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Bronze Age Textile & Wool Economy: The Case of the Terramare Site of Montale, Italy

By SERENA SABATINI[1], TIMOTHY EARLE[2] *and* ANDREA CARDARELLI[3]

At the onset of the 2nd millennium BC*, a wool economy emerged across continental Europe. Archaeological, iconographical, and written sources from the Near East and the Aegean show that a Bronze Age wool economy involved considerable specialised labour and large scale animal husbandry. Resting only on archaeological evidence, detailed knowledge of wool economies in Bronze Age Europe has been limited, but recent investigations at the Terramare site of Montale, in northern Italy, document a high density of spindle whorls that strongly supports the existence of village-level specialised manufacture of yarn. Production does not appear to have been attached to an emerging elite nor was it fully independent of social constraints. We propose that, although probably managed by local elites, wool production was a community-based endeavour oriented towards exports aimed at obtaining locally unavailable raw materials and goods.*

Keywords: Bronze Age, Italy, craft production, spindle whorls, community of practice, contexts of specialisation, political economy, commodity flows

Several studies show consistent and important roles for textile production, trade, and consumption, especially of wool items, in the Bronze Age political economies of the eastern Mediterranean (Barber 1991; Burke 2010; Nosch 2011; 2015; Wright 2013; Breniquet & Michel 2014; Harlow *et al.* 2014; Andersson Strand & Nosch 2015a). As analytical techniques have expanded, studies also shed light on textiles and textile production at this time in continental Europe (Bender Jørgensen 1992; Gillis & Nosch 2007; Gleba 2008; 2012; Gleba & Mannering 2012; Grömer *et al.* 2013; Grömer 2016). Although analyses of textile fragments and tools exist, much remains to be done to grasp the socio-cultural and political significance of textiles and, particularly, the wool textile economy of Bronze Age Europe. We need to study specific and variable contexts of production, trade, and consumption. Because textiles are not normally preserved archaeologically, tools for textile manufacture, especially ceramic or stone spindle whorls, are critical for investigating context and scale of production. In this article we present a study of spindle whorls from the Bronze Age Terramare settlement of Montale in the Po Valley, Italy, and their role in community-based specialised wool economy. An exceptional number of spindle whorls (over 4000 items) have been found at this settlement. What is the significance of this concentration? Our thesis is that such a high density of whorls suggests intense textile production and that at least one of the outcomes is likely to have been the provision of exports for trade against required goods such as metals. The characteristics of the archaeological record from both Montale and the rest of the Terramare area (eg, Bernabò Brea *et al.* 1997a; Cardarelli 2014; Pacciarelli 2016, 168–70) does not provide clear evidence for significant social inequality either in the settlements (with larger or richer households) or in the

[1]Department of Historical Studies, University of Gothenburg, Box 200, 405 30 Göteborg, Sweden, Email: serena.sabatini@archaeology.gu.se
[2]Department of Anthropology, Northwestern University, 1810 Hinman Avenue, Evanston, IL 60208 USA
[3]Faculty of Letters & Philosophy, Rome University *La Sapienza*, Piazzale Aldo Moro, 5, 00185 Roma RM, Italy

necropoleis (with distinguished graves). From a socio-political point of view, we therefore suppose that even large-scale craft practices, such as intense textile production, might have been the outcome of community-based engagement that did not result in significant social inequality.

BRONZE AGE TEXTILES AND WOOL IN CONTINENTAL EUROPE

Any attempt to understand Bronze Age textile production beyond the coasts of the Mediterranean is like doing a jigsaw. Although plentiful, the evidence for textile production is solely archaeological, since no written documents exist. Additionally, the archaeological record is not homogeneously spread, either chronologically or geographically. It seems, therefore, profitable to make use of comparative data and information from areas outside continental Europe, such the Aegean and the Near East.

Although admittedly documenting much more complex political economies than those found in continental Europe, Aegean and Near Eastern written sources provide insight for interpreting broader archaeological patterns. Studies, in particular, of Linear B tablets from palace archives in the Aegean (Killen 2007; 2015, 1–3; Nosch 2011; Del Freo *et al.* 2010) and of Assyrian letters from the lower town of the Anatolian city of Kaneš/Kültepe (Wisti Lassen 2010; Michel & Veenhof 2010; Michel 2014) record resources and labour investment throughout *chaîne opératoires* of textile production, and also quality and quantities of demand. Because textiles are seldom preserved (Skals *et al.* 2015), texts, which are often concerned with wool and woollen products, provide an important, contemporaneous record as to textile manufacture and trade (McCorriston 1997; Michel & Nosch 2010; Wright 2013, 397–8; Breniquet & Michel 2014; Harlow *et al.* 2014; Nosch 2015). All in all, Bronze Age wool production in the Aegean and eastern Mediterranean was a complicated and dynamic enterprise. A growing demand for clothing of different quality fuelled production activities in specific centres that managed collection and redistribution of raw materials and textile making. It was a year-around activity that relied on access to vast numbers of sheep/goats, paid and/or unfree specialised craft-labour, and conspicuous elite consumption (eg, Burke 2010; Breniquet & Michel 2014). But can this model be applied to Europe more generally?

Archaeological examples of wool fragments from across Europe (Broholm & Hald 1940; Bender Jørgensen 1992; Bender Jørgensen & Rast-Eicher 2016; CinBa database; Gleba & Mannering 2012; Grömer *et al.* 2013; Rast-Eicher & Bender Jørgensen 2013) suggest that, early in the 2nd millennium BC, wool became a sought-after material beyond the Mediterranean coastal region. At about the same time, changes in sheep culling suggest that, in some continental regions, raising sheep became geared to wool production (eg, Vretemark 2010). In addition, strontium isotope analyses of woollen clothing from several 14th century BC oak-log coffin graves (Denmark) document that most preserved textiles from these elite contexts were made with non-local wool (Frei *et al.* 2015; 2017). Considering that no convincing archaeological evidence exists for textile manufacture in Bronze Age Scandinavia (eg, Bergerbrant 2007, 49; forthcoming; Sofaer *et al.* 2013, 480), and in disagreement with earlier proposals suggesting that wool might have been a Nordic export (eg, Randsborg 2011, 110), those isotopic analyses hint at the existence of a continental Bronze Age trade providing wool to the north. The archaeological evidence from the Bronze Age Po valley in northern Italy, as presented in this paper, represents a convincing case that, during the 2nd millennium BC, wool economies emerged and developed beyond the coastal region of the Mediterranean to supply continental demand.

BRONZE AGE WOOL IN CONTINENTAL ITALY

The earliest spun wool fibres from the Italian peninsula (Bazzanella 2012; Bazzanella & Mayr 2009, 35, 41–6, 79–8) are from the Early Bronze Age Alpine lake dwellings (Polada Culture, *c.* 2200–1650 BC).[1] Although scanty, they suggest that both the material and the production process were well-known, at least in the northern part of the peninsula, long before the Middle Bronze Age evidence from Montale. The earliest pure woollen fabric is a fragment of tabby weave from the Terramare settlement of Castione dei Marchesi (Parma province), likely dated to the Middle Bronze Age (*c.* 1650–1300 BC)[2] (Bazzanella 2012, 209). Microscopic analyses of its fibres suggest that the wool came from sheep resembling today's Soay breed (Gleba 2012, 328–9), which moult once a year to yield *c.* 0.3–0.9 kg of wool (Robson & Ekarius 2011, 195). This figure corresponds well to the wool unit in Aegean archives, expressed by the sign *145/LANA, which seems to signify a wool sack of

c. 3 kg, containing four adult sheep fleeces of *c.* 750 g or ten fleeces of *c.* 300 g from mixed flocks (Del Freo *et al.* 2010, 340–4). It seems, therefore, that local Terramare sheep most likely resembled, at least in terms of yearly wool yield, those of the Aegean; and that archive documents might provide useful reference material.

According to a neo-Sumerian (*c.* 2050 BC) source, as many as 4 kg of a fourth-class wool (valued on a 1 [royal] to 5 [poorest quality] scale) were necessary just to obtain an average (*guz-za*) fabric of *c.* 3.5 × 3.5 m (eg, Andersson Strand & Cybulska 2013, 113–8). Considering the probable low productivity, in terms of yearly wool yield, of the Terramare sheep, as in the Aegean and the near East (Halstead 1999; Biga 2011; Firth 2014), any Middle Bronze Age specialised wool production in the Po plain would have required management of large herds. As discussed below, a good number of Terramare sites, including Montale, show evidence of intense sheep husbandry. Although sheep provide a range of other products as well, it is evident that wool was, at least potentially, a widely available raw material.

TERRAMARE AND BRONZE AGE TEXTILE PRODUCTION IN THE PO VALLEY

To investigate contexts and scale of textile production beyond the coastal zone of the Mediterranean, we consider the Terramare culture and its settlement of Montale (Modena province). Terramare defines Middle/Recent Bronze Age (Fig. 1) populations of the central part of the Po plain in northern Italy (Bernabò Brea *et al.* 1997a; Blake 2014, 113-49; Cardarelli 2009a; 2014; 2015; Vanzetti 2013).[3] As an archaeological complex, Terramare displays distinctive settlement organisation and land-use. Initially in the Middle Bronze Age, settlements were primarily small (typically 1–2 ha), with estimated populations of 125/130 inhabitants per ha (Cardarelli 2015, 167) confined within substantial fortifications. Subsequently, from Middle Bronze Age 3 into the Recent Bronze Age 1 (Fig. 1), a form of site hierarchy emerged with some larger settlements over 10 ha that held populations of perhaps 1000 or more (eg, Pacciarelli 2016, 168–71). At the same time, extensive irrigation systems have also been documented (eg, Cremaschi *et al.* 2006, 89; Vanzetti 2013, 271–2). For European prehistory, the Terramare irrigation complexes represent an unusually high investment in engineered landscapes, and have been interpreted as probably being associated with community (corporate) ownership (Cardarelli 2015, 168). Terramare fortified settlements probably asserted a willingness of the community to 'stand its ground' in defence of landscape capital (see Earle 2017) and mobile wealth such as crops, raw materials, textiles, and, to a certain extent, animals (see Cardarelli 2009b). Existence for war-like violence is seen in the necropolis of Olmo di Nogara from the neighbouring Verona Province, north of the Po River, where several skeletons had received dramatic wounds (Canci *et al.* 2015; Pulcini 2014, 130–43).

