je doprinijela metodologiji istraživanja rotacijskih svojstava alatki i njihovoj povezanosti s korištenjem različitih vrsta sirovih vlakana.

Apart from pioneering studies on textile traditions in Romania (Mazăre 2014) and Bulgaria (Petrova 2011), which only took into consideration archaeological evidence from confined geographical sections, diagnostic objects from a large area of South East and southern Central Europe have been only recently systematically studied (Grabundžija & Schoch, in press). Although Mazăre's study (2014) of textile tools from the Transylvanian region covered a large period between ca. 6000 and 3500 BC, it left the Late Eneolithic textile production under-investigated and unaddressed. Unfortunately, the 'transitional' centuries of the second half of the 4th and the first half of the 3rd millennium BC, which are not covered by the particular study, are the most interesting for the research of the new fibre material practice. Firstly, in regard to animal fibre resources, as it is proposed by Sherratt's SPR model (Sherratt 1981; 1983), and secondly, in regard to flax fibre cultivation, as it is indicated by the recent studies on botanical evidence (Brombacher & Jacomet 1997; Jacomet 2009; Herbig & Maier 2011; Harris 2014).

On the other hand, Petrova's study (2011) of textile-tools from Bulgaria covers mainly later contexts, focusing more precisely on Bronze and Iron Age tool samples. This again did not allow a more detailed study of the major advancements in the fibre material procurement strategies that are expected for the Eneolithic period. Incidentally, the drawback of both bodies of research is that while focusing on separate periods and confined areas, they left little room for cross-regional comparison of the results.

However, another case study of textile tools, which incorporates a fair number of Eneolithic sites in Poland (Chmielewski 2009), offers a reference for technological changes observed on the Eneolithic tool sample from South East and southern Central Europe (Grabundžija & Russo 2016; Grabundžija & Schoch, in press). Chmielewski's extensive research on textile production covers not only spinning and weaving aspects of the technology but also incorporates zooarchaeological and archaeobotanical data relevant for the textile fibre research. Furthermore, his and Gardyński's functional analysis of spindle whorls, based on the moment of inertia calculations (Chmielewski & Gardyński 2010), made a valuable methodological asset to the investigation of a tools' rotational properties and their possible correlation to different raw fibre materials.

Glavna prepreka u istraživanju pretpovijesnih tehnologija tekstila, a posebice razvoja u proizvodnji i obradi vlakana, je nedostatak objavljenih podataka. Alatke koje i jesu objavljene obično nisu prezentirane u potpunosti, kao cjeloviti skup nalaza, ili pak nedostaju najvažniji podaci poput veličine i težine. Takve je nalaze stoga moguće samo tipološki uspoređivati, jer manjak podataka onemogućava provođenje funkcionalne analize.

Na spomenutim sojeničarskim lokalitetima iz Ljubljanskog barja, na kojima je pronađeno nekoliko komada tkanine, također je otkrivena i velika količina tekstilnih alatki, uglavnom pršljenova. Nažalost, dosad nije objavljena niti jedna sustavna studija o proizvodnji tekstila. Neki od nalaza se ipak spominju, primjerice dio uzorka iz Maharskog Prekopa (Bregant 1974a; 1974b; 1975), lokaliteta istovremenog kompleksu Baden-Boleráz (Parzinger 1984) koji je apsolutno datiran u vrijeme između otprilike 3500. i 3300. god. pr. Krista. Tipologija ovog uzorka istovjetna je tipologiji pršljenova pripisanih kulturnoj skupini Baden-Boleráz (Ruttkay 1995: 145-160), iako se mogu povući jake paralele i s alatkama s lokaliteta kulture Horgen, Arbon-Bleiche 3 u istočnoj Švicarskoj (Leuzinger 2002: Sl. 2). Ovaj je lokalitet apsolutno datiran u vrijeme između 3384. i 3370. god. kal. pr. Kr., što ga čini gotovo istovremenim Maharskom Prekopu (de Capitani & Leuzinger 2001: 721). Utemeljenost usporedbe ova dva skupa nalaza potvrđena je jakim utjecajima kompleksa Baden-Boleráz (de Capitani & Leuzinger 2001: 723). Svi tipovi pršljenova iz Maharskog Prekopa imaju analogije u uzorku s lokaliteta Arbon-Bleiche 3. Ipak, ova se dva uzorka znatno razlikuju u veličini pršljenova. Pršljenovi iz Maharskog Prekopa znatno su veći od primjera s lokaliteta Arbon-Bleiche 3. Još je na jednom lokalitetu iz Ljubljanskog barja, Blatna Brezovica (Korošec 1963), pronađen uzorak pršljenova koji se mogu smatrati otprilike istovremenima onima iz skupa nalaza s lokaliteta Maharski Prekop (Greif 1997: Tab. 1). Na lokalitetu su pronađeni konkretni ostaci tekstila koji su i dalje neobjavljeni, iako je izbor velikih bikoničnih i koničnih pršljenova (kao i ulomak jajolikog utega za tkalački stan s uzdužno probušenom rupom) spomenut u literaturi (Korošec 1963: 17, 18, 20).

Uzorci alatki koji sadrže velike i teške bikonične te konične pršljenove zabilježeni su i u kontekstima kasnog eneolitika diljem kontinentalne Hrvatske: Slavča-Nova Gradiška, Štrosmajerovac, Đakovo-Franjevac, Čepinski Martinci-Dubrava, i Tomašan-

The main setback in investigating prehistoric textile technologies and, in particular, developments in fibre production and processing is the lack of published data. Those tools that do get published are often not reported in their complete assemblages or are lacking the most important data, which include size and weight information. This makes them eligible for typological comparisons but does not provide the needed information for performing a functional analysis.

The already mentioned Ljubljansko Barje pile-dwelling sites, which yielded several pieces of textile, also produced a large amount of textile tools, mainly spindle whorls. Unfortunately, no systematic study of textile production has been published so far. Some of the finds have been reported, among them a part of the sample from Maharski Prekop (Bregant 1974a; 1974b; 1975), a site synchronized with the Baden-Boleráz complex (Parzinger 1984), and dated in absolute terms to the period between ca. 3500-3300 BC. The particular sample typologically corresponds to the spindle whorl sets of the Baden-Boleráz cultural group (Ruttkay 1995: 145–160), although strong parallels can be also made with the tools from Horgen site Arbon-Bleiche 3 in east Switzerland (Leuzinger 2002: Fig. 2). This site is absolutely dated between 3384 and 3370 cal. BC, which makes it roughly contemporary to Maharski Prekop (de Capitani & Leuzinger 2001: 721). The basis for comparison of the two tool sets is supported by the pronounced Baden-Boleráz influence (de Capitani & Leuzinger 2001: 723). All types of whorls from Maharski Prekop reveal parallels in Arbon-Bleiche 3 sample. Although, these two samples obviously differ in the size of the whorls. Spindle whorls from Maharski Prekop appear significantly larger than the examples belonging to the Arbon-Bleiche 3 sample. Another Ljubljansko Barje site, Blatna Brezovica (Korošec 1963), also yielded a spindle whorl sample that could be considered roughly contemporary to the Maharski Prekop assemblage (Greif 1997: Tab. 1). The site produced some actual textile remains that remain unpublished, although a selection of large biconical and conical spindle whorls (including a fragment of an ovoid longitudinally pierced loom weight) was reported in the literature (Korošec 1963: 17, 18, 20).

Comparable spindle whorl samples containing large and heavy biconical and conical spindle whorl types are recorded at several Late Eneolithic contexts across continental Croatia: Slavča-Nova Gradiška, Štrosmajerovac, Đakovo-Franjevac, Čepinski Mar-

Slika / Figure 2. Bikonični pršljenovi, Đakovo-Štrosmajerovac-Pustara / Biconical spindle whorls, Đakovo-Štrosmajerovac-Pustara (foto / photo; I. Krajcar).

Slika / Figure.3. Konični pršljenovi, Jaruge-Gođevo-Berava / Conical spindle whorls, Jaruge-Gođevo-Berava (foto / photo: I. Krajcar).

ci-Palača, (Grabundžija 2016). Radi se o primjercima koji su tipično vrlo velikih dimenzija i ukazuju na češći odabir viših tipova alatki (alatke većeg omjera visine i promjera), što se može smatrati glavnim tehnološkim standardom koji se razvio tijekom kasnog 4./ranog 3. tisućljeća pr. Kr. (Sl. 2-3).

Jedan od najvećih skupova nalaza pršljenova u široj regiji prikupljen je na lokalitetu Ig-Ljubljansko barje. Spomenute alatke potječu iz Dežmanovih istraživanja (Dežmnanova koliščа) koja su provedena krajem 19. stoljeća, a objavljene su bez zabilježenih težina (Korošec & Korošec 1969). Nažalost, i kronološka i kulturološka atribucija ovih nalaza je upitna. Prema autorima (Korošec & Korošec 1969), čini se izglednijim da zbirka potječe iz više od jednog naselja, a uspostavljeno je da se alatke može otprilike datirati u razdoblje od samog kraja eneolitika (vučedolska kultura) do ranog brončanog doba (kultura Somogyvár-Vinkovci/Ljubljana).

