Abhandlung

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Modelling Bronze Age sheepherding and wool production: the case of the Terramara settlement at Montale, Italy

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Zusammenfassung: Um eine ganzheitliche Woll-Textil-Wirtschaft während der Bronzezeit nachzuweisen, werden in dieser Arbeit Charakteristika und Ausmaß der Weidewirtschaft und der Schafhaltung in der Terramare-Siedlung von Montale (Provinz Modena, Italien) bewertet. Frühere Studien konnten zeigen, dass Montale in der Bronzezeit ein Zentrum der Wollproduktion war. Die vorliegende Arbeit erlaubt ein tieferes Verständnis der lokalen Textilwirtschaft durch die Untersuchung von Nachweisen zur Schäferei und dem örtlichen Landschaftsmanagement. Fernerhin wird ein interdisziplinäres Konzept zur Untersuchung und Rekonstruktion pastoraler Ökonomien und Strategien der Schäferei auch für andere prähistorische Kontexte vorgeschlagen.

Schlüsselworte: Weidewirtschaft, Landschaftspflege, Dichte und Größe der Tierpopulationen, Pastoralismus, Archäozoologie, Archäobotanik

Résumé: Cette contribution examine les caractéristiques et l'étendue de l'économie pastorale du site de Montale, dans la province de Modène. Des études récentes sur les matériaux archéologiques et archéozoologiques du site suggèrent que le village de Montale était un centre important de production de laine à l'âge du Bronze moyen et récent. Le but de ce travail est de mieux comprendre le fonctionnement de l'économie textile locale en analysant les indicateurs de l'activité pastorale et de la gestion des terres. Enfin, l'article propose une méthode interdisciplinaire pour l'étude et la reconstruction du pastoralisme dans des contextes protohistoriques.

Mots clés: économie pastorale, gestion des terres, densité et taille de la population animale, pastoralisme, archéozoologie, archéobotanique

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Abstract: Arguing for an integrated wool-textile economy in the Bronze Age, this paper assesses characteristics and scale of pastoral economy and sheepherding at the Terramare settlement of Montale (Modena province, Italy). Previous studies argued that Montale was a Bronze Age centre of wool production. The present work enhances the understanding of the local textile economy by investigating the evidence for sheepherding and landscape management at the site. It also proposes an interdisciplinary-based approach to investigate and reconstruct pastoral economy and sheepherding strategies in other prehistoric contexts as well.

Keywords: Pastoral economy, landscape management, animal population density and size, husbandry practices, archaeozoology, archaeobotany

Riassunto: Il presente contributo propone lo studio delle caratteristiche e dell'entità dell'economia pastorale nel sito terramaricolo di Montale, in provincia di Modena. Recenti studi del materiale archeologico e archeozoologico proveniente dal sito hanno permesso di proporre che l'abitato di Montale fosse un eminente centro di produzione della lana durante l'età del bronzo media e recente. In questo lavoro si vuole approfondire l'argomento attraverso l'analisi degli indicatori di attività pastorale e di gestione del territorio. L'articolo propone, infine, un metodo di carattere interdisciplinare per lo studio e la ricostruzione della pastorizia in ambito protostorico.

Parole chiave: Economia pastorale, gestione del territorio, densità e dimensione della popolazione animale, pastorizia, archeozoologia, archeobotanica

Introduction

Arguing for an integrated wool-textile economy in the Bronze Age, this paper assesses characteristics and scale of pastoral economy and sheepherding at the Terramare

settlement of Montale on the Po plain in northern Italy. Previous studies argued that Montale was a Bronze Age centre of wool production¹. Archaeological evidence from the site in support of this argument includes the astonishing number of textile tools, in particular spindle whorls, but also loom weights². Large numbers of sheep/goat bones among the faunal remains³ suggest that wool was the primary fibre for textile manufacture. The present work enhances the understanding of the local textile economy by investigating the evidence for sheepherding at the site. This paper also proposes an interdisciplinary-based approach to investigate and reconstruct characteristics and scale of pastoral economy and sheepherding strategies in other prehistoric contexts as well.

Wool in the Bronze Age

From the 2nd millennium BC, the introduction of wool and of woollen textile production represented in all likelihood a major innovation in Bronze Age Europe. Archaeological and written evidence show that wool became appreciated and used during the 4th millennium in the Near Eastern region⁴. Archival documents from Mesopotamia, Anatolia, and the Aegean dated to the 3rd and 2nd millennium BC describe that wool and woollen textile production was a complex, but highly rewarding economic activity⁵. Lacking written sources in Europe, the combined interdisciplinary study of archaeological and faunal remains can help us understand the role of wool and woollen textiles⁶.

In recent years, the concept of wool economy has emerged in Bronze Age studies⁷ to underline that engagement with the long chain of essential wool manufacturing processes⁸, would require – to be economically

profitable – also attention to consumption patterns and involvement in trade, thus to be part of an overall political economic design. Raw wool itself, during the Bronze Age, appears to have been a precious and difficult raw material to obtain in large quantities, not to mention qualities⁹. Thanks to ancient written sources, we have rather precise indications as to quantity and quality of the wool obtainable from Bronze Age sheep in the eastern Mediterranean and Mesopotamia. Archive documents from the Aegean show for instance that the standard weight of a sheep fleece was 700–750 g, and mixed herds of ewes and lambs were expected to produce c. 300 g wool per animal¹⁰. The expected wool yield from ewes only would have been around 600 g¹¹. Woollier sheep able to provide a yearly wool yield between 0.7 and 1.12 kg apparently existed in Mesopotamia, suggesting that at some locations, breeding practices improved specific productive traits¹². Finally, Eastern Mediterranean wool economies had access to international wool trade and/or managed large numbers of sheep, which necessarily demanded well-organised herding strategies¹³.

Analyses of textile fragments from Bronze Age Europe hint at sheep fleeces resembling today's so-called primitive races such as Soay sheep¹⁴, which provide an annual wool yield similar to that documented in Aegean archives. As in the Aegean, a profitable continental wool production intended for export would have required access to large numbers of sheep. The possibility to generate intense sheep farming must have, therefore, played a key role for the emergence of continental wool economies. A wealth of evidence from the Terramare settlement of Montale (Modena province, northern Italy), suggests that the site was in the likely control of a large, and environmentally rich territory, in which sizeable herds could be favourably grazing, producing wool beyond subsistence necessities.