In this study, we concentrate on the Terramare settlement of Montale situated in the landscape of the Po plain in the Modena province, which is open and fertile, and in close vicinity to the mountainous areas of the local Apennines (Fig. 2; Bernabò Brea *et al.* 1997b; Cardarelli 2006; Cavazzuti & Putzolo 2015). In Roman times this province had a dense human population, intensive agriculture, substantial animal husbandry, favoured among other things by vicinity to the Appennines summer pastures, and was renowned for its wool production (Corti 2012). Archaeozoological evidence suggests that specialised wool production also existed here in the Bronze Age. Compositions of domesticated animals in the Terramare culture broadly (De Grossi Mazzorin 2013) and at the site of Montale specifically (Table 1), show that sheep/goat herding was significant (De Grossi Mazzorin & Ruggini 2009). Ovicaprids were consistently present on the plain throughout the Middle and Recent Bronze Age, increasing through time to more than 50% of the animal assemblage at some settlements (De Grossi Mazzorin 2013, table 1). Although the archaeozoological data from many sites, including Montale, have been only published preliminarily, where information about culling strategies are available, it would seem that a mixed pastoral economy, producing both meat and wool, dominated across the plain, while only minor attention was paid to milk production (De Grossi Mazzorin 2013; Riedel 1989; 2004). The presence of clay sheep figurines indicates that they had a social and symbolic significance (Desantis 2011, 38; Bianchi & Bernabò Brea 2012, fig. 1).[4]

Terramare communities in general appear to have exploited local environmental, technological, and organisational advantages to meet subsistence needs and to produce exports to exchange for needed non-local commodities. Metal tools, for example, were

Montale	Italy	Greece	Central Europe	Northern Europe
Phase I	**Middle Bronze Age 2A** 1550–1500 BC	**Late Helladic IIA** 1600–1500 BC	**Bronzezeit B1** 1600–1500 BC	**Period IB** 1600–1500 BC
Phase II	**Middle Bronze Age 2B** 1500–1450 BC	**Late Helladic IIB–IIIA1** 1500–1400 BC	**Bronzezeit B2–C** 1500–1300 BC	**Period II** 1500–1300 BC
Phases III–VI	**Middle Bronze Age 3A** 1450–1400 BC			
Phases VII–VIII	**Middle Bronze Age 3B** 1400–1325/1300 BC	**Late Helladic IIIA2** 1400–1300 BC		
Phases IX–XI	**Recent Bronze Age 1** 1325/1300–1225/1200 BC	**Late Helladic IIIB** 1300–1200 BC	**Bronzezeit D** 1300–1200 BC	**Period III** 1300–1100 BC
	Recent Bronze Age 2 1225/1200–1150 BC	**Late Helladic IIIC** 1200–1100	**Hallstatt A1** 1200–1100	

Fig. 1.
Montale's archaeological phases and contemporary main Bronze Age chronologies

widely produced and used, but no local sources of metal were available in the plain. For some Terramare communities, a likely export in exchange for the metal might have been textile products. In this respect, the case of Montale, analysed here, might not have been an isolated one. It is, for instance, possible that specialised weaving activity existed at Beneceto (Parma province), where hundreds of fragmentary loom weights have been recovered (Lincetto 2006, 138–56). Also, at Poviglio (Reggio Emilia province), weaving might have been specialised; a conspicuous number of loom weights and probable evidence of standing warp-weighted looms have been recovered in various structures from different parts of that settlement dated to different Bronze Age phases (Bernabò Brea *et al.* 2003; Bianchi 2004).[5]

Material from 19th century collections, as recorded in Modena Civic Museum registers, provides a striking picture of different frequencies of textile tools from various provincial sites (Table 2). Although these partly unsystematic collections do not offer a safe base for further analyses and comparisons, they provide a good indication of the likely different politico-economic choices of the various settlements as to the intensity of textile manufacture. On the basis of the remarkable quantity of recovered textile tools, Montale provides good evidence for understanding one context of Bronze Age textile production. It suggests, we argue, that it was a community-based specialist production, as defined by Cathy Costin, characterised by 'autonomous individuals or household-based production units, aggregated within a single community,

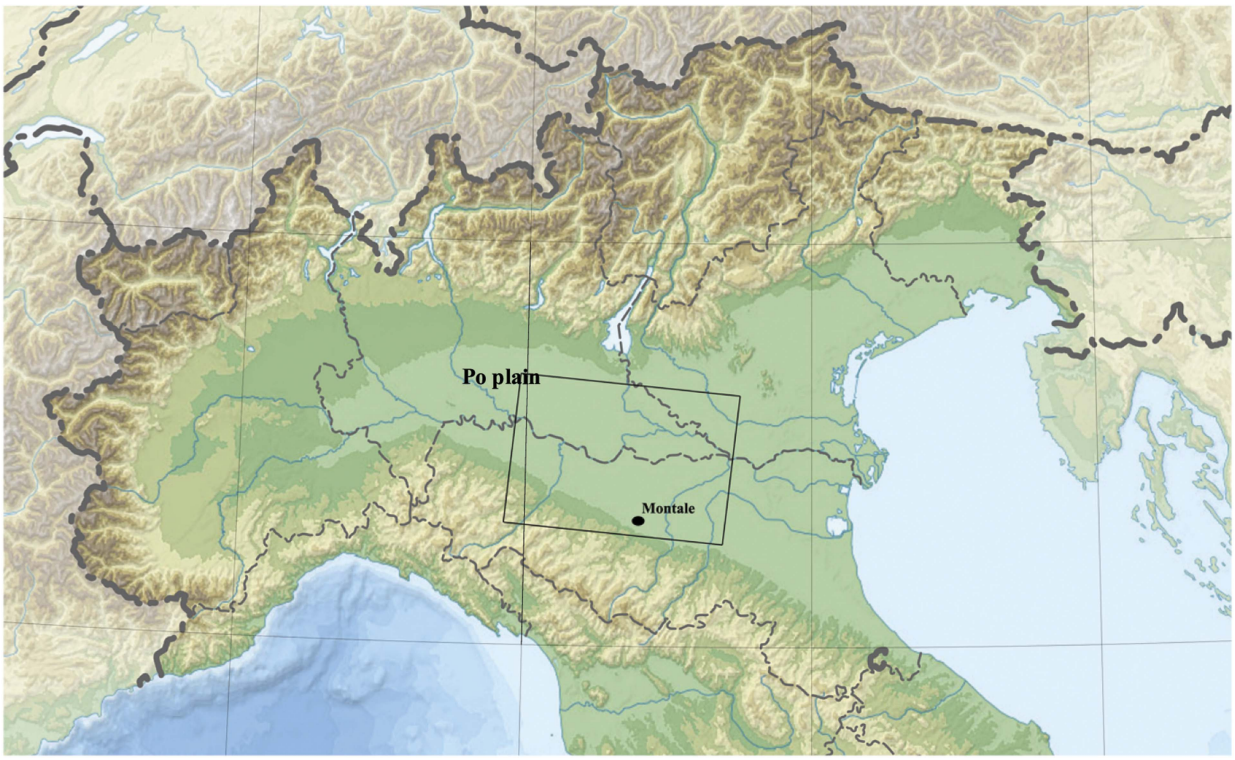

Fig. 2.
The Po plain in Northern Italy with the site of Montale and the area of the terramare

TABLE 1: ANIMAL POPULATION AT MONTALE. APPROXIMATE PERCENTAGE VALUES (STRATIGRAPHIC EXCAVATIONS) (COURTESY OF JACOPO DE GROSSI MAZZORIN)

	Sheep	*Goat*	*Total sheep/ goat*	*Pig*	*Cattle*
MBA2	40	7.2	47.2	41.4	11.4
MBA3	40	8	49.8	37.7	12.5
Recent BA1	48	13.6	61.6	28.1	10.3

producing for unrestricted regional consumption' (Costin 1991, 8).

THE TERRAMARE SETTLEMENT OF MONTALE

Montale was a typical 1 ha fortified Terramare settlement, which was probably home to a local group of perhaps 130 people. It was surrounded by a massive ditch *c.* 40 m wide and 3 m deep, which would have been filled with water (Fig. 3) to serve several functions including defence (Cardarelli & Labate 2009a, 28–30). There is no evidence to suggest a social hierarchy at Montale, although some form of local leadership was most probably involved in the construction of both the ditch and the imposing defensive embankment that lay between the ditch and the settlement. The embankment was still preserved for a width of 10 m and an height of 2 m at the end of the 19th century (Cardarelli & Labate 2009a). The site was partly investigated during the 19th century (cf. Fig. 3), but it is only thanks to recent stratigraphic excavations of a *c.* 45 m^2 portion of the settlement (luckily spared by the local manure quarry works, see Fig. 3) that a densely settled space could be revealed. The material from the excavation also helped establish an 11-phase internal chronology from 1600/1550 to 1250/1200 BC (cf. Fig. 1). The results of the excavation show that houses tended to be built and rebuilt within what look like precisely allocated spaces (Cardarelli & Labate 2009b, fig. 69). They also revealed that the very same space that was occupied by dwellings during Phases I–IV could be used for metallurgical activities during Phase V and return to accommodate housing during the following Phase VI, though in slightly different positions to the earlier structures. In Phase VIII a granary was also present in the excavated

area while, during the remaining phases, no structures could be identified (Cardarelli & Labate 2009b). Phase II is best preserved archaeologically and parts of two different buildings and of the space/street between them, dated to this phase, show that the settlement living quarters were organised in an orthogonal layout, in a fashion similar to that investigated at Poviglio, for instance (Bernabò Brea *et al.* 2003).

What makes Montale exceptional among Bronze Age settlements, not only in the Po plain but also on a wider continental scale, is its unusually high density of textile tools, particularly spindle whorls (cf. eg, Table 2). Over 90% of the textile tools from here were collected in the 19th century, when compost for farming was being quarried. At this time, Modena Museum partly supervised the recovery of archaeological material (cf. Fig. 3), comprising thousands of finds, although without contextual information (Cardarelli 2009b, 16–18). Additional archaeological material comes from well-documented, modern excavations (eg, Candelato *et al.* 2002; Cardarelli 2009b). Finds include items relating to spinning (spindle whorls), weaving (in particular loom weights, possibly also loom combs and at least one loom sword, cf. Cardarelli 2009b, fig. 80.17), and sewing implements (needles).[6]

MONTALE'S SPINDLE WHORLS

According to the Modena Civic Museum register, 4454 spindle whorls were collected during the 19th century (Table 2), of which 4089 nearly complete whorls are still preserved. At the same time, 127 loom weights, of which 78 are today preserved in the collection, were also brought to the Modena Museum (Sabatini in press). During the recent stratigraphic excavations a further 182 whorls (Tables 3 & 4) and 17 loom weights were recovered. Considering that many tools (54% of the spindle whorls (N = 98; Table 3) and 52% of the loom weights (N = 9, cf. Sabatini in press) from recent excavations are fragmentary, the original number of both spindle whorls and loom weights from the Montale quarry excavations must have been much higher than the recorded total of whole textile tools.[7]

This paper focuses on the clay spindle whorls, which are the principal textile tools recovered from Montale. Spindle whorls are flywheels that, fixed on a spindle shaft, help maintain rotation for spinning (Barber 1991, 51–4; Olofsson *et al.* 2015, 77–8). Spinning is the act of 'twisting and drawing out (or *drafting*) the fibres of the raw material into a thread' (Barber 1991, 41). Although spinning can be done in many ways (eg, Barber 1991, 39–51; Bender Jørgensen 2012, 129), the 4000+ whorls recovered at Montale and their routine presence in other Terramare sites and throughout Italy from the Neolithic (eg, Gleba 2008, 104), suggests that using clay whorls was the locally preferred technique for spinning thread. Spinning is a time-consuming task (Bender Jørgensen 2012; Olofsson *et al.* 2015, 84) and, indeed, it dominates labour time in the textile *chaine opératoire*. Recent tests (Andersson Strand & Cybulska 2013) confirmed that, of *c.* 124 working days needed to produce a 3.5 × 3.5 m fabric of average quality from raw wool, as recorded in the neo-Sumerian text mentioned above (Waetzold 1972, T32), one worker would have had to be occupied for over half the time (*c.* 67 days) just spinning the necessary warp and weft thread. In addition, experiments demonstrate that the level of required skills and time increase consistently when spinning thin, high quality threads (Bender Jørgensen 2012, 129; Andersson Strand & Cybulska 2013, 116–8). Although ancient written sources do not seem to document trade in yarn, the production of thread, carried out by carefully recorded specialised labour, must have had a crucial role in both Near Eastern and Aegean economies (see, for instance, Del Freo *et al.* 2010, 354–6; Firth & Nosch 2012; Siennika 2014), and we can assume that it was important in contemporary European economies as well.