Tipološke (bikonični i visoki konični pršljenovi) i morfološke (veliki i teški pršljenovi) analogije za uzorak s lokaliteta Ig moguće je pronaći u rijetkim objavama pršljenova iz kasnog eneolitika s lokaliteta Vučedol-Gradac (Schmidt 1945: Sl. 48) i Sarvaš (Balen 2005: T. 58, 73, 74) u istočnoj Hrvatskoj, ili pak Gomolava u Srbiji (Petrović & Jovanović 2002: 221, 279, 319, 321). Određeni uzorci predstavljaju samo manji dio otkrivenih nalaza koje tek treba detaljno proučiti i dokumentirati.

tinci-Dubrava, Tomašanci-Palača, (Grabundžija 2016). These examples are typically very large in size and display a preference for (tools with greater height/diameter ratio) that can be considered as the main technological standard which developed during the late 4th/early 3rd millennium BC (Fig. 2-3)

One of the biggest sets of spindle whorls in the wider region was recovered at Ig – Ljubljansko barje. The tools in question originate from Dežman's excavations (Dežmanova koliščа) that were carried out at the end of the 19th century and were published without weight values (Korošec & Korošec 1969). Unfortunately, both chronological and cultural attribution of these tools remains uncertain. According to the authors (Korošec & Korošec 1969) it is more than likely that the collection belongs to more than one settlement and it can be established that the tools are roughly dated to the period from the very end of the Eneolithic (Vučedol culture) till the Early Bronze Age (Somogyvár-Vinkovci /Ljubljana culture).

Typological (biconical and high conical spindle whorls) and morphological (large and heavy spindle whorls) analogies for the Ig sample can be traced among rare published examples of Late Eneolithic spindle whorls from Vučedol-Gradac (Schmidt 1945: Taf. 48) and Sarvaš (Balen 2005: T. 58, 73, 74) in eastern Croatia, or Gomolava in Serbia (Petrović & Jovanović 2002: 221, 279, 319, 321). Particular samples represent only a small portion of the tools recovered, which remain to be studied and recorded in detail.

Istraživanje tekstilne tehnologije

Razvoju izvora tekstilnih vlakana moguće je pristupiti kroz proučavanje indikatora tehnoloških promjena, a koje se, kako je predloženo, može prepoznati kroz prilagodbu alatki na svojstva određene sirovine.

Kao što je Kimbrough predložila funkcionalne kategorije za analizu mezopotamskih pršljenova datiranih u 4. tisućljeće pr. Kr. (2006: 135-6), tako je nekoliko autora, primjerice Rast-Eicher (2005: 127) te Chmielewski i Gardyński (2010: 878), povezalo očite promjene u morfologiji pršljenova 4. tisućljeća pr. Kr. s ranim korištenjem vune u Europi.

Početne faze proizvodnje tekstila koje se odnose na obradu vlakana izuzetno su važne pri proučavanju trendova nabavljanja sirovina. Najbrojnije i standardizirane alatke koje omogućavaju dijakronički pristup takvim ciljevima upravo su pršljenovi, zbog toga što oni, u određenoj mjeri, sadrže potencijal za otkrivanje promjena u preferencijama pri odabiru vlakana (Bohnsack 1981; Crewe 1998) i svojstvima krajnjih proizvoda (Grömer 2005).

Glavne odrednice protokola dokumentiranja tekstilnih alatki se, više ili manje, temelje na istom metodološkom modelu kojeg je izradio Centar za istraživanje tekstila u Kopenhagenu. Svaku alatku karakteriziraju: tipološke odrednice, stanje očuvanosti, sirovina, ukras, kvaliteta izrade, tragovi korištenja, dimenzije i težina.

Osim pršljenova, bilježi se i analizira neizravne dokaze tehnologije tkanja. Utezi za tkalački stan često su jedini izvor podataka za proučavanje promjena u tradiciji tkanja. Eksperimentalnu metodu moguće je primijeniti kao dodatan dio analize alatki. Cilj takvih pokusa često je proučiti alternativne izbore alatki i njihovu prilagodljivost (Rahmstorf 2005; Mårtensson et al. 2007b; Pavúk 2012) u nastojanju da se objasni izostanak konvencionalnih tipova alatki u proučavanim kontekstima (Grabundžija et al. 2016).

Tehnologija predenja: glavni funkcionalni parametri

Napravljena je studija slučaja na pršljenovima s lokaliteta Josipovac Punitovački-Veliko polje I i Đakovo-Franjevac u istočnoj Hrvatskoj. Skupovi pršljenova pripisanih retzgajarskoj kulturi srednjeg te kostolačkoj kulturi kasnog eneolitika analizira-

Investigating Textile Technology

Developments in textile fibre resources can be approached through indications of technological change. These are proposed to be recognizable as tool adaptation to the particular raw material properties.

Just like Kimbrough established functional categories for the analysis of Mesopotamian spindle whorls dated to the 4th millennium BC (2006: 135–6), several authors, i.e. Rast-Eicher (2005: 127) and Chmielewski and Gardyński (2010: 878) connected obvious changes in the morphology of the 4th millennium BC spindle whorls with the early wool use in Europe.

Onset stages of textile production which relate to fibre processing are especially important for the investigation of trends in the raw material procurement. The most numerous and standardized tools that allow a diachronic approach to such objectives are spindle whorls. To a certain degree, they hold the potential for revealing changes in both the fibre material preferences (Bohnsack 1981; Crewe 1998) and the final product properties (Grömer 2005).

Main guidelines for textile tool recording protocol are more or less based on the same methodological model established by the Centre of the Textile Research in Copenhagen. Each tool is characterized by: typological assignment, preservation status, raw material, decoration, production quality, use wear, dimensions and weight

Besides spindle whorls, indirect evidence of weaving technology is also being recorded and analyzed. Loom weights are often the only source of information for addressing changes in the weaving traditions. An experimental method can be applied as a remote part of the tool analysis. These tests often aim to explore alternative tool options and their versatility (Rahmstorf 2005; Mårtensson et al. 2007b; Pavúk 2012) with an attempt to explain the absence of conventional tools in the investigated contexts (Grabundžija et al. 2016).

Spinning Technology: Main Functional Parameters

A spindle whorl case study was performed for Josipovac Punitovački – Veliko polje I and Đakovo – Franjevac sites in eastern Croatia. Spindle whorl assemblages associated with the Middle Eneolithic Retz-Gajary and the Late Eneolithic Kostolac culturni su s ciljem proučavanja tehnoloških napredaka u proizvodnji vlakana i njihov odnos sa značajnim kulturnim, društvenim i ekonomskim promjenama koje su se odvijale tijekom 4. i ranog 3. tisućljeća pr. Krista. Osnovna prostorna distribucija aktivnosti predenja i daljnje usporedbe na razini lokaliteta primijenjene su kako bi se ustanovile glavne odlike razvoja zanata, poput specijalizacije i organizacije, i to na lokalnoj razini. Prostorni kontekst tekstilnih alatki doveo je u pitanje proizvodnju tekstila na razini domaćinstva, te su njihova brojnost i koncentracija povezane s intenziviranjem zanatskih aktivnosti. Može se ustvrditi da je kroz promjene u tekstilnoj tehnologiji i razvoj zanatske proizvodnje, već od 4. tisućljeća pr. Kr. moguće pratiti povezanost društvenih strujanja s nastankom novog modela upravljanja sirovinama.

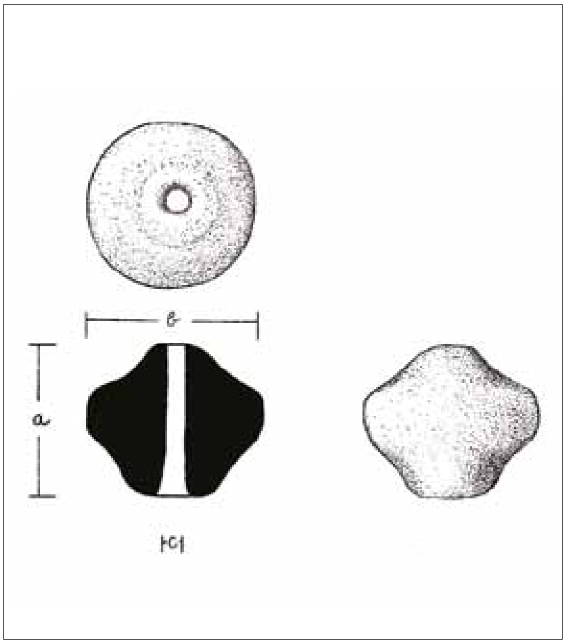
Ako se analizira dovoljno veliki uzorak tekstilnih alatki, moguće je primijeniti nekoliko statističkih metoda. Razlike u osnovnim svojstvima alatki moguće je statistički analizirati na različitim razinama asocijacije. Preciznije, moguće je utvrditi razmjer do kojeg funkcionalna i stilistička svojstva alatke ovise o kontekstu deponiranja i kulturno-povijesnoj atribuciji (Grabundžija, u tisku; Grabundžija et al., u postupku recenzije). Ovo se izravno odnosi na antropološka pitanja o tome zašto se u društvima na velikom zemljopisnom prostoru u određeno vrijeme javljaju sličnosti u materijalnoj kulturi. Već je Boas (1889; 1940) smatrao difuziju i migraciju primarnim metodama širenja materijalne kulture i uzrokom njezinih homogenih svojstava. Znatno kasnije, Steward je u svom višelinijskom evolucijskom modelu (1955) predložio promjene iznutra. Njegov model predlaže da su različite populacije, neovisno jedne od drugih, razvile paralelne značajke bez potrebe za difuzijom i migracijom. Analiza tehnoloških specifikacija nastoji ispitati načine na koje je uključivanje inovacija u proizvodnji tekstila utjecalo na lokalne populacije. *'Tekstil nije samo binarni sustav predenih, uvijanih ili uplitanih vlakana, već, prvo i osnovno, rezultat složenih interakcija između sirovina, tehnologije i društva'* (Andersson et al. 2010: 150).