1 Kristiansen 2016; Sabatini 2018; Sabatini *et al.* 2018a.

2 Sabatini *et al.* 2018a; Sabatini 2019.

3 De Grossi Mazzorin/Ruggini 2009.

4 Barber 1991, 24–25.

5 Breniquet/Michel 2014; Michel/Nosch 2010; Nosch 2015; Waetzold 1972; Wright 2013.

6 See Sabatini 2018; Sabatini/Bergerbrant 2019. Extensive archaeological studies have so far shown the widespread use of wool primarily by cataloguing textile fragments from across Europe (Bazzanella 2012; Bender Jørgensen 1992; Bender Jørgensen/Grömer 2013; Bender Jørgensen/Rast-Eicher 2015; Broholm/Hald 1940; CinBA database; Gleba 2008, 43–45, 2014; Gleba/Mannering 2012; Grömer 2013, 2016; Grömer *et al.* 2013, 2018; Harding 1995; Marić Baković/Car 2014).

7 Breniquet/Michel 2014; Nosch 2015; Sabatini 2018.

8 The wool *chaîne opératoire* includes sheep herding and husbandry practices, wool plucking, sorting, and cleaning, spinning, weaving, post-weaving treatments, and finally tailoring if clothing is to be pro-

duced (cf. Andersson Strand 2014; Andersson Strand/Nosch, 2019; Barber 1991; Bender Jørgensen 2018, 68; Costin 2013; Gleba 2008; Sofaer *et al.* 2013, 477–482).

9 E.g. Andersson Strand 2014; Andersson Strand/Nosch 2019; Barber 1991, 20–30; Gleba 2008, 72–75.

10 Nosch 2014, 192; Del Freo *et al.* 2010, 341.

11 Rougemont 2014, 349–50.

12 Andersson Strand 2014, 44. Cf. also Ryder 1983, 28–29; Sabatini *et al.* 2019.

13 Arbuckle/Hammer 2018; Biga 2014, 141; Firth 2014; Foster 2014, 117; Matošian/Vita 2014; McCorriston 1997, 523–524; Rougemont 2014, 241–45; Wisti Lassen 2010.

14 E.g. Rast-Eicher 2003; see also Gleba 2012.

The Terramare settlement at Montale

Montale was one of the many fortified Terramare settlements on the Po plain. It was c. 1 ha in size, and it was surrounded by a ditch c. 40 m wide and 3 m deep, which was filled with water from a nearby river likely to serve several functions including defence¹⁵. Terramare populations inhabited the central Po plain from the beginning of the Italian Middle Bronze Age until the end of the local Recent Bronze Age (c. 1700/1650–1200/1150 BC). By the end of the Middle Bronze Age, a site hierarchy emerged with several settlements that reach up to 10–20 ha in extension¹⁶. At the end of the Recent Bronze Age, this apparently prosperous system collapses for reasons that are widely debated¹⁷. Differently from other prominent sites on the plain, Montale does not change its original size and is probably abandoned before the end of the Recent Bronze Age¹⁸. The remains of the Bronze Age village were partly investigated during the nineteenth century providing information in particular about the still preserved parts of the embankment once separating the village from the water-filled ditch¹⁹. Thanks to recent stratigraphic excavations (carried out between 1996 and 2001) of a c. 45 m² portion of the settlement spared during the manure-quarry works in the nineteenth century²⁰, a glimpse of the internal organization at the site and an eleven-phase internal chronology (see Tab. 1) was determined.

What makes Montale exceptional among Terramare settlements, and so far among European Bronze Age settlements in general²¹, is its extraordinarily high concentration of textile tools, particularly spindle whorls. Nearly 4500 spindle whorls are known from the site suggesting yarn production close to industrial scale²². The prevalence of sheep/goats among the faunal remains from the site has

Tab. 1: Montale’s archaeological phases and contemporary Italian Middle and Recent Bronze Age chronology

Montale	Italy
	Middle Bronze Age 1 1700–1550 BC
Phase I	Middle Bronze Age 2A 1550–1500 BC
Phase II	Middle Bronze Age 2B 1500–1450 BC
Phases III–VI	Middle Bronze Age 3A 1450–1400 BC
Phases VII–VIII	Middle Bronze Age 3B 1400–1325/1300 BC
Phases IX–XI	Recent Bronze Age 1 1325/1300–1225/1200 BC
	Recent Bronze Age 2 1225/1200–1150 BC

been used to support the hypothesis that wool was the main fibre manufactured there²³; however, so far issues of pastoral economy at the site have not been investigated in depth.

The Archaeozoology of wool

Like most organic material, wool does not normally preserve in the archaeological record. With the exception of a single textile fragment from Castione dei Marchesi (Parma province), likely dating to the Middle Bronze Age²⁴, no other remains of textiles are known from Terramare settlements. Studies on the local wool economy must, therefore, rely on the archaeozoological evidence for wool-producing animals, and the archaeological evidence for wool technology.

Studies of prehistoric sheep/goats demonstrated that a significant variety existed in animal size and morphological traits across prehistoric Europe²⁵. Although archaeozoology cannot offer information as to the woolliness of their fleeces, it can help understand prehistoric herds’ management. The slaughtering age of the animals suggests their primary use²⁶. Adult sheep in general, and wethers

15 Cardarelli/Labate 2009a, 28–30.
16 Cardarelli 2009b; 2015; Pacciarelli 2016.
17 Bernabò Brea *et al.* 1997b; Cardarelli 2009b; Cremaschi *et al.* 2006.
18 Cardarelli/Labate 2009b
19 Boni 1882; 1884; Cardarelli/Labate 2009a.
20 During the nineteenth century, numerous manure quarries were opened in the central Po plain. As it became rapidly evident, those quarries of fertile soil were no more than the remains of Bronze Age settlements (e.g. Bernabò Brea/Mutti 1994; Cardarelli 2009a, 16–18; Saltini 1997).
21 In the rest of Europe, other centres of wool production, such as for instance Százhalombatta-Földvár, in the Hungarian plain (Bergerbrant 2018; Vretemark 2010), certainly existed (see also Belanová Štolcova/Grömer 2010; Kneisel/Schaefer 2019); however more focused research is needed to document them.
22 Sabatini *et al.* 2018a.

23 De Grossi Mazzorin/Ruggini 2009; Sabatini *et al.* 2018a.
24 Bazzanella 2012, 209.
25 e.g. Benecke 1994; Bökönyi 1974; Grömer/Saliari 2018, 135–136; Pipes *et al.* 2014; Ryder 1983; Schmölke *et al.* 2018.
26 Payne 1973; Greenfield 2014.

in particular, produce the largest amount of wool²⁷; high numbers of such individuals in a flock becomes, therefore, solid evidence of wool production. A high number of slaughtered new-born animals would instead suggest attention to milk products, while a primary interest in meat consumption would give herds with kill-off patterns clustering between approximately 6/9 months and 2/3 years depending on access to winter fodder²⁸.