Montale's whorls are of various types that are typical of the region with some types showing considerable standardisation as to shape and decoration (Fig. 4; Bianchi 2004, fig. 280–1; Leonardi 2012). Only the items from the modern excavations underwent a typological analysis. They have been divided in nine main types: truncated conical (eg, Fig. 4E), biconical asymmetric (eg, Fig. 4C–D), biconical asymmetric with protuberances (eg, Fig. 4F), biconical (eg, Fig. 4B), biconical with concentric marks (eg, Fig. 4A), convex-cylindrical (eg, Fig. 4H), disc-shaped (eg, Fig. 4I), globular (eg, Fig. 4G), and pin-head like (eg, Fig. 4J). Most of the sub-types within each of the main types recur across the sequence (Table 5). Because the stratigraphic excavation were limited (cf. Fig. 3), these samples may be unrepresentative, and so the following hypotheses should be taken with some caution. The greater and more articulated presence of whorls during Phase II might, for instance, depend on the fact

TABLE 2: FINDS COLLECTED DURING THE 19TH CENTURY FROM TERRAMARE SETTLEMENTS OF THE MODENA PROVINCE, AS RECORDED IN MODENA CIVIC MUSEUM REGISTERS (COURTESY OF GIANLUCA PELLACANI)

Site	*Estimated chronology*	*Estimated original size*	*M aSL*	*Ceramic objects*	*Spindle whorls*	*Loom weights*	*Total (ceramic objects + spindle whorls + loom weights)*	*% spindle whorls of total*	*% loom weights of total*
Gaiano	MBA2–RBA1	*c.* 1 ha	310	39	18	0	57	31.6	0.0
S. Pietro in Isola	MBA1–MBA2	*c.* 1 ha	180	48	28	1	77	36.4	1.3
Castiglione di Marano	MBA2–RBA1	*c.* 0,8 ha	158	82	19	0	101	18.8	0.0
Ca' de' Monesi	MBA2–RBA	*c.* 1/2 ha	156	30	15	0	45	33.3	0.0
Gorzano	MBA2–RBA2	*c.* 0,8 ha	155	680	443	73	1196	37.0	6.1
Castellarano	MBA2–MBA	unknown	150	14	19	0	33	57.6	0.0
Pontenuovo	MBA2–RBA2	*c.* 1 ha?	140	104	7	0	111	6.3	0.0
S. Anastasio	MBA2–RBA1	*c.* 1 ha	118	101	16	0	117	13.7	0.0
Bazzano	MBA2–early RBA1	*c.* 1 ha	110	76	10	0	86	11.6	0.0
Monte Barello	MBA2–RBA1	*c.* 1/2 ha	103	104	36	1	141	25.5	0.7
Trinità	MBA2–RBA1	*c.* 1 ha	101	47	67	0	114	58.8	0.0
Pragatto	not available	not available	70	162	43	3	208	20.7	1.4
Montale	MBA2–RBA2	*c.* 1 ha	65	1303	4454	127	5884	75.7	2.2
Casinalbo (abitato)	MBA2–RBA2	*c.* 2 ha	65	714	94	28	836	11.2	3.3
Gazzade	MBA1–RBA2	*c.* 1 ha	50	105	25	4	134	18.7	3.0
Savana di Cibeno	MBA2–RBA2	*c.* 3 ha	29	25	4	0	29	13.8	0.0
Rastellino	MBA1–RBA1	*c.* 3 ha	27	89	40	0	129	31.0	0.0
Redù	MBA1–RBA2	*c.* 2 ha (BMBA1-2), *c.* 12–14 ha (MBA3-RBA2)	25	591	105	18	714	14.7	2.5

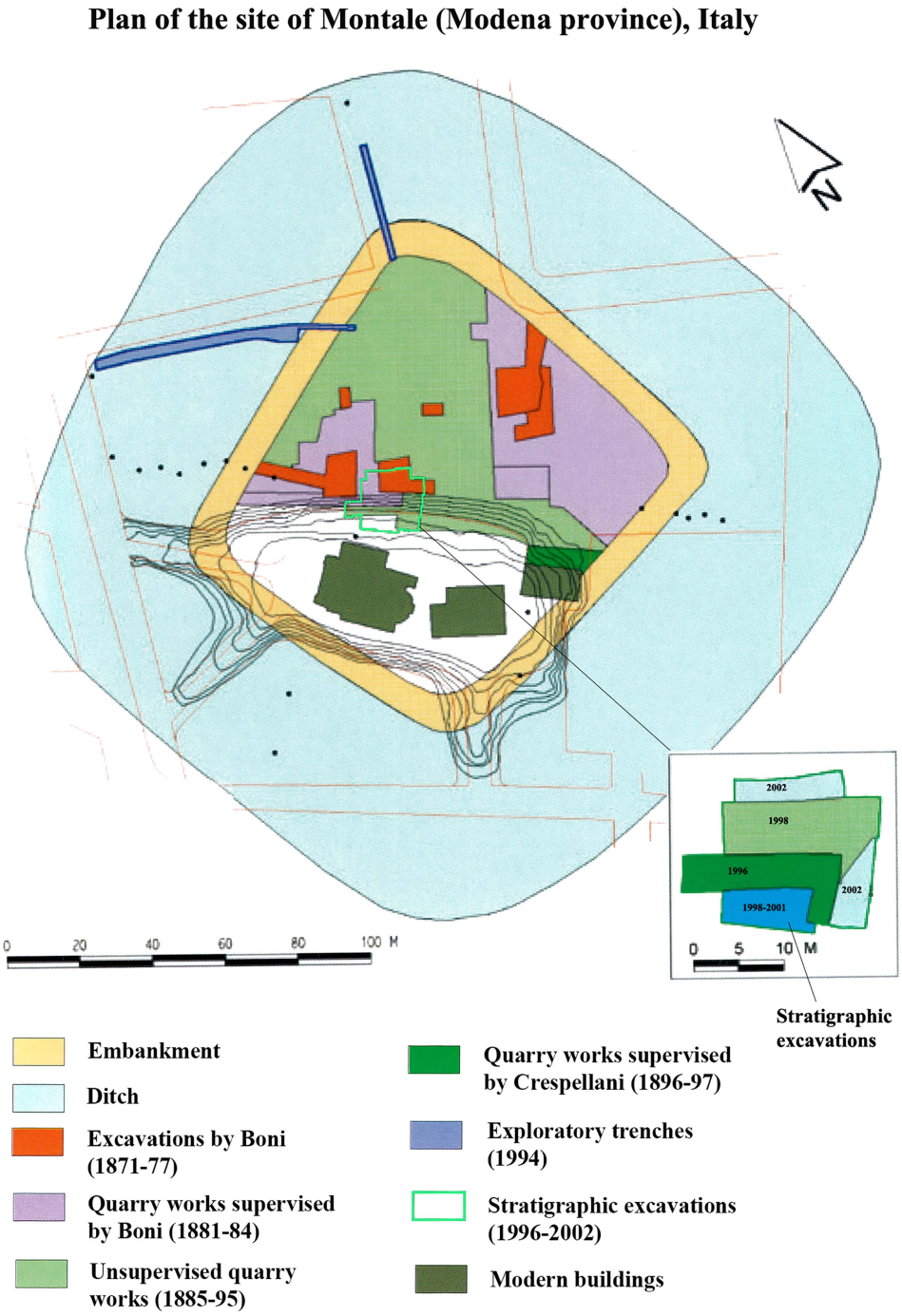

Fig. 3.
Plan of the site of Montale with excavation history (elaborated from Cardarelli 2009b, fig. 9)

that this phase was not only the best preserved, but also the one with larger portions of dwelling structures than other phases.

Here we present the analysis of the weight of the whorls, which seem to encompass a wide range of values (see below) with some chronological patterning.

TABLE 3: WHOLE SPINDLE WHORLS FROM THE STRATIGRAPHIC EXCAVATIONS AT MONTALE PER PHASE (N = 84)

No	*Year*	*Phase*	*Chronology*	*Est. original weight (g)*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Type*
SWM1	2001	I b	MBA2A	15.2	15.2	3	1.9	0.5–0.6	2a biconical asymmetric
SWM2	2001	I b	MBA2A	10.9	10.9	3	1.3	0.5–0.5	2a biconical asymmetric
SWM3	2001	I b	MBA2A	17.4	17.4	3.1	1.9	0.5–0.6	1a truncated conical
SWM4	2001	I b	MBA2A	20.4	20.4	3.6	1.9	0.6–0.7	1a truncated conical
SWM5	2001	I c	MBA2A	12.9	12.9	3.4	1.4	0.6	2a biconical asymmetric
SWM6	2001	I c	MBA2A	15.9	15.9	3.4	2.3	0.5	3 biconical asymmetric with plastic protuberances
SWM7	2001	I c	MBA2A	37	36.2	4.8	2.2	0.6	2a biconical asymmetric
SWM8	2001	I d	MBA2A	15.2	15.2	3.3	1.5	0.8	2a biconical asymmetric
SWM9	2001	I d	MBA2A	18.6	18.6	3.3	1.7	0.5–0.6	2a biconical asymmetric
SWM10	2001	I d	MBA2A	19.5	19.5	3.4	2.5	0.6	2a biconical asymmetric
SWM11	2001	I d	MBA2A	17.1	17.1	3.3	2.7	0.5–0.6	2a biconical asymmetric
SWM12	2001	I d	MBA2A	10.1	10.1	2.9	1.8	0.6	3 biconical asymmetric with plastic protuberances
SWM13	2001	II a	MBA2A	15.4	15.4	3	1.7	0.6	2a biconical asymmetric (with decoration)
SWM14	2001	II a	MBA2A	14.1	14.1	2.9	2.2	0.5	1a truncated conical
SWM15	2001	II a	MBA2A	14.5	14.5	2.8	2	0.55–0.6	2a biconical asymmetric
SWM16	2001	II a	MBA2A	17.5	17.1	3.1	2	0.6	1b truncated conical embossed profile
SWM17	2001	II a	MBA2A	18.9	18.9	3.4	2.4	0.6	3 biconical asymmetric with plastic protuberances
SWM18	2001	II b	MBA2A	12.8	12.8	3.2	2	0.5–0.6	3 biconical asymmetric with plastic protuberances
SWM19	2001	II b	MBA2A	20.4	20.4	4.1	1.3	0.4	2b biconical asymmetric flattened
SWM20	2001	II b	MBA2A	18	17.2	3.4	2.5	0.7–0.8	1a truncated conical
SWM21	2001	II b	MBA2A	18.4	18.4	3.9	1.8	0.6	1b truncated conical embossed profile (with decoration)
SWM22	2000	II c	MBA2B	24.1	24.1	3.9	2.2	0.6	2a biconical asymmetric
SWM23	2001	II c	MBA2B	11.7	11.7	2.2	1.7	0.5	2a biconical asymmetric
SWM24	2000	II c	MBA2B	13.5	13.5	3.2	1.5	0.5–0.6	2a biconical asymmetric
SWM25	2000	II c	MBA2B	14	14	2.5	2.2	0.5	4a biconical
SWM26	2000	II c	MBA2B	14.4	14.4	2.8	2.5	0.6–0.7	5b biconical with concentric marks on 2 cones
SWM27	2000	II c	MBA2B	8.9	8.9	2.3	2.2	0.5	5a biconical with concentric marks on 1 cone
SWM28	2002	II c	MBA2B	17	17	3.1	1.7	0.6	2a biconical asymmetric
SWM29	2000	II c	MBA2B	17.2	17.2	3.2	1.7	0.5	2a biconical asymmetric
SWM30	2000	II c	MBA2B	13.3	13.3	2.9	1.7	0.6–0.7	2a biconical asymmetric
SWM31	2000	II c	MBA2B	14	13.9	2.3	2.6	0.6–0.7	5a biconical with concentric marks on 1 cone
SWM32	2000	II c	MBA2B	8.3	8.3	2.2	2.3	0.45–0.5	5a biconical with concentric marks on 1 cone
SWM33	2000	II c	MBA2B	11	9.9	2.6	1.9	0.5–0.6	4b biconical
SWM34	2001	II c	MBA2B	10.6	10.6	3.2	1.7	0.5	1b truncated conical (with plastic decoration/ protuberances)
SWM35	2000	II c	MBA2B	11	11	2.5	1.9	0.55	2a biconical asymmetric
SWM36	2000	II c	MBA2B	17.9	17.9	3.2	1.7	0.6	6 convex-cylindrical
SWM37	2000	III a	MBA3A	11.3	11.3	2.8	1.8	0.4–0.6	1b truncated conical embossed profile