Tijekom postupka uzorkovanja i obrade, posebna se pozornost obraća na morfološke karakteristike pršljenova (Sl. 4). U istom se polju istraživanja ove značajke smatraju ključnima za određivanje učinkovitosti alatke pri obradi sirovine s različitim svojstvima vlakana (Grömer 2005; Chmielewski & Gardyński 2010). I oblik i veličina pršljena određuju njegova rotacijska svojstva, što pak utječe na mo-

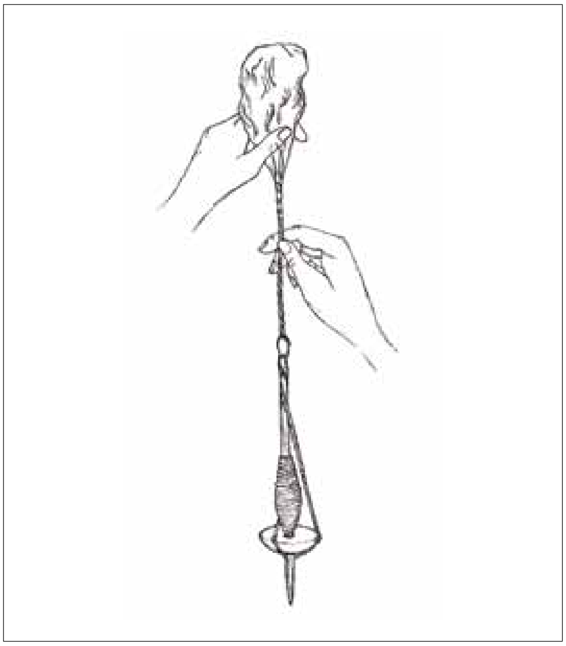
al-historical contexts were analyzed in order to investigate technological developments in fibre production and their connection to the significant cultural, social and economic changes that occurred during the 4th and early 3rd millennium BC. Basic spatial analysis of spinning activities and further inter-site comparisons were applied to access the main craft developments, such as specialization and organization, on a local scale. Textile tools' spatial contexts brought to question the household extent of textile production and their frequencies and concentration was associated with the early craft intensification. It might be argued that a close relationship between changes and developments in craft production, new raw material management and social flux are traceable already to the 4th millennium BC.

If given a big enough textile tool sample, an application of several statistical methods is possible. The differences in the main tool properties can be statistically analyzed on different levels of association. More precisely, it is possible to establish the extent to which a tool's functional and stylistic properties depend on its deposition context and cultural-historical attribution (Grabundžija, in press; Grabundžija et al., in review). This directly addresses anthropological questions regarding why societies over very large geographic regions at certain times exhibit similarities in their material culture. Already Boas (1889; 1940), considered diffusion and migration as the primary methods by which material cultures spread and displayed homogeneous traits. Much later, Steward in his multilinear evolution model (1955) proposed a change from within. Whereas, different populations independently developed parallel features, without the necessity of diffusion or migration. The analysis of technological specifications examines how local populations were affected by incorporating innovation into their textile productions. '*A textile is not simply a binary system of spun, twisted or spliced fibres, but, first and foremost, a result of complex interactions between resources, technology and society*' (Andersson et al. 2010: 150).

During the sampling and post-recording process, morphological traits of spindle whorls are given special attention (Fig. 4). In the respective field of research, these precise characteristics are held responsible for determining a tool's performance with raw materials of different fibre traits (Grömer 2005; Chmielewski & Gardyński 2010). Both the whorl's shape and its size determine its rotation-



Slika / Figure 4. Tri glavne bilježene metričke vrijednosti pršljenova: (a) visina pršljena, (b) promjer pršljena, (c) promjer rupe / Three main metric values recorded for spindle whorls: (a) height of the whorl, (b) diameter of the whorl, (c) perforation diameter (crtež / drawing: A. Grabundžija).



Slika / Figure 5. Predenje vlakana u nit pomoću ručnog, visećeg vretena. / Spinning fibres into thread with a bottom whorl drop spindle (crtež / drawing: A. Grabundžija).

ment inercije koji je ključan u procesu predenja (Sl. 5). Iako težina pršljena više utječe na tenziju, odnosno snagu koja vuče vlakna tijekom procesa predenja, njegova visina i promjer više utječu na brzinu rotacije. Posljedično, što je veća rotacija, to je predivo čvršće namotano (Andersson 2003: 25). Promjer i položaj perforacije također su svojstva koja u znatnoj mjeri utječu na okretanje pršljena, s tim da položaj utječe i na stabilnost pršljena pri rotaciji (Crewe 1998: 12). Perforacija u nekoj mjeri ukazuje i na tip vretena na kojoj je pršljen korišten, pa treba razmotriti i njezine dimenzije i svojstva, budući da su ista također utjecala na proces predenje (Gleba 2008: 3). Težina pršljena igra glavnu ulogu, prvenstveno zbog toga što je se može povezati i s korištenom sirovinom i sa svojstvima predene niti (Andersson 2003: 25). Smatra se da su duža, teža i grublja vlakna, poput onih biljnog porijekla, češće predena uz pomoć težih pršljenova, dok su lakša i kraća vlakna, poput onih životinjskog porijekla, predena uz pomoć lakših pršljenova (Barber 1991: 25; Gleba 2008: 103-106). Osim toga, ako se razmotre opća svojstva predene niti, onda teže i deblje pređe zahtijevaju korištenje težih, dok one lakše i tanje zahtijevaju korištenje lakših pršljenova (Ryder 1983; Costin 1993).

al properties, influencing the moment of inertia, which is crucial for the spinning process (Fig. 5). Although the weight has more influence on tension, namely the strength that pulls the fibres during the spinning process, the height and diameter have a greater impact on the speed of the rotation. Consequently, the higher the rotation the more tightly the yarn is spun (Andersson 2003: 25). Perforation diameter and position are another two properties that effect a whorl's rotation on a significant level, later also being accountable for a spindle whorl's stability while it rotates (Crewe 1998: 12). Perforation is to some extent indicative of a spindle on which a whorl was used, therefore its dimensions and properties have to be considered, since they too influenced the spinning (Gleba 2008: 3). The weight of the whorl is given the central role, mainly because it can be connected with both the raw material and the spun thread properties (Andersson 2003: 25). Longer, heavier and coarser fibres, like those of plant origin, are more often considered to be spun with heavier weights, while shorter and lighter fibres, such as animal ones are brought to connection with lighter whorls (Barber 1991: 25; Gleba 2008: 103–106). Additionally, if general properties of the spun thread are considered, then heavier and thicker yarns necessitate heavy whorls, while lighter and thinner yarns call for light whorls (Ryder 1983; Costin 1993).

Spomenute standarde treba uzeti s oprezom jer na sam proces predenja utječe mnogo združenih čimbenika. Izuzev spomenute težine, veličine i oblika pršljena, ne smije se u potpunosti zanemariti dodatne elemente, kao što su količina niti akumulirane na preslici (Barber 1994: 37), položaj pršljena na vretenu (Barber 1991: 66; Breniquet 2008: 110-112), odabir tehnike predenja (Mazăre 2014: 21) i, naposljetku, individualna vještina i preference prediоca/prelje (Kania 2015).

Eksperimentalnim su istraživanjima utvrđene glavne morfološke specifikacije koje određuju učinkovitost alatke s obzirom na različite vrste sirovina (Verhecken 2010). Smatra se da rezultati pokusnog predenja imaju značajan analitički potencijal za proučavanje strategija u proizvodnji vlakana, barem na razini određivanja da li su iste bile utemeljene na kultivaciji biljaka ili životinja. To je moguće prvenstveno zbog značajnih razlika u očekivanoj snazi i dužini dvaju glavnih kultiviranih vlakana u europskoj pretpovijesti: lana i vune.

The standards mentioned above ought to be taken with caution, since the actual spinning process is influenced by many combined factors. Besides the already mentioned weight, size, and shape of a whorl, additional traits such as the accumulated thread on a spindle (Barber 1994: 37), the whorl's position on it (Barber 1991: 66; Breniquet 2008: 110–112), the spinning technique used (Mazăre 2014: 21) and finally the spinner's skill and preference (Kania 2015) should be considered as well.

Experimental research established the main morphological specifications accountable for the tool's performance with different types of raw material (Verhecken 2010). The results of spinning experiments are held to have a significant analytical potential for investigating fibre production strategies, at least on the level of determining whether the staple has been based on plant or animal cultivates. This is due to a significant difference in the expected tensile strength and length of the main two cultivated fibre resources used in the European prehistory: fibre flax and wool.