Ancient written texts, in particular from Bronze Age Crete²⁹, show that local managements were well-aware of the amount of wool obtainable from different categories of sheep. Specialized herds also existed, but it seems that even in the case of distinct Bronze Age wool productions such as those carefully recorded in Aegean archive tablets, a mixed economy strategy, exploiting various products beside wool, was preferred³⁰. When written documents are missing, some critical research questions concerning reliability of inferences from zoo-archaeological evidence must be considered as to the relations between estimated culling patterns, husbandry practices and wool production:

- 1) To what extent do percentages of different taxa among animal remains in a given place mirror the ancient local domestic fauna?
- 2) In which ways can finding circumstances bias our understanding of the ancient animal population?

The representativeness of the archaeozoological remains has been discussed in a number of forums³¹. As to the study of Bronze Age wool economy, two specific aspects appear particularly relevant; the numerical dimension of the ancient faunal population and the relation between sheep and goats.

The first problem regards the possibility to estimate the ancient animal population from excavated faunal assemblages. Archaeozoological evidence may be biased by various factors and so not provide a full picture of the relative proportions of ancient domesticated species³². Two major issues shall be addressed in the case of Montale. First, the available faunal remains, although abundant (c. 9000 determined remains)³³, and well documented, coming from modern stratigraphic excavations³⁴, docu-

ment behaviour from only a small sample of the ancient Bronze Age village's living area. They may, therefore, be the results of depositional events that cannot be straightforwardly representative for the whole site. Secondly, social, cultural, religious, and practical rules or taboos might have biased the consumption patterns revealed by excavated remains.

To assess the first problem, one should consider that the archaeological evidence from the Terramare area broadly show regular settlement configurations with tightly organized living quarters of similar dimensions, repeatedly rebuilt throughout site sequences³⁵. Montale does not seem to be an exception³⁶; therefore, it is likely that the data acquired for the excavated portion would recur in other parts of the site. On the other hand, animal bones from the settlement ought to be predominantly the remains of meat consumption. Our current understanding of the Terramare societies does not allow to determine whether social, cultural or religious constraints may have influenced eating practices, and the assemblage composition.

Aware of limitations intrinsic to size and circumstances of the available sample, the reconstruction of the ancient pastoral economy at Montale shall be attempted by combining the evidence from archaeological studies with archaeozoological and archaeobotanical investigations, Thiessen polygon models, and strontium isotope tracing analyses. Finally, an attempt to quantify wool production and animal demography is provided. It is proposed that the approach developed by this research has the potential to construct a model useful to investigate other areas and periods as well.

Montale's ancient animal population

Animal remains from the modern excavations at Montale have been preliminarily published³⁷. They suggest that the ancient animal population was largely domestic and that sheep/goats likely prevailed throughout the site sequence. Cattle represented a stable c. 10 % of the bone assemblages and was typically kept until old age, thus likely used in agricultural work. Pigs' bone remains, which can be interpreted as a sign of mixed economy (pigs can be associated to the consumption of leftovers from agricultural produc-

²⁷ Barber 1991, 26–27.

²⁸ Payne 1973, 282.

²⁹ E. g. Del Frio *et al.* 2010; Killen 1964.

³⁰ E. g. Halstead 1998; Payne 1973, 282.

³¹ E. g. Albarella 2017; Bartosiewicz *et al.* 2013; Peres 2010

³² E. g. Barber 1991, 27–28; Grömer/Saliari 2018, 128–129; Peres 2010.

³³ De Grossi Mazzorin 2013.

³⁴ Cardarelli 2009a.

³⁵ See Bernabò Brea *et al.* 1997a; Bernabò Brea *et al.* 2007; Ferrari *et al.* 2018.

³⁶ Cardarelli/Labate 2009b.

³⁷ De Grossi Mazzorin/Ruggini 2009.

tions)³⁸, decreased considerably through time (Tab. 2), possibly in connection to sheep farming and secondary products acquiring a greater economic role³⁹.

The available data about sheep/goat bone from Montale hint at a considerable animal population. Throughout the sequence, their remains dominate the bone assemblages (see Tab. 2). Additionally, their presence seems to increase from approximately 47 % of the local faunal remains during the Middle Bronze Age 2 to c. 62 % of the total during the Recent Bronze Age 1. The sample is not exclusively sheep⁴⁰; on the exclusive base of traditional archaeozoological methods, it has been estimated that goats represent c. 8 % of the domestic caprine population during most of the sequence (phases I–X, see Tab. 1), while during the last phase (XI) of the Recent Bronze Age 1, the percentage of goats doubles⁴¹. A similar pattern has also been observed in other Terramara sites where it has been interpreted as a sign of worsened environmental conditions⁴², since goats seem to have better chances than sheep to cope with adverse, drier circumstances. Across Eurasia since prehistory, sheep and goats have been kept together, although in varying proportions⁴³. The reasons behind such pastoral strategies might be various⁴⁴.

In order to propose a convincing picture of Montale’s wool economy, only the estimated sheep population will be considered⁴⁵, because the presence of goats might

38 cf. De Grossi Mazzorin 2013, 258.

39 De Grossi Mazzorin/Ruggini 2009.

40 Sheep and goats are close, but not equivalent species. Thanks to archaeozoology, and today to zooarchaeology by mass-spectrometry (ZooMS), and ancient DNA (aDNA) studies, it is possible to distinguish between their remains (e. g. Buckley *et al.* 2009; 2010; Campana *et al.* 2013; Sinding *et al.* 2015). While the ZooMS and the aDNA analyses tend to provide definitive results, archaeozoological analyses are limited in their scope by the fact that just a few bones can be used to distinguish between the two taxa (e. g. Salvagno/Albarella 2017; Halstead *et al.* 2002; Gillis *et al.* 2011).

41 De Grossi Mazzorin/Ruggini 2009.

42 Farello 2011.

43 E. g. Becker *et al.* 2016, Fig. 10; De Grossi Mazzorin 2013; Green 1980; Greenfield 2005, 22.

44 Both the primary and the secondary products that can be obtained from them have different nutritional values and different harvesting patterns when eatable (like milk and meat) or different characteristics when the main interest is in their skin/fleeces (see Greenfield 2017). Both species can be used to produce wool (e. g. Barber 1991, 20–30; Del Frio *et al.* 2010, 340; Green 1980, 14), although goat hair has not yet been detected in Bronze Age textiles from continental Europe. Evidence from the Aegean and the Near East (Bender Jørgensen/Rast-Eicher 2018, 34; Frangipane *et al.* 2009, 19–20; Michél 2012, 237) suggest that they were in use in neighbouring areas.