TABLE 3: (Continued)

No	*Year*	*Phase*	*Chronology*	*Est. original weight (g)*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Type*
SWM38	2000	III a	MBA3A	19.2	19.2	3.1	2.1	0.6	4b biconical with embossed profile
SWM39	2000	III b	MBA3A	12.4	12.4	2.1	1.7	0.5	4b biconical with embossed profile
SWM40	2000	III b	MBA3A	15.6	13	2.6	2.2	0.5	5b biconical with concentric marks on 2 cones
SWM41	2000	III b	MBA3A	14	14	2.7	2.9	0.5–0.6	4a biconical
SWM42	2000	III b	MBA3A	14.1	14.1	3	2	0.5–0.6	2a biconical asymmetric (with decoration)
SWM43	1999	III b	MBA3A	18	18	3.1	2.7	0.6	2a biconical asymmetric
SWM44	2000	III b	MBA3A	13.4	13.4	2.5	2.5	0.5	4a biconical
SWM45	2000	III c	MBA3A	10	9.7	2.4	2.3	0.5	4a biconical
SWM46	2000	III c	MBA3A	13.3	13.3	2.5	2.5	0.5–0.6	4a biconical
SWM47	2000	III c	MBA3A	17.4	17.4	3.1	1.9	0.5–0.6	4a biconical
SWM48	2000	III c	MBA3A	18.5	18.5	3.6	1.9	0.6–0.7	2a biconical asymmetric
SWM49	2000	III c	MBA3A	14.5	14.5	2.8	2.6	0.5	5a biconical with concentric marks on 1 cone
SWM50	2000	III c	MBA3A	17.4	17.4	3.1	1.9	0.5–0.6	4a biconical
SWM51	2000	III c	MBA3A	14.5	14.1	2.8	2.5	0.5	5a biconical with concentric marks on 1 cone
SWM52	2000	III c	MBA3A	11.9	11.9	2.5	2.2	0.6	5a biconical with concentric marks on 1 cone
SWM53	1999	IV a	MBA3A	9	8.8	2.4	2.1	0.6–0.65	5a biconical with concentric marks on 1 cone
SWM54	1999	IV a	MBA3A	9.8	9.8	2.4	1.9	0.5–0.57	5a biconical with concentric marks
SWM55	1999	IV a	MBA3A	15.9	15.9	3	1.8	0.5–0.57	4b biconical with embossed profile
SWM56	1999	IV c	MBA3A	19.3	19.3	2.9	2.2	0.5	8 globular (diagonal hole)
SWM57	1999	IV c	MBA3A	12.7	12.7	3	1.4	0.6	6 convex-cylindrical
SWM58	1999	IV c	MBA3A	13	13	2.5	2.3	0.5–0.6	4a biconical
SWM59	1999	VIb	MBA3A + MBA3B	10	9.6	2.9	1.8	0.6	4a biconical
SWM60	1999	VIb	MBA3A + MBA3B	10.7	10.7	2.4	2.3	0.6	4a biconical
SWM61	1999	VIb	MBA3A + MBA3B	17	11.4	2.8	1.7	0.6–0.7	5a biconical with concentric marks on 1 cone
SWM62	1999	VIb	MBA3A + MBA3B	11.9	11.9	2.4	2.2	0.5–0.6	4a biconical
SWM63	1999	VIb	MBA3A + MBA3B	13	12.4	3	2	0.5	1a truncated conical
SWM64	1999	VIb	MBA3A + MBA3B	13	12.4	2.7	2.3	0.5	5a biconical with concentric marks on 1 cone
SWM65	1999	VIb	MBA3A + MBA3B	12.5	12.5	2.5	2	0.55–0.6	4a biconical
SWM66	1999	VIb	MBA3A + MBA3B	16.6	16.6	2.9	2.6	0.5	5a biconical with concentric marks on 1 cone
SWM67	1999	VIb	MBA3A + MBA3B	18.9	18.9	3.1	2	0.6	2a biconical asymmetric
SWM68	1999	VIb	MBA3A + MBA3B	23.8	23.8	3.5	1.8	0.6	4b biconical with embossed profile
SWM69	1999	VIIb	MBA3B	9.3	9.3	2.3	2.1	0.5	5a biconical with concentric marks on 1 cone
SWM70	1999	VIIb	MBA3B	10.5	10.5	2.7	1.5	0.5	2a biconical asymmetric
SWM71	1999	VIIb	MBA3B	13.1	13.1	2.9	2.6	0.6	2a biconical asymmetric
SWM72	1999	VIIc	MBA3B	13.1	13.1	2.7	2.3	0.5	2a biconical asymmetric
SWM73	1999	VIIc	MBA3B	13.8	13.8	3.2	1.6	0.5–0.55	2c biconical asymmetric with embossed profile
SWM74	1999	VIIc	MBA3B	17.7	17.7	3.4	2	0.6	1a truncated conical
SWM75	1999	VIIIb	MBA3B	10.7	10.7	2.8	2	0.5	2a biconical asymmetric
SWM76	1999	VIIIb	MBA3B	15?	14.3	3.8	2	0.7	9 pin-head shaped

TABLE 3: (Continued)

No	*Year*	*Phase*	*Chronology*	*Est. original weight (g)*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Type*
SWM77	1999	VIIIc	MBA3B	18.1	18.1	3.4	1.8	0.6–0.65	4b biconical with embossed profile
SWM78	1999	VIIIc	MBA3B	12.7	12.7	2.7	1.7	0.5–0.6	4b biconical with embossed profile
SWM79	1999	IXa	RBA1	15.6	15.6	2.7	2.3	0.6	2a biconical asymmetric
SWM80	1999	IXa	RBA1	6.7	6.7	2.1	2.1	0.6	5a biconical with concentric marks on 1 cone
SWM81	1999	IXa	RBA1	10.2	10.2	2.6	1.7	0.4	2a biconical asymmetric
SWM82	1999	IXa	RBA1	17.2	17.2	3	2.2	0.5–0.6	2a biconical asymmetric
SWM83	1999	IX b	RBA1	13.1	13.1	2.7	2	0.5–0.7	2a biconical asymmetric
SWM84	1999	IX b	RBA1	16.8	16.8	3.2	2.2	0.5–0.7	4a biconical (with decoration)

Ethnographical and experimental records suggest that weight and, to a certain extent, diameter, rather than shape, are functionally important for spinning. Bearing in mind that the chosen raw material might also influence both spinning techniques and spindle whorl sizes (eg, Barber 1991, 42–4; Siennika 2014, 165), light spindle whorls, under 10 g, seem generally best to spin fine/light threads, whilst heavier whorls are more suited to thicker or coarser threads (Liu 1978; Barber 1991, 51–3; Olofsson *et al.* 2015) or for plying (Gleba 2008, 106). Although recent experiments have questioned these relationships, suggesting that the skills of spinners might be more important (Kania 2013), we believe that the analyses of weights can profitably initiate functional discussions. The material has been grouped at 10 g intervals, in accordance with recent experiments (Olofsson *et al.* 2015, 86–7), to provide a framework for further analyses. Among specimens collected during the 19th century, the lightest spindle whorls weight was as little as 1 g, the heaviest, 85.5 g; the majority of whorls (almost 70% of the total, 2848 pieces) weigh 10–20 g (Fig. 5).

Of the well-dated 84 complete whorls recovered from modern excavations (Table 3), the lightest whorl weighs 6.7 g and the heaviest, 37 g; as in the earlier collections, the majority of whorls were 10–20 g (Fig. 6). We have also attempted to correlate the weights with their diameters among the stratigraphically excavated whorls. The analyses of this sample suggests some diachronic differences, although counts are small. The scatter plot for diameter/weight of the material (Fig. 7) shows that a positive correlation apparently exists and that the larger and heavier whorls characterise the earliest period (Phase I), while (with the exception of Phases II and VI) any other period includes only items below 20 g and the largest number of whorls of 30 mm or less in diameter. Perhaps a craft/tradition prefering large whorls (>30 mm in diameter) occurred mostly in Phases I and II. Finally, the greatest variety of spindle whorls, in terms of both weight and size, appears in Phase II, which might be a sign of more technological experimentation. In general, the great majority of the whorls fall between *c.* 10 g and 20 g (see also Figs 5–6) suggesting that a rather stable crafting tradition existed at Montale through time, although the frequency of spinning may have changed.