Tehnologija tkanja: zagonetka utega za tkalački stan

Na temelju opće definicije onoga što sačinjava tkano platno, Andersson Strand dala je kratku i preciznu definiciju tehnologije tkanja koja obuhvaća sve tipove tehnika i tkalačkih stanova koji su mogli biti korišten tijekom pretpovijesti: '*Platno nastaje tkanjem dvaju sustava niti. Jedan od tih sustava, osnova, pada paralelno s bočnom stranom tkalačkog stana i nategnuta je tijekom cijelog procesa tkanja. Drugi sustav, potka, provlači se pod pravim kutem u odnosu na osnovu i naizmjenično prolazi preko i ispod njezinih niti'* (Andersson Strand 2012: 34).

Povećana proizvodnja niti, koja se obično očituje kroz veću frekvenciju pršljenova, postavlja pitanje o tkalačkim stanovima i tehnologiji tkanja, bilo da su korišteni za proizvodnju platna ili tapiserija.

Metode natezanja niti osnove razlikuju se među kulturama i razdobljima, a smatra se da je za tkanje u pretpovijesti korišteno nekoliko tipova tkalačkih stanova. Horizontalni podni tkalački stan smatra se jednim od najstarijih tipova tkalačkih stanova, iako je najraniji prikaz , s lokaliteta Badari u Egiptu, datiran u kasni neolitik (Broudy 1979: 38; Barber 1991: 83). Još jedan od ranih tipova je

Weaving Technology: Loom weight Puzzle

Based on the general definition of what constitutes a woven fabric, Andersson Strand gives a short and precise explanation of the weaving technology that covers all types of techniques and looms that might have been used during prehistory: '*A fabric is created by weaving together two thread systems. One of these systems, the warp, runs parallel to the side of the loom and is kept stretched during weaving. The other system, the weft, lies at right angles to the warp and runs alternately over and under the warp threads'* (Andersson Strand 2012: 34).

The intensified production of threads, which is generally attested by a higher frequency of spindle whorls raises a question of the loom and weaving technology, whether it was to produce cloth or for tapestry making.

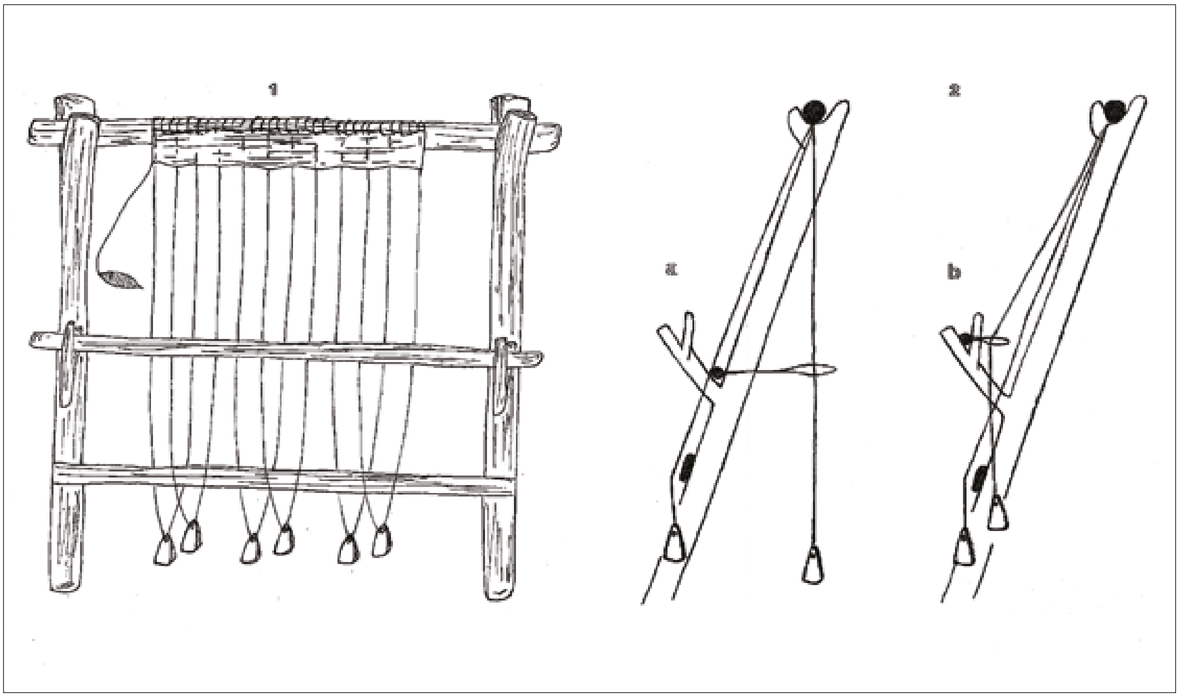
Methods of stretching the warp threads vary among different cultures and time periods, and several types of looms are proposed to have been used for weaving in the prehistoric times. The horizontal ground loom is considered to be one of the oldest loom types, even though the earliest depiction is dated to the Late Neolithic and comes from Badari, Egypt (Broudy 1979: 38; Barber 1991: 83). Another tkalački stan s osnovom nategnutom utezima, koji je smatran karakterističnim tkalačkim stanom pretpovijesne Europe (Hoffman 1964) i čije je korištenje pretpostavljeno u kontekstu kulture Körös u ranom neolitiku Mađarske, već u 7. ili ranom 6. tisućljeću pr. Kr. (Barber 1991: 93-94). Naposljetku, smatra se da se dvogredni tkalački stan, pretpostavljenog porijekla iz Sirije ili Palestine, razvio uvođenjem vune jer je bio pogodan za izradu šarenih tkanih tapiserija (Broudy 1979: 44; Barber 1991: 113).

Nažalost, tkalački stanovi sami po sebi nisu očuvani, budući da su bili izrađeni od propadljivih organskih materijala. Osim prikaza (Barber 1991: 83-116, 295; Wright 2013: 406) i tekstova (Maekawa 1980; Waetzoldt 1987) koji pružaju nenadomjestive podatke o pretpovijesnim tehnologijama tkanja, a koji izostaju iz europskog konteksta, čest dokaz njihovog korištenja su utezi za tkalački stan. Iako poprilično diskriminativno, oni ukazuju isključivo na upotrebu tkalačkih stanova s nategnutom osnovom (Sl. 6). U iznimnim slučajevima i druge tekstilne alatke, odnosno neizravni indikatori tkanja poput lađica ili češljeva, također ostaju sačuvani u pretpovijesnim kontekstima (Bazzanella et al. 2003; Kapeller 2003: 229).

early type is the warp-weighted loom, which is considered the characteristic loom of prehistoric Europe (Hoffman 1964) and is proposed to have been used in the Early Neolithic Körös culture of Hungary, already in the late 7th, or early 6th millennium BC (Barber 1991: 93–94). Finally, the two-beam loom, or tubular loom, which is proposed to have originated in Syria or Palestine, is considered to have been developed during the introduction of wool, due to its convenience for colorful tapestry weaving (Broudy 1979: 44; Barber 1991: 113).

Unfortunately, looms themselves haven't been preserved, since they were made of perishable, organic materials. Besides depictions (Barber 1991: 83-116, 295; Wright 2013: 406) and texts (Maekawa 1980; Waetzoldt 1987) that provide indispensable information about the prehistoric weaving technologies, both of which are lacking in European contexts, other common evidence for their use are loom weights. Although quite discriminatively, these are only indicative of the warp-weighted type of loom (Fig. 6). Exceptionally, other textile tools, like weaving swords or weaving combs, also get preserved in prehistoric contexts (Bazzanella et al. 2003; Kapeller 2003: 229) as an indirect indication of weaving.

Slika / Figure 6. Tkanje na tkalačkom stanu s nategnutom osnovom s prednje strane (1). Prirodna osnova (a) i umjetna osnova (b) označene su na bočnom prikazu (2) / Weaving on a warp-weighted loom from frontal perspective (1). Natural shed (a) and artificial shed (b) are denoted in the side perspective (2) (crtež / drawing: A. Grabundžija).



Slika / Figure 7. Uteg, Kamanje kod Vrlovke / Loom weight, Kamanje by Vrlovka (foto / photo: I. Krajcar).

Tkalački stan s osnovom nategnutom utezima možda je korišten i na lokalitetu Çatal Höyük, zbog čega se i Anatoliju i srednju Europe može smatrati izvorištima te vrste tehnologije (Barber 1991: 254), koja se mogla proširiti Europom iz bilo kojeg od ta dva centra. Na Bliskom Istoku i Egiptu su, pak, prevladavali podni tkalački stanovi.

Pronalaženje utega za tkalački stan *in situ* česta je pojava u neolitičkim kontekstima diljem Europe (Barber 1991: 91-100), a Barber čak opisuje tkanje na tkalačkim stanovima s nategnutom osnovom kao *'središnju kulturološku aktivnost*' tijekom tog razdoblja (Barber 1991: 97). S tim na umu, njihov izostanak u kontekstima kasnog eneolitika postavlja važna pitanja o promjeni tehnologije.

Iako rijetki, utezi iz kasnog eneolitika značajno su drugačiji od ranijih uobičajenih utega s perforacijom na gornjem dijelu, primjerice koničnih, diskoidnih ili eliptičnih tipova (Sl. 7), jer su najčešće cilindričnog ili jajolikog oblika koji je uzdužno perforiran (Grabundžija 2016).

Utezi za tkalački stan obično su izrađivani od pečene gline, iako valja spomenuti utege iz srednjeg eneolitika iz proučavane regije, prvenstveno one lasinjske kulture, a koji su uglavnom loše pečeni (niske temperature/oksidacijsko pečenje gline).