45 According to the available data from De Grossi Mazzorin/Ruggini 2009.

Tab. 2: Approximate percentages of the domestic taxa recovered at Montale during the stratigraphic excavations 1996–2001.

	Sheep	Goats	Total sheep/ goats	Pigs	Cattle
Middle Bronze Age 2	40 %	7,2 %	47,2 %	41,4 %	11,4 %
Middle Bronze Age 3	40 %	8 %	49,8 %	37,7 %	12,5 %
Recent Bronze Age 1	48 %	13,6 %	61,6 %	28,1 %	10,3 %

imply that a percentage of the domestic caprines was not kept for wool.

Thiessen polygons and archaeobotanical records from Montale’s territory

A Thiessen polygon model associates settlements with their surrounding territories, and can be applied to the Modena province during the Bronze Age to associate settlements with resource areas. Despite its relatively small size (1 ha), Montale appear to have dominated, during its initial phases I–II (Middle Bronze Age 2), an unusually large territory of c. 2200 ha⁴⁶. According to the Thiessen polygons’ model, the average size of the territories associated with the other Terramare sites of Modena’s *alta pianura* (= part of the Po plain south of Modena, cf. Fig. 1) is a much more modest 260 to 890 ha. Of course, Thiessen polygons represent an abstract model, and other factors invisible to the archaeological record might affect regional landscaped management⁴⁷; nonetheless, access to an extensive surrounding landscape would doubtlessly represent a crucial factor to the development of intense sheepherding targeted at wool production. Political control over a relatively wide territory would allow the Bronze Age Montale’s community to carry out at the same time large-scale animal husbandry integrated with prosperous agriculture.

A substantial confirmation for the interconnected prosperity of Montale seems to come from the pollen diagrams. Pollen analyses from the Terramare area have shown that emphasis on pastoral economy is differen-

46 Cardarelli 2009c, 43–48.

47 Ibid.

Fig. 1: Map of Italy indicating the Modena province and close up of Modena's *alta pianura* and neighbouring Appenine foothills with names of the sites mentioned in the text. The black ovals marks locations where samples for strontium isotope baseline have been collected (Graphics: S. Sabatini)

tial on the plain, and that not all the sites would pursue the same economic strategies. An important indicator for pasture and grazing land has been identified by the presence of cichorieae (one of the six tribes of the sub-family Cichorioidea) in pollen diagrams⁴⁸. Pollen studies from Montale, as from the neighbouring site of Baggiovara, show a significant presence of chicorieae⁴⁹, strongly suggesting that they were surrounded by a landscape where animal grazing had a relevant role. Pollen diagrams from other Terramare villages, such as the well-studied site of Poviglio, provide a different picture revealing a surrounding territory, with a prevalent agriculture and just few limited zones probably devoted to pastoral activities⁵⁰.

As mentioned earlier, Montale is situated in the *alta pianura* (the southern margins of the Po plain) near the potential summer pastures offered by the Appenine Mountains, which were exploited for sheep raising in Roman times⁵¹. Earlier studies, based on the archaeological evidence, have suggested interaction between the plain and those mountainous areas throughout the Middle and

Recent Bronze Age⁵². Although they did not provide conclusive evidence as to Bronze Age sheepherding, Montale's herds could potentially have had access to these mountainous pastures (or perhaps to forage harvested there). Although not proved, the possibility that Montale's community could exploit the mountainous pastures offered by nearby Appenine uplands is not contradicted by the geochemical analyses carried out at the site⁵³.

Strontium isotopes and Bronze Age husbandry practices at Montale

Strontium isotopes have proven to be an interesting means to measure relationships between people, animals and organic material from the past and the landscape in which they were found⁵⁴. Within the THESP project supporting the present work⁵⁵, a twofold series of strontium isotope

⁴⁸ Florenzano *et al.* 2015.

⁴⁹ Accorsi *et al.* 2009; Mercuri *et al.* 2006, 55.

⁵⁰ Cremaschi *et al.* 2016, 168.

⁵¹ Corti 2012.

⁵² Cardarelli 2006; Cavazzuti/Putzuolo 2015.

⁵³ Sabatini *et al.* forthcoming.

⁵⁴ E. g. Frei *et al.* 2015, 2017.

⁵⁵ See: <https://historiskastudier.gu.se/english/research/bronze-age-wool-economy>

analyses was carried out to explore the characteristics of the pastoral economy at Montale, and in particular, to understand whether animal seasonal mobility was used to optimise landscape management. A primary goal of the sampling strategy has been to map the biologically available regional strontium baselines around Montale, including both the plain surrounding the site, and the neighbouring northernmost slopes of the Appennine Mountains⁵⁶. The two largest rivers of the area, with a relatively consistent water flow all year around (Secchia to the west, and Panaro, to the east of Montale) were chosen as eastern and western borders of the studied area. They likely represented considerable landmarks⁵⁷. The local baseline values have been measured in water and vegetal samples and in soil from different excavation layers at both the site of Montale and at the neighbouring and roughly contemporary necropolis of Casinalbo⁵⁸.

The second aim of the sampling strategy was to collect sheep teeth from the stratigraphic excavations at Montale to provide evidence to test pastoral mobility. Thirty-five teeth (between two and five per each 11 archaeological phases investigated at the site, Tab. 1) have been sampled for strontium isotope analyses⁵⁹. Most teeth have been subjected to multiple sampling to investigate mobility through time in the same animal individuals⁶⁰. The results of the analyses are in course of publication and cannot therefore be provided here. For the scope of this paper, one can say that they are not in contradiction with the hypothesis put forward in this paper that domestic caprines primarily grazed in the territory around Montale, and possibly, if convenient, used Appennine mountain pastures⁶¹.

Animal demography and wool economy: attempting quantification

Sheep grazing and stocking rates

In terms of pastoral economies, various attempts have been done to calculate the amount of land necessary for successful prehistoric sheepherding⁶². The extent of grazing land varies greatly depending on climate, environmental factors (i.e. characteristics of the vegetation, access to fresh water, weight and size of the grazing animals) and the degree of human intervention and regulation⁶³. Desert pastures similar to those available for southern Mesopotamian Bronze Age wool economies would need between 6–8 ha to support one sheep in a year, while in the steppe environment of northern Mesopotamia this figure would decrease to 4.5 ha. Probably, about 24.5 ha would be necessary to produce around 3 kg of raw wool in a year or 2 kg of clean/ready to use wool in the south, and 15.75 ha, in the north of Mesopotamia⁶⁴. On the northern edge of western Eurasia, 1 ha of actively managed heathland could sustain one adult double-coated old Norse sheep, producing 1–2 kg of raw wool per year⁶⁵. Long-term investigations on the feral Soay population living in the Village Bay sector (c. 175 ha) of the Hirta Island, Scotland, UK, have shown that even when the human intervention is practically non-existent, a harsh environment could sustain between 313 and 423 sheep between 1961 and 1967 and from 211 to 513 animals during the period 1985–1990; thus, between 1.2 and 2.9 animals per hectare⁶⁶.