Diachronic analysis of spindle whorls from modern excavations, both whole (Table 3) and fragmentary (Table 4), shows that *c.* 50% (52 whole and 41

TABLE 4: FRAGMENTARY SPINDLE WHORLS FROM THE STRATIGRAPHIC EXCAVATIONS AT MONTALE PER PHASE

No.	*Excavation data*	*Phase*	*Chronology*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Observations = Type*
SWM85	US3406 G12-13 13-07-01	Ib	BM2A	7.5	–	2.1	–	*c.* 1/2 missing – 2a BIC. ASYMM.
SWM86	US546 F11 05-07-99	I c	BM2A	6	2.65	–	–	*c.* 3/4 missing – 1c TRUNC. BELL SHAPED
SWM87	US3009 H12-13 22-06-01	I c	BM2A	6.2	2.35	2.2	0.45	*c.* 1/2 missing – 3 BIC. ASYMM. PROTUBER.
SWM88	US3270 G.H12 29-06-01	I c	BM2A	6.4	3.3	1.95	0.5	*c.* 2/3 missing – 2a BIC. ASYMM.
SWM89	US3295 E12 29-06-01	I c	BM2A	3.4	–	1.6	–	fragmentary – 2c BIC. ASYM. EMB. PROF.
SWM90	US3295 E 12 02-07-01	I c	BM2A	9.5	3.2	1.8	0.55	*c.* 1/2 missing – 2c BIC. ASYM. EMB. PROF.
SWM91	US 3008 G10-11 08-05-01	I d	BM2A	5.2	3.2	1.8	0.5	fragmentary – 1a TRUNC. CONICAL
SWM92	sotto us2022 E12-13 17-05-01	I – II a	BM2A	11.5	2.95	2.2	0.6	*c.* 1/3 missing – 2a BICONIC. ASYMM.
SWM93	US2652 F8 21-05-01	II a	BM2A	3.2	–	1.6	–	fragmentary – 2c BIC. ASYM. EMB. PROF.
SWM94	US2682 G7-8 24-05-01	II a	BM2A	9.1	3.2	1.2	0.5	*c.* 1/2 missing – 2a BIC. ASYMM.
SWM95	US2434 E6 23-04-01	II b	BM2A	6.2	2.9	1.95	0.5	fragmentary – 2a BIC. ASYM.
SWM96	US2314 F.G10 19-04-01	II b	BM2A	6.3	2.8	2	0.4	*c.* 1/2 missing – 8 GLOBULAR
SWM97	US2209 E5 -2001	II c	BM2B	3	–	–	–	fragmentary – TYPE?
SWM98	US3385 G8 09-07-01	II c	BM2B	33.2	5.7	2.7	1	fragmentary – 2c BIC. ASYM. EMBOS. PROF.
SWM99	US2203 F7 24-10-00	II c	BM2B	4.5	3	2	0.4	fragmentary – 4b BIC. EMBOSS. PROF.?
SWM100	US2176 E7 18-10-00	II c	BM2B	27.4	4.65	3.2	0.8	*c.* 1/2 missing – 2c BIC. ASYM. EMB. PROF.
SWM101	US2014 H9 15-09-00	II c	BM2B	1.7	–	–	–	fragmentary – 5b BIC. CONCENTRIC MARKS 2 CONES
SWM102	US2148 F13 20-09-00	II c	BM2B	6.3	2.9	–	0.5	fragmentary – 1c BELL SHAPED (+ decoration)
SWM103	US2085 H.G12 21-09-?	II c	BM2B	5.7	3.1	–	0.4	*c.* 1/2 missing – 3 BIC. ASYM. PROTUBER.
SWM104	US2277 G13-14 31-10-00	II c	BM2B	7.8	3.1	1.9	0.4	*c.* 1/2 missing – 2b BIC. ASYM. FLATTENED
SWM105	US2014 G13 14-09-00	II c	BM2B	6.1	3	2.45	0.5	*c.* 2/3 missing – 2c BIC. ASYM. EMB. PROF.
SWM106	US2014 F11 14-09-00	II c	BM2B	3.5	2.35	–	0.5	fragmentary – 5a BIC. CONCENTRIC MARKS 1 CONE
SWM107	US2014 H9 18-09-00	II c	BM2B	2.9	–	–	–	fragmentary – 5a BIC. CONCENTRIC MARKS 1 CONE
SWM108	US2130 F.G11 -2000	II c	BM2B	6.1	2.7	1.55	0.6	*c.* 1/2 missing – 6 CO NVEX–CYLINDRICAL?
SWM109	US2302 G9 13-04-01	II c	BM2B	10.7	4.2	1.8	0.9*	*1 frag. another too small to measure *c.* 1/2 missing – 6 CONVEX–CYLINDRICAL?

TABLE 4: (Continued)

No.	*Excavation data*	*Phase*	*Chronology*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Observations = Type*
SWM110	US2336 G8 17-04-01	II c	BM2B	9.6	–	–	–	fragmentary – TYPE?
SWM111	US2257 E14 23-04-01	II c	BM2B	3.1	–	–	–	fragmentary – TYPE?
SWM112	US788 & 963 E7-8 29-09-00	II–III	BM2 + BM3A	2.1	–	–	–	fragmentary – TYPE?
SWM113	US2002 G10 12-09-00	III a	BM3A	3	2.2	–	0.45	fragmentary – 5b BIC. CONCENTRIC MARKS 2 CONES
SWM114	US761 I9 27-06-00	III b	BM3A	3.3	2.7	1.5	0.5	fragmentray – 2b BIC. ASYMM. FLATTENED
SWM115	US761 G5 28-06-00	III b	BM3A	4.8	2.5	1.7	0.45	*c.* 1/2 missing – IRREGULAR
SWM116	US761 H9 27-06-00	III b	BM3A	4.4	2.95	–	0.5	fragmentray – 1c TRUNC BELL SHAPED?
SWM117	US761 H9 27-06-00	III b	BM3A	2.9	2.2	1.65	0.4	*c.* 2/3 missing – 2c BIC. ASYM. EMBOS.PROF.
SWM118	US658 F14 20-07-00	III b	BM3A	4.5	2.5	2.6	0.5	*c.* 2/3 missing – 4a BICONICAL
SWM119	US906 H11 25-07-00	III b	BM3A	8.6	2.85	2.2	0.4	*c.* 1/2 missing – 4b BIC. EMBOS. PROF.
SWM120	US957 G10 03-08-2000	III b	BM3A	5.9	2.9	1.95	0.5	*c.* 1/2 missing – 3 BIC. ASYM. PROTUBER.
SWM121	US913 H14 31-07-00	III b	BM3A	3.1	–	–	–	fragmentray, irregular – TYPE?
SWM122	US874 F13 25-07-00	III b	BM3A	13.2	2.95	2.9	0.5	fragmentray – 4a BICONICAL
SWM123	US906 E13-14 25-07-00	III b	BM3A	4.9	2.3	–	0.5	*c.* 1/2 missing – 5a BIC. CONCENTRIC MARKS 1 CONE
SWM124	US656 E11 10-07-00	III c	BM3A	7.6	2.6	2.8	0.45	*c.* 1/2 missing – 4a BICONICAL
SWM125	US706 G9 29-06-00	III c	BM3A	5.6	3	2.5	0.5	fragmentray – 5a BIC. CONCENTRIC MARKS 1 CONE
SWM126	US656 25-06-00	III c	BM3A	9.9	2.95	2.4	0.6	*c.* 1/2 missing – 4a BIC. (EMBOSS. PROF.?)
SWM127	US687 H11-12 1999	IV a	BM3A	5.8	3	–	0.6	fragmentary – 2a BYC. ASYMM.
SWM128	US697 F9 21-06-00	IV a	BM3A	16.2	3.4	2.6	0.55	failed during manufacture – 4a BICONICAL
SWM129	US755 F5 21-06-00	IV a	BM3A	7.7	3.1	2.2	0.55	*c.* 1/2 missing – 1c TRUNC. BELL SHAPED?
SWM130	US710 H.G9 22-06-00	IV a	BM3A	5.6	2.9	–	0.5	*c.* 2/3 missing – 4a BICONICAL
SWM131	23-06-2000	IV a	BM3A	6.5	–	–	–	very fragmentary – TYPE?
SWM132	US741 F8 19-06-00	IV c	BM3A	1.7	–	–	–	very fragmentary – 4a BICONICAL?
SWM133	US704 E6 20-06-00	IV c	BM3A	4.2	2.4	2.35	0.4	*c.* 2/3 missing – 4a BICONICAL
SWM134	US641 G11 11-10-99	IV c	BM3A	3.4	–	–	–	fragmentary – 4b BIC. EMB. PROF.?
SWM135	US632 H5 15-10-99	IV c	BM3A	4.9	2.8	1.9	0.5	*c.* 2/3 missing – 1b TRUNC. CONICAL EMB. PROF.
SWM136	US641 E10 12-10-99	IV c	BM3A	4.3	2.7	–	0.5	*c.* 2/3 missing – 1b TRUNC. CONICAL EMB. PROF.?

TABLE 4: (Continued)

No.	*Excavation data*	*Phase*	*Chronology*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Observations = Type*
SWM137	US641 06-10-99	IV c	BM3A	5.3	–	2.7		*c.* 60% missing – 4a BICONICAL
SWM138	US677 E.F6 21-10-99	V b	BM3A	4	2.4	2.4	0.4	*c.* 2/3 missing – 4a BICONICAL
SWM139	US636 G6-7 16-09-99	VI b	BM3A + BM3B	2.4	–	–	–	fragmentary – TYPE?
SWM140	US 636 G6-7 16-09-99	VI b	BM3A + BM3B	7.4	2.8	2.6	0.6	*c.* 1/2 missing (2 fr.) – 4a BICONICAL
SWM141	US674 E7-8 12-10-99	VI b	BM3A + BM3B	3.8	–	–	0.5	fragmentary – 1a TRUNCATED CONICAL
SWM142	US674 E8 12-10-99	VI b	BM3A + BM3B	3.5	2.4	2	0.4	*c.* 3/4 missing – 4a BICONICAL
SWM143	US674 E8 12-10-99	VI b	BM3A + BM3B	3.5	–	–	0.6	fragmentary – TYPE?
SWM144	US593 F8 22-09-99	VI b	BM3A + BM3B	7.8	2.6	1.95	0.5	*c.* 1/2 missing – 2a BICONIC. ASYM
SWM145	US593 F8 22-09-99	VI b	BM3A + BM3B	6	2.45	2.3	0.45	*c.* 1/2 missing – 4a BICONICAL
SWM146	US593 F8 22-09-99	VI b	BM3A + BM3B	8.2	3	–	0.55	*c.* 2/3 & bases missing – 4a BICONICAL
SWM147	US607 H.i13 09-09-99	VI b	BM3A + BM3B	4.5	2.5	1.8	0.45	*c.* 1/2 missing – 5a BIC. CONCENTRIC MARKS 1 CONE
SWM148	US 635 E.F 9-10 23-09-99	VI b	BM3A + BM3B	4.7	–	2.8	–	*c.* 2/3 missing – 4a BICONICAL
SWM149	US593 F6 22-09-99	VI b	BM3A + BM3B	7.1	2.8	2.15	0.5	*c.* 1/2 missing – 4b BIC. EMB. PROF.
SWM150	US593 H9 23-09-99	VI b	BM3A + BM3B	4.5	–	–	–	fragmentary – 4a BICONICAL
SWM151	US593 H9 23-09-99	VI b	BM3A + BM3B	2.9	–	–	–	fragmentary – 1a TRUNCATED CONICAL
SWM152	US593 F7 22-09-99	VI b	BM3A + BM3B	7.5	2.95	2.1	0.55	*c.* 1/2 missing (2 fr.) – 4b BICONIC. EMB. PROF.
SWM153	US593 F7 22-09-99	VI b	BM3A + BM3B	2.4	–	2	–	fragmentary – 4a BICONICAL
SWM154	US583 F8 17-09-99	VII a	BM3B	2.4	–	–	–	fragmentary – 2a BICONIC. ASYM.
SWM155	US583 E8 24-09-99	VII a	BM3B	3.2	–	–	–	fragmentary – TYPE?
SWM156	UIS601 E6 07-09-99	VII b	BM3B	1.9	–	–	–	fragmentary – TYPE?
SWM157	US590 H14 22-07-99	VII b	BM3B	8.1	2.85	2	0.55	*c.* 1/2 missing – 2a BIC. ASYMM.
SWM158	US578 E.F7 20-07-99	VII c	BM3B	7.9	2.95	2.2	0.5	*c.* 1/2 missing –5a BIC. CONCENTRIC MARKS 1 CONE
SWM159	US582 G6 23-07-99	VII c	BM3B	7	2.8	2.1	0.6	*c.* 60% missing – 2a BIC. ASYMM.
SWM160	US582 F8 23-07-99	VII c	BM3B	3	–	–	–	fragmentary – TYPE?
SWM161	US621 F5 13-09-99	VII c	BM3B	8.3	2.8	2.4	0.55	*c.* 1/2 missing – 4b BICONIC. EMB. PROF.
SWM162	US582 H9 07-09-99	VII c	BM3B	10.6	3.55	2.85	0.5	*c.* 55% missing – 1b TRUNC. CON. EMB. PROF.
SWM163	US629 H6 09-09-99	VII c	BM3B	7.5	2.95	1.85	0.5	*c.* 1/2 missing – 2c BIC. ASYMM. EMB. PROF.
SWM164	US555 E6 29-06-99	VIII a	BM3B	11.5	3.25	2.6	0.5	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.