Izostanak utega za tkalački stan u pojedinim regijama i razdobljima, primjerice u slojevima V i rani VI u Troji (Pavúk 2012: 126), arheolozima je zagonetan. Isto tako, pretpostavlja se da je prekid u korištenju utega tijekom cijelog brončanog doba Egeide posljedica mogućeg uvođenja nove tehnologije tkanja (Nosch 2014: 6-7). Ipak, izuzev promjene u tipu korištenih tkalačkih stanova, postoji još nekoliko prihvatljivih objašnjenja za izostanak konvencionalnih utega za tkalački stan u arheološkim

A warp-weighted loom might have also been utilized at Çatal Höyük, thus, both Anatolia and Central Europe may be considered as possible origins of this particular technology (Barber 1991: 254). It could have spread throughout Europe from either of these two centers, while the ground loom prevailed in the Near and Middle East, as well as Egypt.

Findings of in situ loom weights are a common occurrence in Neolithic contexts across Europe (Barber 1991: 91–100) and Barber even describes weaving with a warp-weighted loom as a '*central cultural activity'* during the period (Barber 1991: 97). With this in mind, their disappearance in Late Eneolithic contexts raises an important question of technological change.

Exceptionally rare, Late Eneolithic weights largely differ from earlier, more conventional upper-perforated, for example conical, discoid or elliptical types (Fig. 7), since they have a cylindrical or ovoid shape and are usually lengthwise-perforated (Grabundžija 2016).

Typically, loom weights are made of fired clay, although it is worth mentioning that Middle Eneolithic loom weights from the region, specifically Lasinja examples are generally very poorly fired (low temperature/oxidation firing of clay).

The disappearance of loom weights in specific areas and periods, for example in Troy V and Early VI (Pavúk 2012: 126) puzzles textile archaeologist. Likewise, in the case of their interrupted use throughout the Bronze Age in the Aegean, it has been proposed that a new type of loom or weaving technology might have been introduced (Nosch 2014: 6–7). Nonetheless, there are several plausible explanations for the absence of conventional loom weights in archaeological contexts, besides the kontekstima. Prvo, utezi za tkalački stan mogu izostati iz arheološkog konteksta ukoliko su bili izrađivani od propadljivih materijala. Osim toga, prema nekim autorima, za postizanje potrebne napetosti za niti osnove mogli su biti korišteni nekonvencionalni oblici poput kalemova (Rahmstorf 2005: 156; Mårtensson et al. 2007b: 15; Pavúk 2012: 123-124). Kao što je prethodno spomenuto, ova su pitanja prepoznavanja tekstilnih alatki, koje su često višenamjenskog karaktera, predmet eksperimentalne arheologije (Grabundžija et al. 2016).

Postoje čvrsti argumenti koji govore u prilog povezanosti korištenja sve tri vrste tkalačkih stanova i upotrebe vunenih niti. Zbog činjenice da je njime moguće brže tkati nego na vertikalnom (Hoffmann 1964: 130-131, 225, 258), horizontalni tip tkalačkog stana uklapa se u scenarij povećane proizvodnje kakav je predložen u slučaju mezopotamskih tekstilnih industrija koje su se razvile i prosperirale na iskorištavanju vunenih vlakana (McCorriston 1997; Kimbrough 2006).

S druge pak strane, vunu je prilično lako bojiti, osobito u usporedbi s lanom, a baš je ta karakteristika mogla potaknuti tkanje tapiserija za čiju je proizvodnju najprikladniji dvogredni tkalački stan (Broudy 1979: 44; Barber 1991: 113).

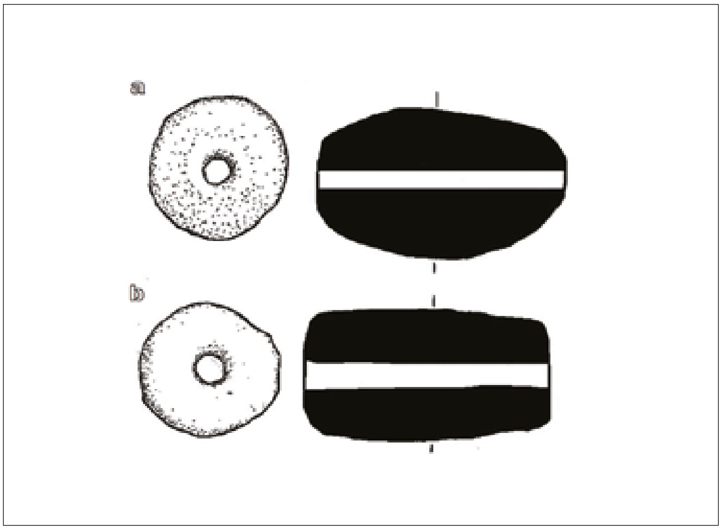
Naposljetku, mnogobrojni rezultati eksperimentalnog tkanja na tkalačkim stanovima s osnovom nategnutom utezima (Mårtensson et al. 2005-2006; 2007a; 2007b; Schierer 2005) i njihovo korištenje u proizvodnji vunenog platna u modernim vremenima (Hoffmann 1964) povezuju baš taj tip s proizvodnjom vunenog platna.

change of the utilized loom type. First and foremost, loom weights could be lacking in archaeological contexts due to the perishable materials used for their production. Additionally, according to some authors, more unconventional forms such as spools might have also been applied for providing the necessary tension for warp threads (Rahmstorf 2005: 156; Mårtensson et al. 2007b: 15; Pavúk 2012: 123-124). This particular issue of recognizing textile tools, which often have a multifunctional character is, as has already been mentioned, addressed in experimental research (Grabundžija et al. 2016).

It is possible to find sustainable arguments which would connect the use of all three types of looms with woolen threads. Due to the fact that it can be operated much faster than the vertical loom (Hoffmann 1964: 130–131, 225, 258), the horizontal type fits the intensified production scenario, which is the proposed method for the Mesopotamian textile industries that developed and strived on wool fibre exploitation (McCorriston 1997; Kimbrough 2006).

On the other hand, wool is quite easy to dye, especially in comparison to flax, and this particular characteristic could have promoted tapestry weaving, for which the two-beam loom is considered to be the most convenient type (Broudy 1979: 44; Barber 1991: 113).

Finally, numerous results of weaving experiments on the warp-weighted loom (Mårtensson et al. 2005–2006; 2007a; 2007b; Schierer 2005) and its use for producing woolen fabrics in modern times (Hoffmann 1964) connect this particular type that utilizes loom weights with woolen fabrics as well.



Slika / Figure 8. Dvije glavne varijante tipova utega za tkalački stan s uzdužno probušenom rupom iz kasnog eneolitika: jajoliki tip (a) i cilindrični tip (b) / Two main variations of a Late Eneolithic loom weight type with a longitudinal perforation: ovoid type (a) and cylindrical type (b) (crtež / drawing: A. Grabundžija).

Kada bi se istraživanje proizvodnje tekstila oslanjalo isključivo na neizravne dokaze tkanja, tada bi se, diljem jugoistočne i srednje Europe, kasni eneolitik mogao smatrati razdobljem velikih prilagodbi. Ustaljeno i dobro razvijeno korištenje tkalačkog stana s nategnutom osnovom tijekom neolitičkog razdoblja, u drugoj polovici 4. tisućljeća pr. Kr. naizgled je izblijedjelo ili čak nestalo. Ipak, u srednjem brončanom dobu tkalački stan s osnovom nategnutom utezima opet postaje najčešće korišteni tip (Sofaer et al. 2013: 480), što jasno ukazuje na točku u vremenu kada su novi aspekti proizvodnje tekstila već široko rašireni i potpuno ujednačeni na tehnološkoj razini. Na ovakav zaključak ukazuju složenije tehnike tkanja, bojanja i, ponajviše, predenja, budući da su, kako pokazuju konkretni ostaci tekstila (Grömer et al. 2013), različite pređe glavna varijabla brončanodobnog tekstila u Europi (Sofaer et al. 2013: 479).

Jedno od glavnih obilježja zabilježenih skupova nalaza tekstilnih alatki kasnog eneolitika na području Hrvatske je rijetko pronalaženje utega za tkalački stan (Grabundžija 2016), ali još je zanimljivije to što je slična pojava zabilježena i u kompleksima kasnog 4. i 3. tisućljeća pr. Kr. u susjednim regijama gdje se većina, iako rijetkih, nalaza utega može pripisati masivnim i izduženim tipovima (s uzdužno probušenom rupom, sl. 8). Paralele za oblik i veličinu utega zabilježene su na lokalitetima Gomolava (Petrović & Jovanović 2002: 126, 211) i Sitagroi 4 (Renfrew et al. 1986: Pl. XXXIV) te u naseljima u Bugarskoj koja su datirana u proto- i rano brončano doba (Petrova 2011).

If the research on changes in textile production would solely depend on indirect evidence for weaving, all across the South East and southern Central Europe region, Late Eneolithic could be considered as the period of major adjustments. Established and developed use of the warp-weighted loom during the Neolithic period, simply seems to diminish or even disappear in the second half of the 4th millennium BC. Nonetheless, warp-weighted loom becomes the most commonly used type again by the Middle Bronze Age (Sofaer et al. 2013: 480), which is clearly the point in time when new aspects of textile production are already widely spread and completely consolidated on the technological level. This is suggested by more elaborate techniques of weaving, dyeing and, most of all spinning, since different yarn types are the main variable of the European Bronze age textiles (Sofaer et al. 2013: 479), as evinced by the actual textiles remains (Grömer et al. 2013).