Controlled grazing may increase the number of animals in a given landscape and guarantee – i.e. by storing surplus vegetation from the spring/summer seasons – adequate food intake during the winter months⁶⁷. Controlled grazing and rotational practices, including multispecies grazing, seem to provide ecological and economic advantages and to a certain extent higher resistance to parasites, toxic plants, and predators⁶⁸. Ethnographical studies show that traditional pastoral societies actively practice forms of rotation and controlled grazing⁶⁹. Archaeobotan-

⁵⁶ Sabatini *et al.* 2018b, Fig. 1.

⁵⁷ An indirect confirmation of their geographical role might be considered the somewhat different development of the area at the end of the Middle Bronze Age. In the whole Terramare area by the end of the Middle Bronze Age 3 and more clearly during the Recent Bronze Age, site hierarchy emerges with large sites dominating vast portions of the landscape. In the *alta pianura* between Secchia and Panaro, the earlier Middle Bronze Age political situation would seem to remain rather unchanged.

⁵⁸ Sabatini *et al.* forthcoming. About the necropolis of Casinalbo see Cardarelli 2014.

⁵⁹ Sabatini *et al.* 2018b.

⁶⁰ Cf. Sabatini *et al.* forthcoming.

⁶¹ Sabatini *et al.* forthcoming

⁶² E. g. Becker *et al.* 2016, 109–112; Bendrey 2011; Gregg 1988, 111–118; Hadjigeorgiou *et al.* 2005; Randall 2010, 29–82.

⁶³ E. g. Avondo *et al.* 2013; Grace *et al.* 2018; Milligan *et al.* 2016; Molle *et al.* 2001; 2004.

⁶⁴ McCriston 1997, 524.

⁶⁵ Bender Jørgensen 2012, 179.

⁶⁶ Clutton Bruck *et al.* 1991.

⁶⁷ E. g. Molle *et al.* 2004, 197.

⁶⁸ E. g. Esmail 1991; Randall 2010, 43–50; Walker 1994.

⁶⁹ Elliott *et al.* 2014; Randall 2010, 40; Sieff 1997, 526–531.

ical studies from Montale seem to confirm that the immediate benefits of such practices were exploited by local community (Mercuri *et al.* 2006).

A study from Virginia, USA, shows that a modern supposedly ‘safe’ rate of 2.5 sheep/acre (c. 5 animals per ha) in favourable environmental conditions can be doubled with controlled grazing⁷⁰. A survey of modern controlled farming from New Zealand for the period 1987–1990 reports an average eight stock units (each unit consisting of one ewe and one lamb) for summer dry properties and 10.8 stock units for summer moist pastures⁷¹. Similar rates are obtained in Sardinia, where irrigated lowlands can apparently be grazed by 10–20 ewe/ha, while the dry hills by 1–3 animal/ha⁷². Studies on the Appennine mountains of the Parma province, in northern Italy, show a subsistence capacity similar to that estimated for the Sardinian hills, with rates between 0.97 and 3.93 sheep/ha⁷³. As to the scope of this work, one should consider that Modena province’s *alta pianura* during the Bronze Age probably offered relatively good quality pastures all year around, thus high stocking rates (or numbers of animal per units of land). Today, local farmers report that seven to nine sheep per hectare is a convenient stocking rate⁷⁴. In Roman times, a few kilometres north-east of Montale at the site of Baggiovara, 2 sheep/ha was average for small-scale, single-family farms following a mixed subsistence economic model⁷⁵. Modern organic farming standards recommend for average quality pastures a sustainable stocking rate at 1.2 livestock units (1 livestock unit = 5 domestic caprines) per ha⁷⁶. In Italy, current standards for organic farms have set a maximum number of sheep per hectare at 13.3 animals⁷⁷. According to a study of grazing methods in modern semi-arid Mediterranean conditions, natural pastures appear suitable for a low-medium rate of 1–5 heads/ha; forage crops of grass and legumes can sustain medium-high rates of 5–10 heads/ha, while high-quality forage crops and legumes support generally high rates of 10–15 heads/ha⁷⁸.

To calculate carrying-capacity rates for the territory of Montale, one should consider that modern rates target bigger and heavier sheep (with adults ewes from 60 up to 130 kg as in the case for instance of the Suffolk breed)

than more ‘primitive’ sheep such as the Soays (adult ewes generally between 25–30 kg). The latter are, as mentioned above, able to survive at low-medium stocking rates even in the unmanaged harsh north-Atlantic landscape of Hirta Island, Scotland. Thus, Bronze Age sheep farming could likely use a more convenient coefficient of animal/ha than those applied for modern herding. Additionally, light primitive sheep cause a generally limited degree of damage – when it comes to trampling of the grazed land – supposedly effecting a faster recovery of the vegetation throughout the year⁷⁹. A confirmation that Bronze Age sheep from the Po valley would resemble Soay sheep in size comes from archaeozoological studies revealing that the average withers’ height is c. 60 cm or below⁸⁰. Soay sheep’s wither height is around 52 cm for ewes and 56 cm for rams⁸¹.

The information just summarized show that it is possible, although hypothetical, to attempt to reconstruct stocking rates for the sheep population in given landscapes. In the case of Montale, considering: 1) its vicinity to potential mountainous pastures on the neighbouring Appennine, 2) the small size of the Bronze Age sheep, 3) the likely good quality of the pastures, and 4) the abundance of water, the local territory was probably able to support significant stock rates, between at least 5 to 10 domestic caprines per hectare.

Sheep stocking rates and other domestic fauna

To calculate the stocking rates proposed in the following models (Tab. 3–5), it has been considered that other domestic fauna were also present in the area.

Around 10 % of the local animal remains throughout the site sequence (Tab. 2) belong to cattle, this number paired with the advanced age of the analysed animals suggest that cattle were used primarily as aid in the agricultural work⁸². The absolute number of cattle at the site was probably limited to a few per household and thus likely well below a stocking rate of one animal/ha. Multispecies grazing experience suggests that one cattle per more than one hectare otherwise used for sheep should not alter the food intake of the prevailing species since they eat different forage. Additionally, the Bronze Age cattle from the plain appear to have been relatively small

⁷⁰ Kintzel 2010; Umberger 2009.

⁷¹ Cacho *et al.* 1995, 44.

⁷² Hadjigeorgiou *et al.* 2005, 53.