TABLE 4: (Continued)

No.	*Excavation data*	*Phase*	*Chronology*	*Actual weight (g)*	*Max. Ø (cm)*	*Height (cm)*	*Ø hole (cm)*	*Observations = Type*
SWM165	US561 F7 06-09-99	VIII a	BM3B	3.4	–	2	–	fragmentary – 4b BICONIC. EMB. PROF.
SWM166	US548 E13 13-07-99	VIII b	BM3B	14.3	3.95	–	0.7	fragmentary – 9 PIN–HEAD
SWM167	US548 G14 12-07-99	VIII b	BM3B	6	3.3	–	0.5	*c.* 1/2 missing – 1c TRUNC. BELL SHAPED?
SWM168	US 548-558 G11 06-07-99	VIII b	BM3B	9.1	2.8	2.5	0.6	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.
SWM169	US548-558 E10 06-07-99	VIII b	BM3B	8.9	3.2	1.9	0.45	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.?
SWM170	US548-558 E10 06-07-99	VIII b	BM3B	4.5	–	–	–	fragmentary – TYPE?
SWM171	US546 G13-14 02-07-99	VIII c	BM3B	8.4	2.9	2	0.4	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.
SWM172	US549 H8 IItagl. 28-06-99	IX a	BR1	3	3.1	–	–	Very fragmentary – TYPE?
SWM173	US547 E8 IItagl. 01-07-99	IX a	BR1	4.1	2.4	1.7	0.45	*c.* 1/2 missing – 8 GLOBULAR
SWM174	US549 E6 28-06-99	IX a	BR1	7.7	2.4	2.7	–	*c.* 1/2 missing– WHORL? TYPE?
SWM175	US550 H5-6 26-06-99	IX a	BR1	3.4	2.1	–	–	*c.* 3/4 missing – 4b BIC. EMB. PROF.?
SWM176	US550 H5 28-06-99	IX a	BR1	6.5	3	2.05	0.55	*c.* 2/3 missing – 2c BIC. ASYM. EMBOSS. PROF.
SWM177	US549 E.F5 28-06-99	IX a	BR1	5.8	3.15	1.8	0.6	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.?
SWM178	US550 G6 28-06-99	IX a	BR1	8.4	2.95	2.4	0.6	*c.* 1/2 missing – 4b BIC. EMBOSS. PROF.
SWM179	US544 H4-5 23-06-99	IX b	BR1	5	–	–	–	*c.* 3/4 missing – 2a BICONIC. ASYMM.
SWM180	US542 F9-10 24-06-99	IX b	BR1	5.6	2.7	1.6	0.5	*c.* 1/2 missing – 1c TRUNC. BELL SHAPED
SWM181	US542 H13 22-06-99	IX b	BR1	3.3	3.1	–	0.4	*c.* 2/3 missing – 1c TRUNC. BELL SHAPED?
SWM182	US521 IIItagl. G.F 12 16-06-99	X a	BR1	10.3	3.5	2.85	0.5	*c.* 3/4 missing – 4b BIC. EMB. PROF.?

fragmentary) belong to Phase I–III and that, with the exception of two fragmentary items, one from Phase V and one from Phase X, practically no whorls exist from Phase V, X, and XI. Small sample sizes, however, make trends unreliable. The lack of spindle whorls from Phase V, for example, clearly reflects that the small area excavated ceased to be a dwelling space during that phase as it was involved primarily in metallurgy. The lack of whorls in Phase X–XI might reflect poor preservation (Cardarelli 2009b, 45, 50–1, 63). Although detailed regional studies are needed, which could add important new information, the decrease of clay spindle whorls during the Recent Bronze Age may reflect a transformation in textile production modes or outcomes across the whole Terramare area.[8]

DISCUSSION

On the base of the available data (cf. Bernabò Brea *et al.* 2003; Bianchi 2004; Lincetto 2006, see also Table 2), the counts of clay spindle whorls from Montale seem to have no equal among Terramare settlements, nor in fact in other Bronze Age European settlements (cf. Gleba & Mannering 2012; Grömer 2013; 2016; Kneisel & Schaefer in press). For the Mediterranean, where written sources speak of intense production, the impressive database created by the Centre for Textile Research in Copenhagen, although far from being exhaustive, counts only a total of 3994 entries (Andersson Strand & Nosch 2015b, 149), including known evidence from major Bronze Age centres around the Eastern Mediterranean coast. With the exception of Troy (Guzowska

Fig. 4.
Examples of spindle whorls from Montale (photos: S. Sabatini)

et al. 2015), spindle whorl counts from all the investigated sites do not exceed a few hundred (Andersson & Nosch 2015). Therefore, the assemblage of thousands of spindle whorls from Montale strongly suggests that the settlement was unusual, specialising in intense yarn production. Although weight distributions (Figs 5 & 6) show wide variation, a significant presence of light whorls (≤10 g) and a clear dominance of medium–light spindle whorls (10–20 g) suggests the production of a variety of threads including thin or fine yarn. That thin yarn was manufactured or used on site has been suggested on the basis of the numerous needles from Montale with small eyes appropriate for thin threads (Pulini & Righi 2009, 100).

Evidence from Montale suggests that specialised workers were probably active at the site and that production was on a large scale. As discussed earlier, spinning is a sizable task in textile production and so the high quantity of spindle whorls suggests their importance in the settlement's everyday activities. In this respect, the rather abrupt disappearence of whorls in Phases X–XI (Fig. 1) is difficult to explain, in particular when considering that, during these phases, the number of sheep/goats in the bone assemblage increased (Table 1). Although the representativeness of the excavated collection for the whole site is unknown, one can propose that more intense yarn production occurred during the Middle Bronze Age followed by increasing diversification of productive activities in

TABLE 5: TYPES OF SPINDLE WHORLS FROM THE MODERN STRATIGRAPHIC EXCAVATIONS PER PHASE

Montale's phases *Whorls (stratigraphic excavations)* *(fragmentary items)*		*I* *19* *(7)*	*II* *44* *(20)*	*III* *31* *(15)*	*IV* *17* *(11)*	*V* *1* *(1)*	*VI* *25* *(15)*	*VII* *16* *(10)*	*VIII* *12* *(8)*	*IX* *16* *(10)*	*X* *1* *(1)*
Type 1. Truncated conical	1a	3(1)	2(0)				3(2)	1(0)			
(a) regular,	1b		3(0)	1(0)	2(2)			1(1)			
(b) embossed profile, (c) bell-shaped	1c	1(1)	1(1)	1(1)	1(1)				1(1)	2(2)	
Type 2. Biconical asymmetric	2a	10(2)	12(3)	3(0)	1(1)		2(1)	6(3)	1(0)	5(1)	
(a) regular	2a		1(0)	1(1)							
(b) flattened (c) embossed profile	2c	2(2)	3(3)	1(1)				2(1)		1(1)	
Type 3. Biconical asymmetric with plastic protuberances	3	3(1)	3(1)	1(1)							
Type 4. Biconical	4a		2(0)	10(4)	6(5)	1(1)	11(7)			1(0)	
(a) regular, (b) embossed profile,	4b		2(2)	3(1)	2(1)		3(2)	1(1)	7(5)	3(3)	1(1)
Type 5. Biconical with concentric marks	5a		5(2)	5(2)	2(0)		4(1)	2(1)		1(0)	
(a) on one cone, (b) on both cones,	5b		2(1)	2(1)							
Type 6. Convex-cylindrical	6		3(2)		1(0)						
Type 7. Disc-shaped	7		1(1)								
Type 8. Globular	8		1(1)		1(0)					1(1)	
Type 9. Pin-head	9								2(1)		
No type/too fragmentary			(3)	(3)	(1)		(2)	(3)	(1)	(2)	

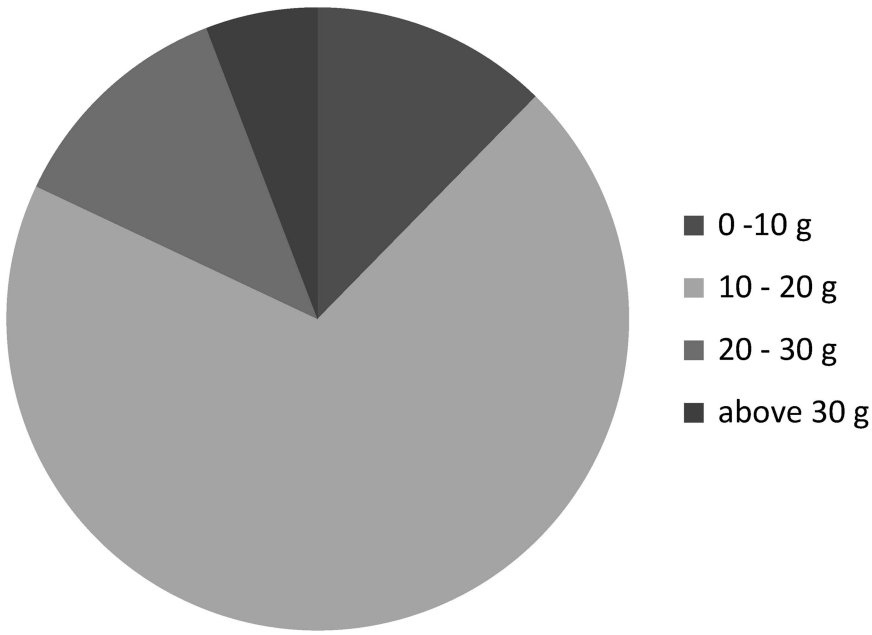

Fig. 5.
Spindle whorls from the 19th century collection at Montale according to categories of weight (N = 4089)

later phases. One reasonable suggestion is that, at the onset of Montale Phase X, emphasis on raw wool as an export became more profitable than yarn production, perhaps indicating some transformations of regional management practices or an emerging trade in other products. Archaeobotanical samples from modern excavations suggest that, at Montale, another economic transformation occurred at the end of Phase VIII and more evidently in Phase IX. With the introduction of grape there (Accorsi *et al.* 2009, 67; Cardarelli *et al.* forthcoming), perhaps new products, such as wine, might have replaced spinning as Montale's primary export. Of course, spinning techniques could also have changed or clay spindle whorls might have been substituted by whorls made in other materials.[9] Although definitive conclusions cannot be drawn, the consistent economic transformations that seem to have occurred at Montale at the beginning of the Recent Bronze Age are in chronological correspondence with the establishment of settlement hierarchies throughout the Terramare area (eg, Cardarelli 2015; Pacciarelli 2016, 168–72). Montale does not change its size with time, as other prominent Terramare settlements do, but interregional political dynamics probably played a major role in its particular economy.