One of the main features of the recorded Late Eneolithic textile tool assemblages from Croatia is the rarity of loom weights (Grabundžija 2016), but it is even more interesting that a similar observation can be made for complexes of the late 4th and subsequent 3rd millennium BC in the neighboring regions, where all the rare loom weight finds almost exclusively belong to the same massive and elongated (lengthwise perforated) types (Fig. 8). Parallels in shape and size are known from Gomolava (Petrović & Jovanović 2002: 126, 211), Sitagroi 4 (Renfrew et al. 1986: Pl. XXXIV), and from Proto-Bronze and EBA settlements in Bulgaria (Petrova 2011).

Primjena analize alatki u praćenju inovacije

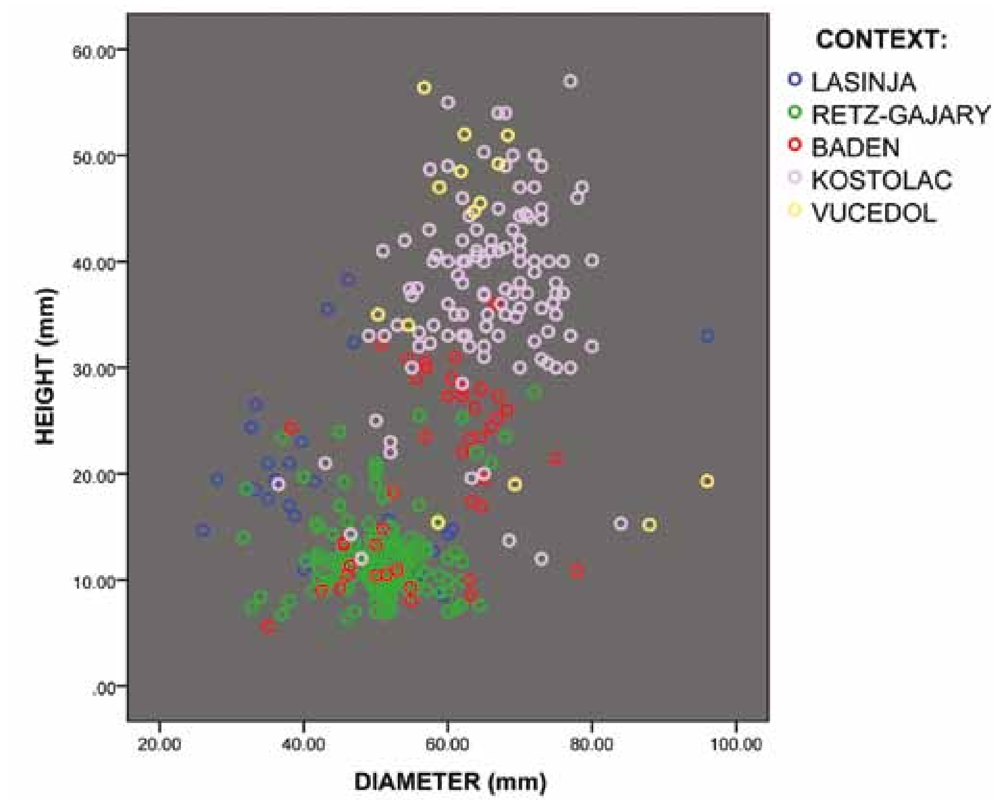
Iako izostanak i nestanak određenih kategorija i tipova alatki ne ukazuje nužno na izostanak aktivnosti ili prakse, ovakvim se promjenama u arheološkim kontekstima mogu pripisati određene tehnološke implikacije. Izuzetno je važno ovakva pitanja sagledavati u širem zemljopisnom kontekstu, jer to može omogućiti procjenu i razmjera i važnosti određene tehnološke prilagodbe.

Nedavno provedenom studijom pršljenova iz jugoistočne i srednje Europe utvrđeno je da se varijabilnost veličine/težine alatki znatno povećala tijekom 4. tisućljeća pr. Kr. (Grabundžija & Schoch, u tisku). Određeni trend u povećanju visine pršlje-

Applying Tool Analysis for Tracking Innovation

Even though the absence and disappearance of certain categories and types of tools does not necessarily indicate a lack of activity or practice, these changes in the archaeological record can be regarded as having specific technological implications. It is of great importance to observe these particular issues in an enlarged geographical context, as it can enable an estimation of both the reach and the significance of the particular technological adjustment.

A recent study of spindle whorls from South East and southern Central Europe established that during the 4th millennium BC tool size/weight variabili-



Slika / Figure. 9. Distribucija vrijednosti promjera i visina pršljenova obzirom na kulturno-povijesni kontekst / Spindle whorl diameter and height value distribution regarding culture-historical context_N379.

nova započeo je već u srednjem te je nastavljen i u kasnom eneolitiku, kada je postao izraženiji zbog dominacije bikoničnih i visokih koničnih oblika (Grabundžija & Russo 2016). Na različitim dijelovima Balkanskog poluotoka, osobito na prostoru takozvanog "Post-Cernavoda III Boleráz fenomena" (Govedarica 2001; Jevtić 2001; Köninger et al. 2001), primijećene su slične promjene: u kostolačkoj i vučedolskoj kulturi središnjeg Balkana, u kulturama Coţofeni i Ezero na istočnom Balkanu, kao i u kulturama ranog brončanog doba u sjevernoj Grčkoj. Neki od objavljenih primjera potječu iz ranobrončanodobnih slojeva humka Ezero u jugoistočnoj Bugarskoj (Georgiev et al. 1979: 388-90, T. 224), s višeslojnih lokaliteta u sjevernoj Grčkoj, kao što je Sitagroi u ravnici Drame (Elster 2004: 231-33), i iz Tesalije (Christmann 1996: 305). Ovi veliki bikonični i konični oblici često se pojavljuju i u uzorku pršljenova iz sjeverne Hrvatske (Sl. 9).

ty developed significantly (Grabundžija & Schoch, in press). A particular trend in the increase of spindle whorl height was already initiated during the Middle Eneolithic period and continues into the Late Eneolithic, when it becomes more pronounced, due to the dominance of biconical and high conical forms (Grabundžija & Russo 2016). In different parts of the Balkan Peninsula, especially in the area of the so called "Post-Cernavoda III Boleráz Phenomenon" (Govedarica 2001; Jevtić 2001; Köninger et al. 2001), similar changes can be observed as well: in Kostolac and Vučedol cultures in the Central Balkans, Coţofeni and Ezero cultures in the Eastern Balkans, similar to Early Bronze Age cultures in North Greece. Some of the published examples come from Early Bronze Age layer at Ezero mound in South East Bulgaria (Georgiev et al. 1979: 388-90, T. 224), multilayer settlements in the northern Greece, like Sitagroi in the plain of Drama (Elster 2004: 231-33) and Thessaly (Christmann 1996: 305). These large size biconical and conical forms are well presented in the north Croatian spindle whorl sample (Fig. 9).

Istovjetan tipološki razvoj zabilježen je i u drugim regijama Europe: može ga se pratiti kroz velike i teške primjerke pripisane kulturi Jevišovice u Moravskoj i Donjoj Austriji, a jedan je od primjera skup nalaza pršljenova pripisanih kulturi Chamer u Gornjoj Austriji i južnoj Njemačkoj (Grömer 2005: 109).

Važno je primijetiti da ovaj specifičan tipološki trend nije bio ograničen na lokalnu razinu. Upravo suprotno, čini se da je bio univerzalan, odnosno da je bio rasprostranjen na širokom postoru te da je bio otprilike istovremen.

Ovaj trend moglo bi se objasniti optimizacijom i prilagodbom alatki. Ako je tomu tako, to bi ukazivalo na značajne i široko rasprostranjene inovacije poput uvođenja nove sirovine. Chmielewski kao objašnjenje za bikonizaciju alatki s poljskih lokaliteta predlaže isto (Chmielewski 2009; Chmielewski & Gardyński 2010).