⁷³ Superchi *et al.* 2007.

⁷⁴ Andrea Cardarelli, University of Rome *La Sapienza*, personal communication.

⁷⁵ Labate 2011, 31.

⁷⁶ Randall 2010, 42.

⁷⁷ Vizioli 2015.

⁷⁸ Molle *et al.* 2004, 197.

⁷⁹ E. g. Blakesley/Buckley 2016, 73–74.

⁸⁰ De Grossi Mazzorin 2013, 258; see also Riedel 1996, 53–54.

⁸¹ Alderson 2016, 915.

⁸² De Grossi Mazzorin/Ruggini 2009.

in size with a withers' height around 110 cm⁸³, thus probably needed a lower food intake than modern cattle.

Pigs represent the second most common domestic taxa at Montale (Tab. 2); their diet is often thought to have been largely human leftovers and temporary browsing in forested areas⁸⁴, which would be quite consistent (660–436 ha) in the hypothetically calculated Montale's territory. Hence, they too would hardly affect sheep's grazing.

Goats have the same stocking rates as sheep⁸⁵, and are obviously present in a relatively rather stable 4:1 ratio throughout all phases (I–X), but one (phase XI) when the ratio raise to almost 4:2. All the same, goats normally target different plants than sheep, and in the ratios evident at Montale, they could profitably graze on the same landscape without interfering with each other as to food intake⁸⁶.

The figures proposed, that feature 2–5 sheep/ha or modern low-medium stocking rates⁸⁷, are probably modest; however, they should allow excluding the other domestic taxa (cattle, goat and pigs) from the modelling without affecting the potential significance of projected results.

Sheep and wool economy at Montale

About 1 hectare of land per person would secure agricultural subsistence⁸⁸ and with an estimated population of between 120–130 individuals at Montale, perhaps 130 hectares of land immediately around the settlement should have been dedicated to agricultural production. It has been assessed that the landscape around Terramare settlements was generally managed as following: c. 20 % of the available land was devoted to agriculture, between 20 % and 40 % was covered by forest, while the remaining 40 % to 60 % of the land was used for pasture⁸⁹. Pollen diagrams from Montale suggests that c. 30 % of the territory surrounding the site was forested⁹⁰, thus the remaining 50 % could have been grazing land.

The Thiessen polygon model suggests that, during the Middle Bronze Age 2, Montale could have controlled a ter-

ritory of 2200 ha⁹¹, 20 % of which is 440 ha or well beyond that required to support the settlement's small population. Results open up for at least two possibilities; in the first case (scenario A), Montale's inhabitants could have been practising agriculture that produced surplus for export. In the second case (scenario B), a considerably lower percentage (around 6 %) of the territory around the site could have been used for subsistence. Maintaining that 30 % (or 660 ha) was forested and generally used for other purposes than sheep farming, the remaining 50–64 % of the land (c. 1100–1400 ha) could have been devoted to grazing of the local domestic caprines. Quantifications are therefore proposed in two different scenarios (Tab. 3–5):

- A) Intense agriculture (both agriculture and sheep-farming are export-oriented)
- B) Subsistence agriculture (only sheep-farming is export-oriented)

Middle Bronze Age 2

The proposed model (Tab. 3) largely confirms the hypothesis that Montale was an early centre of wool production and export⁹². Despite using a combination of low coefficients (a modest low-medium stocking rate of 2–5 sheep/ha, and an annual wool yield of c. 300 g of wool per animal)⁹³, modelling show that the hypothetical territory of Montale could support an animal population between 2640 (at 2 heads/ha) and 6600 animals (at 5 heads/ha). Using as a frame of reference production figures proposed by Eva Andersson Strand and Marie-Louise Nosch⁹⁴ and considering that a third of the raw wool would have been discarded during cleaning, Montale's territory could easily deliver slightly over 1.3 ton of clean ready to use wool per year.

Since the archaeological evidence suggest yarn production at Montale close to an industrial scale⁹⁵, it is likely that locally produced wool was cleaned and spun at the site for export. At an average speed of 40 m per hour to obtain a middle range thread⁹⁶, we get a workload for the hypothetical maximum amount of wool per year (Tab. 3 scenario B), of about 380.000 hours. The latter would

⁸³ De Grossi Mazzorin 2013, 261; Riedel 1996, 54.

⁸⁴ De Grossi Mazzorin 2013, 258; Gregg 1988, 118–123; Randall 2010, 49.

⁸⁵ Cf. Eurostat LSU.

⁸⁶ Cf. Elias/Tischew 2016.

⁸⁷ Molle *et al.* 2004, 197.

⁸⁸ Cardarelli 2009b, 461; 2009c, 44.

⁸⁹ Cardarelli 2009b, 461.

⁹⁰ Cremaschi *et al.* 2016, 168; Mercuri *et al.* 2006, 263.

⁹¹ Cardarelli 2009b, 462.

⁹² Sabatini 2018; Sabatini *et al.* 2018a.

⁹³ According to Bronze Age Aegean archive 300 g of wool per animal is the expected yield of a mixed flock with only ewes and lambs (e. g. Del Frio *et al.* 2010; Nosch 2014).

⁹⁴ Andersson Strand/Nosch 2019, 22–24.

⁹⁵ Sabatini *et al.* 2018a.

⁹⁶ Andersson Strand/Nosch 2019, Tab. 2,1.

Tab. 3: Hypothetical quantification of average wool production at Montale during the Middle Bronze Age 2 (calculations about time, fibre and labour consumption are based on Andersson Strand/Nosch 2019, Tab. 2,1)

Farming land at Montale (BM2)	Scenarios	Total available pasture (ha)	Number of sheep per ha	Sheep population size	Minimum Wool yield per year (c. 300 g per animal)	Spinning 1 kg wool = 10.310m (40m/h)	Approximate number of 1 × 2.5 m tabby weave that could be produced
1540ha (= 2200 ha – 660 ha [30 %] of forested area)	A) Intense agriculture (c. 440 ha)	1100 + 220 of 'resting' agricultural land = 1320 ha	2	2640	792 kg (c. 528 kg of clean wool) –	5 443 680 m of yarn at 136 092 hours (c. 17 011 working days at 8h/day = 46 years/persons per year)	528
			5	6600	1980 kg (c. 1320 kg clean wool)	13 609 200 m of yarn at 340 230 hours (c. 42 528 working days at 8h/day = 116 years/persons per year)	1320
	B) Sub-sistence agriculture (c. 130 ha)	1410 + 65 of 'resting' agricultural land = 1475 ha	2	2950	885 kg (c. 590 kg of clean wool) –	6 082 900 m of yarn at 152 072 hours (c. 19 009 working days at 8h/day = 52 years/persons per year)	590
			5	7375	2212.5 kg (c. 1475 kg of clean wool)	15 207 250 m of yarn and 380 181 hours (c. 47 522 working days at 8h/day = 130 years/persons per year)	1475

make c. 47.000 working days (at 8 hours per day)⁹⁷, which is a 130 years long occupation for one person or a year-around labour for 130 craft-workers. 130 people would be the entire settlement population and thus entailing a critical workload for the community, which could be compensated for instance with the help of workers from outside the settlement, or with intense spinning carried out by the whole community during evening hours, or by trading part of the wool as a raw material.