To understand the social context of any specialised production, it is important to assess its possible link to the political economy that supported the emergence of social hierarchies (Earle & Spriggs 2015). The role of specialisation in the formations of social hierarchies has been discussed archaeologically since at least Childe (1942). Brumfiel and Earle (1987b) have drawn attention to the ability to control some prestige goods, like cloth, by what they call attached specialisation, meaning simply that elites sponsored production and thus effectively controlled distribution of socially meaningful objects. Kristiansen (1987) has developed this argument for metal production in Scandinavia during the Bronze Age.

Although the characteristics of archaeological evidence from Montale makes it difficult to assess whether textile production in general, and spinning in particular, could have been controlled by an emerging Terramare elite, the timing of this specialised manufacture, which began much earlier than the emergence of settlement hierarchies in the Terramare area (at the end of the Middle Bronze Age 3), suggests that Bronze Age wool production, as documented by Montale, was not being channelled into manageable 'bottlenecks'. A bottleneck, such as attached specialisation or dominance of trade, is a point of restriction in the commodity chain, which would allow elites to channel the flow of critical commodities (Earle *et al.* 2015). More case studies are needed, but one could

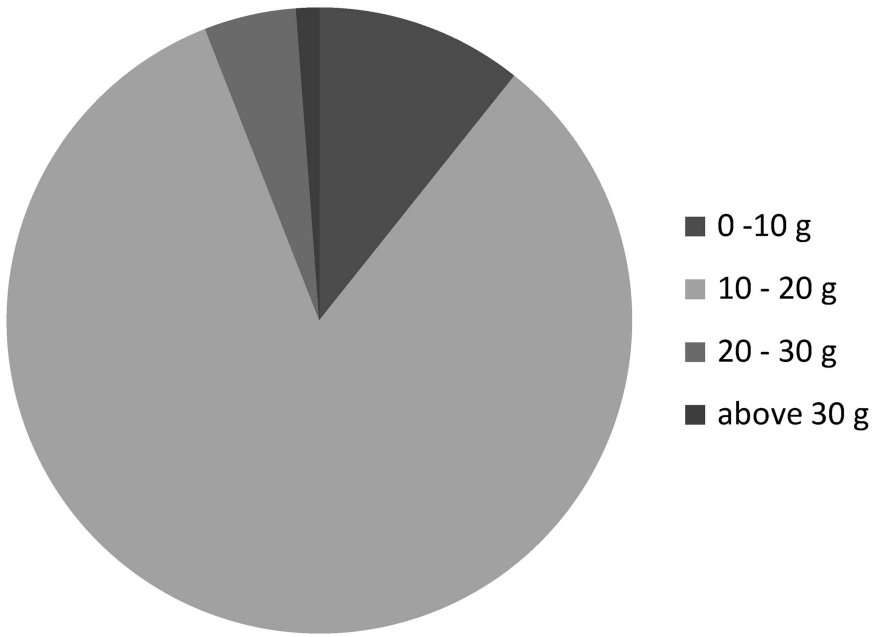

Fig. 6.
Spindle whorls from the stratigraphic excavations (1998–2002) at Montale according to categories of weight (N = 84)

tentatively suggest that patterns of Terramare textile making and trade might have been rather deeply affected by external factors which determined profitability.

All in all, the huge quantity of spindle whorls recovered at Montale argues strongly for intensive yarn production. Additionally, considering the limited size of the settlement (*c.* 1 ha and a probable maximum population of *c.* 130 inhabitants, cf. Cardarelli 2015, 167), a conspicuous part of the local population probably participated in such production. What can be said about the social context of this textile production, as evident at Montale? The lack of material culture signalling the existence of a well-defined elite is a recurrent issue in studies of the Terramare area attempting to assess modes of political and economic management and control (eg, Cardarelli 2015; Pacciarelli 2016). Our proposal, as far as textile specialisation at Montale is concerned, is to envisage a community-based (corporate) entrepreneurship. As mentioned, the existence of a corporate structure in Terramare settlements has also been proposed in order to explain the conspicuous and recurrent collective effort that must have been put into, among other things, digging and maintaining the large ditches and corresponding embankments normally surrounding local settlements (Cardarelli 2015, 168). A similar coordinated and communal effort has also been proposed for the construction of other features from the plain such as the imposing ritual basin of Noceto, Parma province, (Bernabò Brea & Cremaschi 2009; Cremaschi & Ferrari 2009, 106–7) or irrigation systems dated to the end of the Middle Bronze Age (Cardarelli 2015, 168). Even dismissing the hypothesis of attached production, it seems unlikely, given such premises, that single household or individual workshops actively pursued manufacturing activities for private wealth accumulation, as is suggested for independent, market-driven production models (Brumfiel & Earle 1987b).

Rather, the high quantity of spindle whorls at Montale suggests a broad, community-based specialisation, in which many spinners (or a large number of community members) participated. We propose that the characteristics of the archaeological record fit well with what has been called a 'community of practice'. Relying on an anthropological study of modern work groups (Wenger *et al.* 2002), communities of practice can be defined as close-knitted groups of specialists, often situated socially in single environments, communicating and sharing knowledge, exchanging

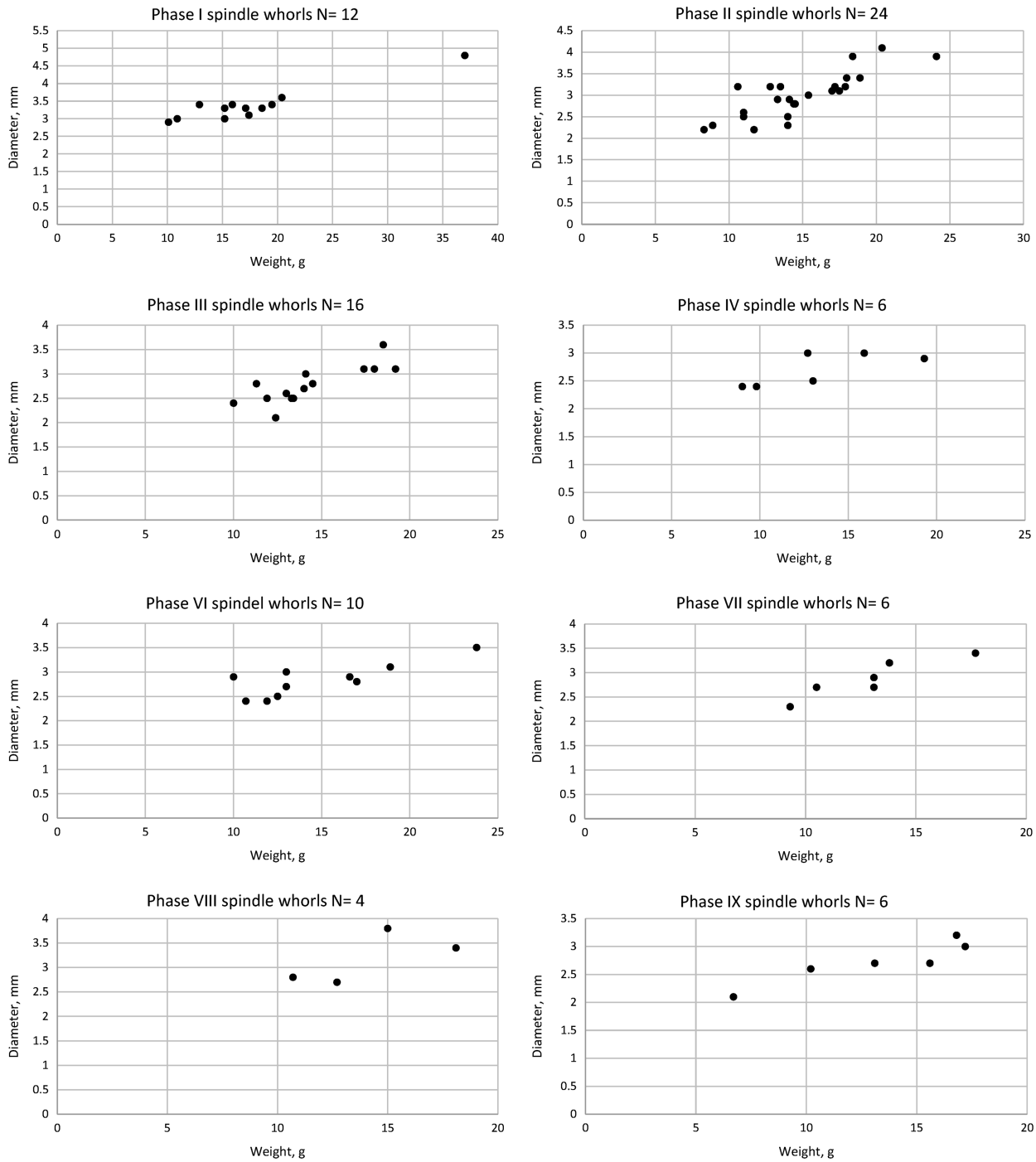

Fig. 7.
Scatter plot of the complete items from the stratigraphic excavations at Montale (N = 84) by weight/diameter

services, training novices through social learning systems, and, at times applying practice-based social pressure to ensure that all participants conform and that expected outcomes are achieved (Wenger 2010; compare Santacreu *et al.* 2014). As to our concern with Terramare social organisation, in a community of practice, leadership and practice management ought to acquire an internal intrinsic legitimacy that enables the establishment of effective organisation (eg, Wenger 1998a; 1998b, 72–9). Such a community of practice can result in several characteristics, including concentrated specialist activities in one locale, standardised production methods, and a localised competitive advantage defined by 'the regime of competence' that social learning and shared knowledge create (cf. Wenger 2010). Certainly the concentration of spinning tools at Montale easily fits the first criterion. The homogeneity of shapes within some of Montale's types of whorls (see Fig. 4), suggests also that the technology used in specialised textile production might have been produced in a standardised way (by the very same communities of practice or, perhaps, by workshops manufacturing these tools for the rest of the community?). Although further studies and analyses are necessary to test such hypotheses, the evidence hints at coordinated productive activities within the village. Looking specifically at weaving practices, a community of practice model has been also proposed to interpret the archaeological evidence for the Terramare loom weights (Sabatini in press). A comparative analyses of the available evidence from various sites of the Po plain and of the neighbouring Garda lake/Trentino area suggests that changes – in particular in the weight of the loom weights – occur contemporarily over the Po plain, but not in the Garda lake/Trentino area. In other words, weaving practices might not have been exclusive in the various villages, but rather shared widely. The known Terramare loom weight assemblages suggest that looms with unevenly heavy weights characterise Middle Bronze Age 2, while relatively light and similar weights generally distinguished Middle Bronze Age 3 and Recent Bronze Age 1 (cf. Fig. 1) assemblages. During Recent Bronze Age 2 heavy items of 1–2 kg appear instead the most common loom weights. Although further research is necessary to provide a secure reconstruction of Bronze Age weaving traditions on the plain, it seemed reasonable to envisage Terramare weaving as a dynamic activity developed by communities of specialists who networked broadly across Terramare villages, actively negotiating and developing regional weaving technologies.