Važno je istaknuti činjenicu da je do kraja eneolitika ovaj trend, koji je započeo naglašenom morfološkom varijabilnošću pršljenova, doveo do jasne prevlasti visokih tipova drastično većih dimenzija i težine. Tipovi pršljenova kasnog 5. i ranog 4. tisućljeća pr. Kr. s prostora jugoistočne i srednje Europe počeli su postupno, ali drastično, mijenjati oblik (Sl. 10). Spljošteni, zaravnjeni diskoidni i lećasti tipovi, kakvih ima u retzgajarskim (Čeminac-Vakanjac, Cugovec-Barbarsko, Ivandvor, Jagodnjak-Na-

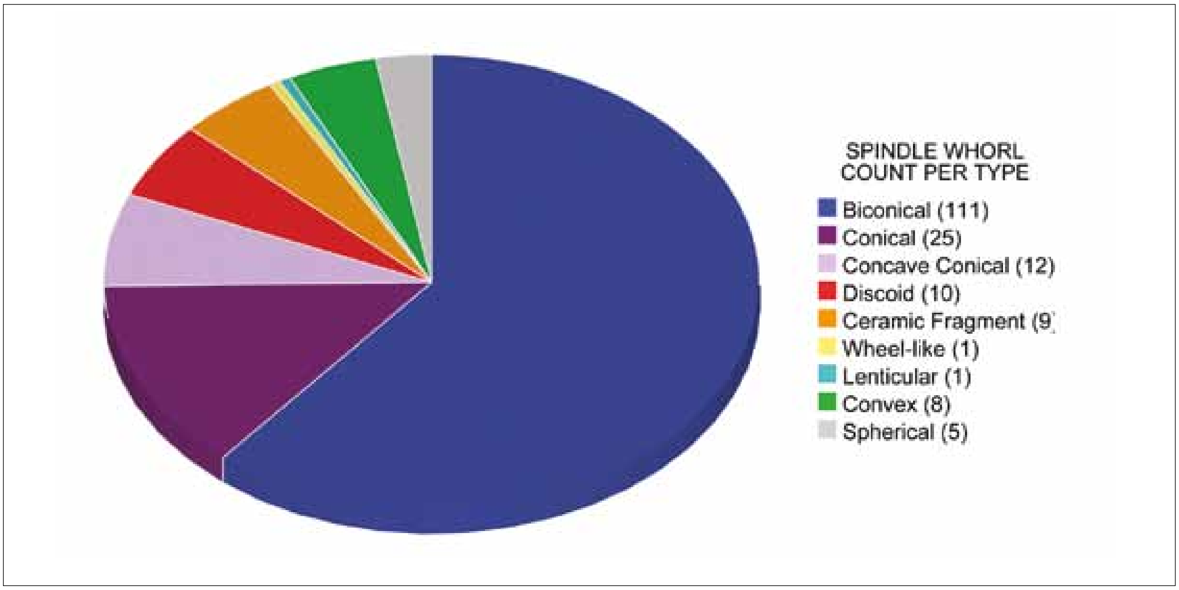
A corresponding typological development is observed in other European regions as well: it can be traced in large and heavy examples attributed to the Jevišovice Cuture in Moravia and Lower Austria, one example being spindle whorl sets attributed to the Chamer Culture in Upper Austria and Southern Germany (Grömer 2005: 109).

It is important to observe that this particular typological trend was not confined locally. On the contrary it appears to have been universal, meaning both spatially widely spread and roughly simultaneous.

This specific trend might be explainable through the optimization and adaptation of tools. If that is the case, this could imply a significant and wide spread innovation, such as the introduction of new raw materials. Chmielewski also proposes this as an argument for explaining the biconization of the tools observed at Polish sites (Chmielewski 2009; Chmielewski & Gardyński 2010).

It has to be pointed out that by the end of the Eneolithic period, a trend that started as a pronounced morphological variability of spindle whorls resulted in a clear dominance of high types with a drastically increased size and weight. Late 5th and early 4th millennium BC spindle whorl types from the territory of South East and southern Central Europe, gradually, but drastically started to change form (Fig. 10). Flat, planate discoid and lenticular types,

Slika / Figure 10. Tipološka varijabilnost kasno eneolitičkih pršljenova / Typological variability of Late Eneolithic spindle whorls_ N 182.



puštene njive, Josipovac Punitovački-Veliko polje I) i lasinjskim (Čepinski Martinci-Dubrava, Pajtenica-Velike livade, Tomašanci-Palača) kontekstima sjeverne Hrvatske, polako su se počeli mijenjati u više tipove (Grabundžija & Russo 2016).

Slično uvođenje prvih niskih koničnih i konveksnih oblika moguće je pratiti i u najudaljenijim područjima: od Rachmani (Christmann 1996: 305-306, Sl. 162) i Krivodol-Salcuţa-Bubanj (Bonev & Alexandrov 1996: Sl. 42) konteksta u jugoistočnoj Europi, pa sve do nešto kasnijih Chassey, Cortaillod (Odone 1998: Sl. 21) ili Pfyn/Horgen (Leuzinger 2002: 148-150, Sl. 2) konteksta u sjeverozapadnoj Europi.

Povećanje visine pršljenova bilo je popraćeno povećanjem sveukupnih dimenzija i težine, što je tijekom kasnog eneolitika dovelo do veće varijabilnosti svih morfoloških parametara (Grabundžija & Russo 2016). Ovakav spori razvoj rezultirao je dominacijom teških i velikih bikoničnih i koničnih pršljenova koji su zatim, u 3. tisućljeću pr. Kr., postali normativ.

Kako bi se moglo istražiti do koje mjere ove tehnološke promjene odražavaju prilagodbu na promjene uvjeta u okolišu te kako bi se moglo raspravljati o njihovom društveno-ekonomskom utjecaju na eneolitičke zajednice, nužno je inkorporirati okolišni pristup. Primjećenu razvojnu shemu ranih tekstilnih industrija nije moguće u potpunosti shvatiti bez uključivanja rezultata istraživanja klime i geografije.

Integracija disciplina i istraživanje strategija pribavljanja sirovina

Pršljenovi s nalazišta u sjevernoj Hrvatskoj jasno preslikavaju navedene tehnološke promjene. Kako bi se moglo bolje razumjeti uzroke ovih promjena, potrebno je zasebno proučiti utjecaj klime (Grabundžija & Russo 2016) i „kulture" (Grabundžija, u tisku) na uočene trendove. U sferi društva i ekonomije, moguće izravne posljedice moguće je proučavati kroz razvoj u specijalizaciji zanata i promjeni strukture društva (Grabundžija et al., u postupku recenzije). Izuzev promjena u društveno-ekonomskoj sferi, očekuje se da je, do određene mjere, predloženo povećanje proizvodnje vlakana utjecalo i na promjene u holocenskom okolišu (Schumacher et al. 2015). Za one dijelove Europe

which can be seen in Retz-Gajary (Čeminac – Vakanjac, Cugovec – Barbarsko, Ivandvor, Jagodnjak – Napuštene njive, Josipovac Punitovački – Veliko polje I) and Lasinja (Čepinski Martinci – Dubrava, Pajtenica – Velike livade, Tomašanci – Palača) contexts in northern Croatia, started to slowly transform into higher types (Grabundžija & Russo 2016).

We can track a similar introduction of the first low conical and convex forms in the most remote areas: from Rachmani (Christmann 1996: 305-306, Taf. 162) and Krivodol-Salcuţa-Bubanj (Bonev & Alexandrov 1996: Fig. 42) contexts in the south-east to the later Chassey, Cortaillod (Odone 1998: Fig. 21) or Pfyn/Horgen contexts (Leuzinger 2002: 148-150, Fig. 2) in the north-west of Europe.

The increase in the spindle whorl height that was accompanied by the increase in the overall size and weight as well, eventually leads to the higher variability of all the morphological parameters during the Late Eneolithic period (Grabundžija & Russo 2016). This slow development results in the dominance of heavy and large biconical and conical spindle whorls that eventually came to represent the 3rd millennium norm.

In order to investigate the extent to which these technological changes reflect an adaptation to the altering environmental conditions and to further discuss their socio-economic impact on the Eneolithic communities, an environmental approach has to be incorporated. The observed development patterns in early textile industries cannot be fully understood without incorporating climate and geographic research.

Integration of Disciplines and the Investigation of Raw Material Procurement Strategies

Spindle whorls from the North Croatian sites clearly reflect the outlined technological changes. In order to better understand the causality of these advances, the influence of climate (Grabundžija & Russo 2016) and "culture" (Grabundžija, in press) on the observed trends was separately examined. Within the socio-cultural sphere, possible direct consequences are addressed through developments in craft specialization and altering social structures (Grabundžija et al., in review). Besides the transformation of the socio-cultural sphere of the human environment, it is expected that, to a certain extent, the proposed fibre production intensification also affected the Holocene landscape gdje šumski pokrov nije bio ograničen klimatskim uvjetima (suhe i subarktičke zone, obale zapadne Europe izložene vjetru), moguće je pretpostaviti da je uzgajanje ovaca postalo važno tek nakon što je antropogenim djelovanjem uklonjena izvorna šumska vegetacija. Dakle, kako bi se pratio razvoj vunaste ovce u Europi, potrebno je uključiti istraživanja pradavnih okoliša (Becker et al. 2016: 103). Rezultati studije promjena u okolišu povezanih sa stočarstvom tijekom srednjeg holocena (Schumacher et al. 2016a; 2016b) daju dodatne dokaze za rano korištenje vune te podupiru tezu da je ono moglo započeti tijekom 4. tisućljeća pr. Krista. Iako je početak povećanja stočarskih aktivnosti moguće pratiti u tragovima iz okoliša, Schumacherova analiza (2015; 2016a; 2016b) sugerira da početak korištenja sekundarnih proizvoda životinjskog porijekla nije uzrokovao značajne promjene u jugoistočnoj i srednjoj Europi, već da su okoliši bili dovoljno otporni da izdrže pritiske rane ispaše. Diljem jugoistočne i srednje Europe, u razdoblju neolitika vidljiv je mali utjecaj stočarstva, dok se tragovi povećanih stočarskih aktivnosti pojavljuju u kasnijem, eneolitičkom razdoblju. Ti bi se tragovi, kako predlaže Schumacher (Schumacher et al. 2016b), mogli preklapati s dokazima koji govore u prilog ranom transhumantnom stočarstvu na središnjem Balkanu (Arnold & Greenfield 2006). Osim toga, akumulacija sedimenta povezanog s ljudskim aktivnostima na padinama Bükkalja datirana je u vrijeme oko 4800. god. kal. pr. Kr. (Schumacher et al. 2016a) i može je se povezati s povećanjem pokazatelja stočarskih aktivnosti na obližnjim lokalitetima (Magyari et al. 2010; 2012).