In a fully developed economy such figures would entail producing the necessary yarn for weaving from approximately 528 (lowest figure in scenario A) to 1475 (highest figure in scenario B) balanced tabby weave of 1 m × 2.5 m (Tab. 3)⁹⁸. Even in the unlikely case of c. 130 pieces of cloth distributed every year to each member of the local

population, the figures clearly show the necessary hard work, but also the potential economic profits from the local wool economy.

Middle Bronze Age 3

During the Middle Bronze Age 3, the Thiessen polygon model suggests that the Montale's territory shrunk to around 1530 ha⁹⁹. The archaeological evidence from the stratigraphic excavations show a more limited number of textile tools during phases III–VIII than in the previous Middle Bronze Age 2 phases, however, the limited size of the excavated area might easily affect the reliability of such data¹⁰⁰. The relative presence of sheep/goats among the archaeozoological material did not change. One could, therefore, imagine a slightly more intense, in

⁹⁷ We have no possibility to infer the average working hours of craft-worker during the European Bronze Age, however, recent experiments have shown that a skilled spinner today would produce an amount of yarn similar to those reported in Mesopotamian archives when working an average of 8 hours per day (Andersson Strand/Cybulska 2012).

⁹⁸ Cf. Andersson Strand/Nosch 2019, Tab. 2,1.

⁹⁹ Cardarelli 2009c, Fig. 38.

¹⁰⁰ It is relevant to consider that during phase V the excavated area features metallurgical activities and that during phase VII it hosts a granary (Cardarelli/Labate 2009b), thus no textile work could have been profitably going on there during at least these two phases.

Tab. 4: Hypothetical quantification of average wool production at Montale during the Middle Bronze Age 3 (calculations about time, fibre and labour consumption are based on Andersson Strand/Nosch 2019, Tab. 2,1)

Farming land at Montale (BM3)	Scenarios	Total available pasture (ha)	Number of sheep per ha	Sheep population size	Minimum Wool yield per year (c. 300 g per animal)	Spinning 1 kg wool = 10.310 m (40m/h)	Approximate number of 1 × 2.5 m tabby weave that could be produced
1071 ha (= 1530 ha – 459 ha [30 %] of forested area)	A) Intense agriculture (c. 214 ha)	857+ 107 of 'resting' agricultural land = 964 ha	2	1928	578.4 kg (c. 385 kg of clean wool) –	3 969 350 m of yarn at 99 234 hours (c. 12 404 working days at 8h/day = c. 35 years/persons per year)	385
			5	4820	1446 kg (c. 964 kg clean wool)	9 938 840 m of yarn at 248 471 hours (c. 31 059 working days at 8h/day = 84 years/persons per year)	964
			7	6748	2024 kg (c. 1350 kg of clean wool)	13 918 500 m of yarn at 347 962.5 hours (c. 43 495 working days at 8h/day = 119 years/persons per year)	1350
	B) Sub-sistence agriculture (c. 130 ha)	941 + 65 of 'resting' agricultural land = 1006 ha	2	2012	603.6 (c. 402 kg of clean wool)	4 148 744 m of yarn at 103 719 hours (c. 12 965 working days at 8h/day = 35 years/persons per year)	402
			5	5030	kg 1509 (c. 1006 kg of clean wool)	10 371 860 m of yarn and 259 296 hours (c. 32 412 working days at 8h/day = 88 years/persons per year)	1006
			7	7042	2112.6 (c. 1408 kg of clean wool)	14 516 480 m of yarn at 362 912 hours (c. 45 364 working days at 8h/day = 124 years/persons per year)	1408

terms of stocking rates, sheep farming (Tab. 4). Indeed, a somewhat higher stocking rate of seven sheep per hectare (which was probably still an easily sustainable rate) would provide production figures similar to those from the earlier Middle Bronze Age 2 (Tab. 4).

Recent Bronze Age 1

During the Recent Bronze Age 1 (Montale's phases IX–XI), there is a marked decrease of textile tools in the archaeological record; however, archaeological preservation for the last phases (IX–XI) was poor. No structures could be identified, which strongly limits knowledge of that

period¹⁰¹. Interestingly, during this period a considerable increase of sheep/goat animal bones has been detected, while in the last phase (XI), the percentage of goats increase consistently suggesting additional economic transformations.

Terramare societies appear to have been oriented towards exploitation of their immediate territories with surplus productions to be used in exchange for non-local commodities¹⁰². Archaeobotanical samples from the modern excavations suggest several consistent transfor-

¹⁰¹ Cardarelli/Labate 2009b.

¹⁰² Sabatini *et al.* 2018a, 379.

mations of the landscape around Montale during this period. In the first place, the forested area decreased from c. 30 % to 20 % of the total land surface¹⁰³. Cereals also decrease in the pollen diagrams, data possibly confirmed by a contemporary sharp diminution of pigs that consumed agriculture leftovers (Tab. 2). On the other hand, already at the end of Phase VIII and more evidently in Phase IX, the cultivation of grape – previously non-existent in the local pollen diagrams – is introduced¹⁰⁴. Perhaps grape and its by-products (i. e. wine), might have replaced other activities such as yarn and/or textile production to obtain exchangeable export products. Thanks to an increased diversification of productive activities, raw wool might for instance have become a more profitable export than yarn or clothing¹⁰⁵.

According to the Thiessen polygons model Montale's landscape during this period would be of c. 2180 ha¹⁰⁶. Given the transformations in agricultural practices and land-management, it is difficult to estimate the area of pasturage; however, if one considers that the forested areas is now much smaller than during the Middle Bronze Age, an increased 10 % of the available land could have been used for increased sheep and especially goat raising. Applying the same coefficients of 2–7 sheep/ha proposed for the Middle Bronze Age 3 (Tab. 4), Montale's territory could have produced an expanded annual wool yield (Tab. 5). The hypothetical labour required to clean and spin such amount of wool would – in particular in the case of seven sheep/ha – exceed the workload that the community could reasonably meet, thus theoretically supporting the idea of an economic transformation entailing production and trade in raw wool.