CONCLUSIONS

In addition to the well-known metal trade, textiles must have been important commodities in the Bronze Age generally (eg, Frei *et al.* 2015; 2017; Kristiansen 2016; Vandkilde *et al.* 2015). Textual evidence from the Aegean and the Near East documents how textile manufacture was closely supervised, involving the interplay of resource procurement and labour specialisation. The lack of written evidence and the poor archaeological preservation of textiles has limited prehistorians' ability to capture the organisation of Bronze Age textile economies outside the Mediterranean. Rather, outside this region, attention must focus on textile technologies and their tools, such as spindle whorls, which can be studied in terms of settlement and household variability as a means to describe labour specialisation and its multiple roles in the political economy (Sabatini in press). The evidence from Montale suggests that textile crafts could have consituted a major settlement specialisation based on the capacities of local population to exploit environmental and human resources, including specialised labour, and – as to wool production – management of large herds. Montale's community might, therefore, have managed production to meet wider continental demands, as documented for northern Europe, where woollen clothing, at least during the 14th and the 13th centuries BCE, was used apparently without convincing signs for local wool production (Bergerbrant in press; Kristiansen & Stig Sørensen in press).

But what was the political significance of specialised textile production at Montale? We propose a simple model that would help explain the pattern of textile specialisation in the broader context of what is known of the local communities' socio-political organisation (Cardarelli 2009a; 2014; 2015). Terramare societies appear to have been oriented towards exploitation of their immediate territories with surplus productions in exchange for non-local commodities. Probably, already from Middle Bronze Age 3 (Fig. 1), a number of Terramare settlements employed irrigated agriculture (eg, Cremaschi *et al.* 2006, 89; Vanzetti 2013,

271–2), which must have involved fairly large-scale capital improvements. In order to defend their substantial investments and, most likely, the products of their labour, Terramare societies constructed their fortified settlements and imported metals for harvesting tools, weapons to defend their land, and elaborate ornaments and ritual objects (see Carancini 1997; Marzatico 1997) suggesting a hard-working but sophisticated society. To obtain unavailable raw materials such as metal, export products were essential. Montale, despite its limited size, has already attracted attention as applying a Thiessen polygon model indicates that it dominated an unusually large territory of 2200 ha, when compared with the average (260–890 ha) for the neighbouring sites of the province (Cardarelli 2009c, 43). Access to such a wide landscape might have allowed the Montale community to carry out both an intense agricultural production and animal husbandry at close range. In addition, Montale is situated in proximity to the southern margins of the plain, thus close to potential summer pastures offered by the Appenines which were abundantly used for sheep farming during Roman times, for example (Corti 2012). Combined with the archaeological evidence for intense sheep/goat husbandry (De Grossi Mazzorin & Ruggini 2009), our hypothesis is that the favourable regional environmental conditions and the likely capacity for development of communities of practice in spinning and weaving created the necessary local comparative advantage that made surplus production and exports in wool feasible.

The evidence from Montale suggests that the role of specialised textile production in the European Bronze Age was highly variable and dependent on the broader political economy in which it was imbedded. This focus on variability is critical to understanding different forms of specialisation generally and the wool textile economy specifically. We encourage the investigation of textile production as a means by which to study alternative pathways for social formation, some emphasising hierarchy while others possibly remaining resistant to elite control. As it must be documented archaeologically, during the Bronze Age, communities and regions appear to have engaged in continent-wide trade in many commodities in quite different ways and with quite different effects.

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Endnotes

[1] The Bronze Age chronology for mainland Italy can be summarised as follows: Early Bronze Age (*c.* 2200–1700/1650 BC); Middle Bronze Age (*c.* 1700/1650–1325/1300 BC); Recent Bronze Age (*c.* 1325/1300–1150 BC); and Final Bronze Age (*c.* 1150–950/925 BC).

[2] The excavations carried out at Castione dei Marchesi during the 19th century did not provide stratigraphic evidence and thus the possibility of securing material to a precise chronology. The site was in use between the Middle and the Recent Bronze Ages (cf. Fig. 1). Since the organic material came from the lowest levels, it is likely to have belonged to the Middle Bronze Age.

[3] The term *terramara* is, in local dialects, the name of the organic soil dug out in the 19th century from numerous local manure quarries. As evident even then, the quarries were the remains of Bronze Age settlements (eg, Bernabò Brea & Mutti 1994; Saltini 1997). Available archaeological evidence today consists, therefore, of two main groups of material: the finds collected during the 19th century and those from modern excavations.

[4] Flax, hemp, nettle, and *Tilia* (lime bast) (all well-known taxa in textile production, see Barber 1991, 9–35) were present in the plain and possibly cultivated (Ravazzi *et al.* 2004; Mercuri *et al.* 2006; Aceti *et al.* 2009, 124; Rottoli & Castiglioni 2009). Thus, wool, was possibly not the only fibre manufactured.

[5] The hypothesis of warp weighted looms standing against the wall of some of Poviglio's structures has been formulated on the base of the distribution of loom weights archaeological evidence. Clear rows of loom weights have been found parallel to the walls in more than one structure (Bernabò Brea *et al.* 2003; Bianchi 2004).

[6] Montale's material has not yet been published in its entirety and there are no approximate numbers for all the implements named here, except for the spindle whorls and the loom weights; the latter have been thoroughly presented elsewhere (Sabatini in press).

[7] It is worth stressing that the high frequency of spindle whorls in the small area of the modern excavation and the limited number of loom weights, is in harmony with numbers and proportions of the 19th century collections confirming that, at Montale, major emphasis was probably put on yarn production.

[8] The phenomenon has not yet been scientifically addressed but existing publications of textile tools show a possibly similar trend at Poviglio during Recent Bronze Age 2 (Bianchi 2004, 611; Lincetto 2006, 119 & 201).

[9] A case in point is represented by the wheel-like objects made of animal bone and horn which largely characterise Recent Bronze Age material culture from the plain. They have been interpreted as pin-heads, but also as possible spindle whorls (eg, Provenzano 1997, 533).

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RÉSUMÉ

Economie de la laine et du textile de l'âge du Bronze: Le cas du site de Terramare à Montale, Italie, de Serena Sabatini, Timothy Earle, et Andrea Cardarelli

A l'aube du 2ème millénaire avant J.-C. une économie lainière a fait surface à travers l'Europe continentale . Des sources archéologiques, iconographiques et écrites provenant du Proche Orient et de l'Egée attestent que l'économie de la laine à l'âge du bronze impliquait un considérable travail spécialisé et un élevage d'animaux à grande échelle. Ne reposant que sur des témoignages archéologiques, la connaissance détaillée des économies lainières dans l'Europe de l'âge du bronze était limitée, mais de récentes investigations du site de Montale à Terramare dans le nord de l'Italie documentent une densité élevée de fusaïoles et de poids qui confirme avec force l'existence de fabrication spécialisée de fil au niveau du village. La production ne semble pas avoir été rattachée à l'émergence d'une élite et n'était pas non plus totalement indépendante de contraintes sociales. Nous proposons que, bien que probablement dirigée par des élites locales, ,la production de laine était une entreprise basée sur la communauté et orientée vers l'exportation afin d'obtenir des matières premières et des biens qui n'étaient pas disponibles localement

ZUSSAMENFASSUNG

Textil- und Wollwirtschaft der Bronzezeit: Das Beispiel der Terramare-Siedlung von Montale, Italien, von Serena Sabatini, Timothy Earle, und Andrea Cardarelli

Zu Beginn des 2. Jahrtausends BC entwickelte sich eine Wollwirtschaft im gesamten kontinentalen Europa. Archäologische, ikonographische und schriftliche Quellen aus dem Vorderen Orient und der Ägäis zeigen, dass die bronzezeitliche Wollwirtschaft eine beträchtliche spezialisierte Arbeit sowie Viehzucht in großem Maßstab umfasste. Bezog sich die Forschung allein auf archäologische Daten, blieben die Erkenntnisse zur Wollwirtschaft im Europa der Bronzezeit beschränkt, aber jüngere Untersuchungen in der Terramare-Siedlung von Montale in Norditalien belegen eine große Dichte von Spinnwirteln, die deutlich für die Existenz von spezialisierter Manufaktur von Garn auf der Ebene von Dörfern spricht. Die Produktion scheint nicht mit dem Entstehen einer Elite zusammenzuhängen, noch war sie gänzlich unabhängig von sozialen Einschränkungen. Wir schlagen vor, dass die Herstellung von Wolle, auch wenn sie wahrscheinlich von lokalen Eliten geleitet wurde, eine gemeinschaftsbasierte Unternehmung war, ausgerichtet auf den Export mit dem Ziel, vor Ort nicht erhältliche Rohmaterialien und Güter zu erlangen.

RESUMEN

La economía de los textiles y de la lana en la Edad del Bronce: el caso del yacimiento de Terramare, Italia, por Serena Sabatini, Timothy Earle, y Andrea Cardarelli

En el inicio del II milenio cal BC surge la economía de la lana a lo largo del continente europeo. Las fuentes arqueológicas, iconográficas y escritas procedentes de Oriente Medio y del Egeo muestran que la economía de la lana en la Edad del Bronce supuso un considerable trabajo especializado y la cría de animales a gran escala. Centrándonos sólo en la evidencia arqueológica, el conocimiento detallado de las economías de la lana de la Edad del Bronce ha sido limitado, pero recientes investigaciones en el yacimiento de Terramare de Montale, en el norte de Italia, han documentado una elevada densidad de fusayolas que permiten sostener la existencia de una producción especializada de hilo a escala de aldea. Esta producción no parece haber estado vinculada a una élite emergente ni era completamente independiente de las restricciones sociales. Proponemos que, aunque probablemente estuvo gestionada por élites locales, la producción de lana fue un esfuerzo comunitario orientado a la exportación con el objetivo de obtener materias primas y bienes no disponibles en el entorno local.