Iako bi uvođenje vune predstavljalo sasvim novi element u prethodnim strategijama pribavljanja vlakana, a koje su se uglavnom temeljile na biljnim vlaknima (Cybulska & Maik 2007: 186), ne postoje pokazatelji koji sugeriraju da je to dovelo do snižavanja vrijednosti biljnih vlakana. Upravo suprotno, rezultati analize pršljenova (Grabundžija & Russo 2016; Grabundžija & Schoch, u tisku) ukazuju na njihovu rastuću važnost na prijelazu u 4. tisućljeće pr. Kr., što bi moglo biti povezano s povećanjem proizvodnje lanenih vlakana. Kultivacija tekstilnih biljaka smatra se prirodnom posljedicom spontanog smanjenja biljnih sirovina zbog vrste ekonomije specifične za razdoblje eneolitika (Mazăre 2014: 33). U kontekstu pritiska klimatskih promjena i dinamičnih kulturoloških utjecaja koji su prelazili planine (Alpe, Karpate i Balkan) te se spuštali u Panonsku nizinu, eneolitičke su tekstil-

change (Schumacher et al 2015). In those parts of Europe in which forest cover was not restricted by climatic factors (arid and sub-arctic zones, wind exposed coastal fringes of western Europe), sheep husbandry can be expected to have gained importance only in the course of an increased anthropogenic opening of the primeval forest vegetation. Therefore, to follow the track of the woolly sheep in Europe it is necessary to include research on ancient landscapes (Becker et al. 2016: 103). The results of the study on the mid-Holocene herding-related landscape change (Schumacher et al. 2016a; 2016b) provide additional arguments for the early wool use, supporting the idea that it might have started during the 4th millennium BC. Schumacher's analysis (2015; 2016a; 2016b) suggests that the emerging use of secondary animal products did not cause large-scale landscape disturbances in South East and Central Europe, whereas landscapes seem to have been resilient enough to withstand early grazing pressure, although the initial intensification of herding activities can be traced in environmental records. During the Neolithic period, low herding impact was indicated throughout the South East and Central Europe study area, whereas intensified herding is noticed for the succeeding Eneolithic period and could be, as proposed by Schumacher (Schumacher et al. 2016b), in accordance with the evidence of early transhumant pastoralism in the central Balkans (Arnold & Greenfield 2006). Additionally, the sediment accumulation related to human activity in the Bükkalja foothill area is evident around 4800 cal BP (Schumacher et al. 2016a) and it can be synchronized with the increased herding indication at nearby sites (Magyari et al. 2010; 2012).

Even though the appearance of wool would have introduced a completely new element into the earlier fibre procurement strategies, which were mainly based on plant resources (Cybulska & Maik 2007: 186), there are no indications that would suggest this had led to plant fibre materials becoming an inferior good. On the contrary, the results of the spindle whorl analysis (Grabundžija & Russo 2016; Grabundžija & Schoch, in press) propose their growing importance at the turn of the 4th millennium BC, which could be considered relating to the intensification of flax fibre cultivation. Cultivation of textile plants is assumed to be a natural consequence of the spontaneous vegetation resource depletion due to the type of economy specific to the Eneolithic period (Mazăre 2014: 33). In the context of climate change pressure and dynamic cultural in-ne tradicije očito prolazile kroz tehnološke prilagodbe koje je moguće objasniti kroz dva različita trenda u korištenju sirovina, što pak neizravno sugerira uzgoj i životinjskih i biljnih vlakana.

Biljna vlakna nisu korištena samo u proizvodnji tkanog tekstila, već i za užad, konopce i mreže (Good 2007: 182). Poteškoće oko uzgajanja tekstilnih biljaka, posebice lana, kao i težak i dugotrajan proces izvlačenja vlakana (McCorriston 1997: 522-523), vjerojatno su dodatno povećavala njihovu važnost i vrijednost (Mazăre 2014: 33).

Inovativni element upotrebe vune znatno bi promijenio sve faze eneolitičke proizvodnje tekstila i njezino bi uvođenje drastično smanjilo količinu vremena i rada potrebnih za proizvodnju i obradu vlakana. Osim toga, zbog svojih termoizolacijskih svojstava, vodootpornosti i mogućnosti bojenja, vuna je također mogla znatno utjecati na standard krajnjih proizvoda.

Najnovija istraživanja govore u prilog tome da je vuna u proučavanoj regiji najvjerojatnije uvedena i korištena već tijekom eneolitika (Djurdjevac Conrad et al. 2018; Park et al., u postupku recenzije), kao što je prvotno predložio Sherratt u svom SPR modelu (1981; 1983). Kritike Sherrattove hipoteze uglavnom su ispitivale mogućnost međusobnog povezivanja i istovremenosti (Chapman 1982) različitih načina korištenja životinja. Dakle, i sam je Sherratt jako naglašavao složenost lokalnih prilagodbi sekundarnih proizvoda, ukazujući time na važnost društvene simbolike i prestiža povezanog s određenim inovacijama u stočarstvu (Sherratt 1986). Moguće je neizravno povezati ciljani uzgoj lana s naprecima u poljoprivredi do kojih je došlo uvođenjem pluga, što sačinjava još jedan element Sherrattovog „paketa". U svakom slučaju, postaje sve jasnije da su izvori tekstilnih vlakana, kako životinjskog, tako i biljnog porijekla, imali sve veću ulogu u oblikovanju eneolitičkih ekonomija i da su zbog toga njihov uzgoj i obrada sudjelovali, a moguće i poticali, raslojavanje društva.

Kako bi se moglo u potpunosti razumjeti snagu određenih okidača koji su promicali korištenje različitih sirovina u različitim kontekstima, potrebna su nova istraživanja. Većina studija koje se bave tekstilnim vlaknima fokusirana je na određen tip sirovine, što ograničava uvid u sveukupne faktore koji su mogli uvjetovati dinamiku iskorištavanja pojedinog izvora vlakana unutar šireg spektra mogućnosti i prilika za odabir. Proučavanje odnosa između različitih izvora vlakana i načina njihovog

fluences which were crossing the mountains (Alps, Carpathians and the Balkans) and percolating into the Pannonian Plain, the Eneolithic textile traditions apparently experienced technological adjustments, explainable through two distinct trends in the raw material use, which indirectly propose the cultivation of both animal and plant fibres.

Vegetal fibres have not only been used in the production of woven textiles, but also resourced for cordage, ropes and nets (Good 2007: 182). The difficulties involved in growing textile plants, and flax in particular, as well as the laborious and time-consuming process of extracting fibres (McCorriston 1997: 522-523) most probably further magnified their importance and increased their value (Mazăre 2014: 33).

The innovative element of wool would have fundamentally affected and changed all stages of the Eneolithic textile production. Its appearance would have drastically decreased the time-labour investment in fibre production and processing. Additionally, it might have fundamentally influenced the final product standards, due to its thermo-isolation, water-proof and dying properties.

The most recent research supports that wool was most likely introduced and exploited in the region already during the course of the Eneolithic period (Djurdjevac Conrad et al. 2018; Park et al., in review), as initially outlined by Sherratt in his SPR model (1981; 1983). Criticism around Sherratt's hypothesis mainly questioned the interconnectivity and simultaneousness (Chapman 1982) of different forms of animal exploitation. Therefore, Sherratt himself has increasingly stressed the intricacy of local adaptions of secondary products, pointing to the importance of social symbolism and prestige related to the particular innovations in the animal husbandry (Sherratt 1986). It is possible that the more focused flax cultivation could be indirectly connected to the advancements in farming, due to the plough agriculture, which is yet another element from Sherratt's 'package'. In any case, it is more and more evident that textile fibre materials, both of animal and plant origin, played a significant role in the formation of Eneolithic economies and as such their cultivation and processing participated and possibly even stimulated social stratification.

In order to really understand the potency of particular triggers which promoted different raw materials in different contexts, further research is necessary. Most of the studies on textile fibres iskorištavanja moglo bi dati konkretnije odgovore na pitanja kulturološki uvjetovanih odabira, kao i uvjetovanosti okolišem.

Do 3. tisućljeća pr. Kr., oba osnovna materijala (vuna i lan) su već vjerojatno bila široko rasprostranjena, kako u smislu uzgoja i korištenja, tako i trgovine diljem cijele jugoistočne i srednje Europe. Prijelaz iz kasnog eneolitika u rano brončano doba karakteriziraju znakovite društveno-ekonomske promjene koje omogućavaju detaljnije proučavanje specijalizacije, upravljanja sirovinama i trgovine koji su usko povezani s praksama uzgajanja vlakana.

focus on one particular raw material, which restricts addressing specific factors that might have conditioned the dynamics of their use within the wider fibre repertoires and selection opportunities. Further focus on the relationship between different fibre resources and modes of their exploitation could provide more concrete answers to questions on cultural choices and environmental conditioning.

By the 3rd millennium BC both staple materials (wool and fibre flax) were most probably very widely spread in terms of cultivation, use and quite possibly trade across the entire South East and Central Europe. Transition from the Late Eneolithic to the Early Bronze Age period is characterized by profound socio-economic changes, which enable a more detailed study of developments in specialization, resource management and trade that were closely connected to fibre cultivation practices.

English translation: Ana Grabundžija

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