Montale's pastoral economy: concluding remarks

The archaeological evidence for textile tools combined with the archaeozoological indications of a significant sheep/goat population have led to the proposal that the Terramare site of Montale was an early centre of large-scale wool production for export¹⁰⁷.

Wool economy is a complex endeavour entailing a long chain of working processes and the interplay of

several actors¹⁰⁸. In the Aegean and the Near East, early wool economies seem to have been the outcome of precise choices managed, and strictly controlled by the central political authorities¹⁰⁹. European Bronze Age communities, however, had fundamentally different social and political organizations than those of contemporary Mediterranean and Near Eastern societies¹¹⁰. The European societies were unlikely able to control at once large workforces, wide territories, and extensive trade routes. Therefore, engagement in a profitable surplus-oriented wool economy must have been possible only in the presence of favourable environmental, social, and/or economic preconditions. The small size of Bronze Age sheep and the limited amount of wool yield per head/year must have represented a major problem. Access to wide pastoral landscape and the possibility to organize intense sheepherding near a settlement would have created primary economic factors enabling what would have supported the rise of local wool economies. The aim of this paper has been to assess whether such a wool economy was possible at Montale, and at the same time, to provide a model for comparable studies in other settlement and/or environmental contexts.

Different data sets have been combined and discussed including archaeozoological and archaeobotanical studies, Thiessen polygon models, and to a minimum extent strontium isotope tracing analyses. The results show that Montale likely controlled an unusually extensive landscape, a considerable portion of which served for animal grazing. The site is also characterised by a strategic geographical position in close vicinity to possible summer pastures in the Appennine Mountain (cf. Fig. 1). Considering in particular, the economic value of their wool, herds likely grazed close to the settlement, but could potentially have used nearby mountain pastures. Considering the difficulties represented by the relatively homogenous bio-available strontium isotope of the entire Emilia-Romagna region¹¹¹, the strontium measured in local sheep teeth¹¹², cannot probably confirm, but certainly makes a case for, the idea that what could be the local environmental comparative advantage was potentially fully exploited by Montale's community.

In order to provide a frame of reference to discuss the nature and size of the local wool economy, it has been

¹⁰³ Accorsi *et al.* 2009; Mercuri *et al.* 2006.

¹⁰⁴ Accorsi *et al.* 2009, 67; Cardarelli *et al.* forthcoming.

¹⁰⁵ Sabatini *et al.* 2018a, 373.

¹⁰⁶ Cardarelli 2009c, Fig. 41.

¹⁰⁷ Sabatini *et al.* 2018a.

¹⁰⁸ Andersson Strand 2014; Andersson Strand/Nosch 2019; Bender Jørgensen 2018; Costin 2013.

¹⁰⁹ Breniquet/Michel 2014; Killen 1997; McCorriston 1997; Michel 2014; Michel/Nosch 2010; Nosch 2014, 2015.

¹¹⁰ Cf. Earle/Kristiansen 2010; Harding/Fokkens 2013.

¹¹¹ Cavazzuti *et al.* 2019.

¹¹² Sabatini *et al.* forthcoming.

Tab. 5: Hypothetical quantification of average wool production at Montale during the Recent Bronze Age 1 (calculations about time, fibre and labour consumption are based on Andersson Strand/Nosch 2019, Tab. 2,1)

Farming land at Montale (RB1)	Scenarios	Total available pasture (ha)	Number of sheep per ha	Sheep population size	Minimum Wool yield per year (at c. 300 g per animal)	Spinning 1 kg wool = 10.310 m (at 40m/h)	Approximate number of 1 × 2.5 m tabby weave that could be produced
1744 ha (= 2180 ha – 436 ha [20 %] of forested area)	A) Intense agriculture (c. 348 ha)	1396 + 174 of 'resting' agricultural land = 1570 ha	2	3140	942 kg (c. 628 kg of clean wool)	6 474 680 m of yarn at 161 867 hours (c. 20 233 working days at 8h/day = c. 55 years/persons per year)	628
			5	7850	2355 kg (c. 1570 kg of clean wool)	16 186 700 m of yarn at 404 667 hours (c. 50 583 working days at 8h/day = 138 years/persons per year)	1570
			7	10990	3297 kg (c. 2200 kg of clean wool)	22 682 000 m of yarn at 567 050 hours (c. 70 881 working days at 8h/day = 194 years/persons per year)	2200
	B) Sub-sistence agriculture (c. 130 ha)	1614 + 65 of 'resting' agricultural land = 1679 ha	2	3358	1007 (c. 671 kg of clean wool)	6 918 010 m of yarn at 172 950 hours (c. 21 618 working days at 8h/day = 59 years/persons per year)	671
			5	8395	kg 2518.5 (c. 1679 kg of clean wool)	17 310 490 m of yarn and 432 762 hours (c. 54 095 working days at 8h/day = 148 years/persons per year)	1679
			7	11753	3526 kg (c. 2350 kg of clean wool)	24 228 500 m of yarn at 605 712 hours (c. 75 714 working days at 8h/day = 207 years/persons per year)	2350

attempted to quantify the potential number of sheep managed by the site, and the wool yield that could be obtained each year. Data from the Bronze Age wool economies of the eastern Mediterranean as much as from modern guidelines for organic sheep farming show that husbandry practices are variable and dependent on both local regional environments and socio-political organizations of producing communities. Thus, the proposed quantifications have a strong hypothetical value.

The size of the local herds has been calculated using rather low stocking rates; however, even in the most unfavourable scenarios (see Tab. 3–5), Montale's surroundings could support a considerable number of sheep. In the same conservative scenarios, when applying the minimum

wool yield possible (according to relevant Aegean Bronze Age texts), the total wool yield per year would nonetheless reach beyond any reasonable local consumption. The more favourable scenarios, probably still below the local maximum livestock farming capacity, would suggest that most of the community could be fully employed crafting between 0.5 and over 2 tons of wool per year.

The exceptional abundance of spindle whorls recovered at Montale has led to propose a community of practice model to explain the characteristics of the local engagement in wool economy¹¹³. Given the lack of clear

113 Sabatini *et al.* 2018a; Sabatini 2019.

archaeological indicators for economic inequality, wool economy at the site is envisioned as a corporate investment where the whole community would participate in different ways. This model contrasts sharply with the state regulation known for the Aegean and Mesopotamian Bronze Age, suggesting a group-up line of economic development involving community specialization. Different from other Terramare villages of the Po plain, Montale and the settlements of Modena's *alta pianura* do not seem to radically change in size and structure with time¹¹⁴. Maybe organized corporate investments and successful economic management could be at the core of such apparent political stability? The question is for future studies.

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