IpoTESI di Preistoria

VOL. 14 | 2021 | PP.123-142

ISSN 1974-7985

https://doi.org/10.6092/ISSN.1974-7985/14334

*Il paesaggio agrario tra età del Rame ed età del Ferro.*
Metodi di analisi delle risorse di sussistenza e delle modalità di gestione per una stima demografica.
Workshop, Università di Bologna, 19 Novembre 2021

# THE SECONDARY PRODUCT REVOLUTION: A MODEL FOR THE UNDERSTANDING OF POPULATION DYNAMICS IN NORTHERN ITALY BETWEEN THE ENEOLITHIC AND THE BRONZE AGE.

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Rivoluzione dei Prodotti Secondari; Età del Rame; Età del Bronzo.

**KEY WORDS**
Secondary Products Revolution; Eneolithic; Bronze Age.

**RIASSUNTO**
La RPS appare nella letteratura scientifica agli inizi degli anni '80 del secolo scorso (SHERRATT 1981; Id 1983) e con essa Sherratt propone un modello teorico per analizzare i cambiamenti a livello economico, politico e sociale che si possono riscontrare tra la fine del Neolitico e l'inizio dell'età del Bronzo nel Vicino Oriente ed in Europa: il motore di questi cambiamenti viene individuato in un mutato approccio dell'uomo nei confronti dello sfruttamento della risorsa animale, non più allevata per essere fonte di prodotti primari (carne, pelle e ossa) a seguito della macellazione, ma tenuta in vita per fornire una serie di prodotti secondari (latte, lana, forza lavoro) che non comportano l'uccisione dell'animale. La forza del modello di Sherratt risiede infatti nel sottolineare che la serie di innovazioni da lui considerate nel modello della RPS "spread and interacted with each other so as to cause major economic changes" (SHERRATT 1981, p. 183).
Il cambio di scala sullo sfruttamento della risorsa animale ha come risultato una forte intensificazione della produzione agricola e parimenti della mobilità di merci e di genti: l'aratro a trazione animale rende sostenibile la lavorazione di una serie di terreni prima considerati troppo poveri e porta quindi ad un'espansione delle aree occupate e allo stesso tempo l'adozione del carro o delle bestie da soma rende possibile raggiungere aree prima impensabili e stabilire un sistema di scambi su lungo raggio per produzioni specializzate (lana, metallurgia...). Il più rapido ciclo di utilizzo delle aree agricole lascia poi sufficienti aree di maggese a disposizione di una pastorizia che acquista sempre maggiore importanza. Fenomeni che si erano cominciati a delineare millenni prima con la domesticazione di piante ed animali ma che solo ora subiscono un salto di magnitudo: ed è proprio questo che caratterizza la RPS. Non si tratta quindi di indagare i luoghi ed i tempi della prima attestazione di latte, lana, aratro, carri, ecc., bensì si deve provare a capire quanto l'insieme di questi fattori porti alla comparsa di quei fenomeni di deforestazione, espansione delle aree insediate, aumento delle aree coltivate e adibite a pascolo, incremento della popolazione che, in continua e costante relazione biunivoca le une con le altre hanno permesso il sorgere di quel sistema di produzione e scambio di prodotti che "*marked the birth of the kinds of society characteristic of modern Eurasia*" (SHERRATT 1983). Nonostante si sappia ora che lo sfruttamento del latte è di sicuro anteriore a quanto ipotizzato da Sherratt, è il formarsi di un "pacchetto di prodotti" che in questa sede si vuole porre al centro dell'attenzione. In quest'ottica quindi si concorda con l'idea di "*pensare all'età del Rame come a una sorta di "grande officina" ove avvenne la prima sperimentazione di quelle tecnologie e di quelle pratiche che nell'età del Bronzo furono poi perfezionate e impiegate con un salto di scala*" (RAPI 2013, p. 526).
In questo quadro metodologico si analizzeranno l'origine e la diffusione dei diversi "prodotti" in Europa ed in Italia e si cercherà poi di cogliere il momento in cui questi entrino a sistema.

**ABSTRACT**
The SPR appeared in the scientific literature at the beginning of the 1980s (SHERRATT 1981; Id 1983) when Sherratt proposed a theoretical model to analyse the economic, political and social changes that occurred between the end of the Neolithic and the beginning of the Bronze Age in the Near East and in Europe: the driving force behind these changes is identified in a changed human approach to the exploitation of the animal resource, no longer bred to be

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slaughtered as a source of primary products (meat, skin and bone), but kept alive to provide a range of secondary products (milk, wool, labour power) that do not involve killing the animal. The force of Sherratt's model lies in the fact that the series of innovations he considered in the SPR model "*spread and interacted with each other so as to cause major economic changes*" (SHERRATT 1981, p. 183).
The change of scale in the exploitation of the animal resource results in a strong intensification of agricultural production and likewise of the mobility of goods and people: the animal-drawn plough makes sustainable the working of a series of lands previously considered too poor and thus leads to an expansion of the occupied areas. At the same time the adoption of the cart makes it possible to reach areas which were previously unreachable and to establish a system of long-range trade for specialised productions (wool, metallurgy...). The more rapid cycle of utilisation of agricultural areas also left sufficient fallow land available for pastoralism, which was becoming increasingly important.
Phenomena that had begun to emerge in the earlier millennia with the domestication of plants and animals, only now underwent a leap in magnitude: and it is precisely this that characterises the SPR. It is therefore not a matter of investigating the places and times when milk, wool, ploughs, carts, etc. were first attested, rather of trying to understand how much the combination of these factors led to the appearance of those phenomena of deforestation, expansion of settled areas, increase in cultivated and grazed areas, increase in population that, in a continuous and constant biunivocal relationship with each other, allowed the rise of that system of production and exchange of products that "*marked the birth of the kinds of society characteristic of modern Eurasia*" (SHERRATT 1983). Although we now know that the exploitation of milk certainly predates Sherratt's hypothesis, it is the formation of a "package of products" that we wish to focus on here. From this point of view, therefore, we agree with the idea of "*big workshop, where the first experiments were carried out with those technologies and practices that were later perfected and used in the Bronze Age with a scale jump.*" (RAPI 2013, p. 526; English translation by the author). In this methodological framework, the origin and diffusion of the different "products" in Europe and Italy will be analysed, and an attempt will then be made to grasp the moment in which they became part of a system.

> "*Andrew Sherratt's seminal article on the 'secondary products revolution' is an interesting example of an archaeologist making a very important contribution yet being wrong. […] Sherratt, despite getting the context and dating wrong, was right to point to the significant impacts of these 'secondary products'.* ***From the second millenium BC onwards****, the essential role of production and trade in wool, yarn and woollen textiles runs as a common thread through what one may call 'the history of European civilisation'.*" (KRISTIANSEN, SØRENSEN 2020, p. 317; boldface by the author)

## INTRODUCTION

This is how the two Scandinavian scholars begin their concluding contribution to the very recent volume dedicated by Serena Sabatini and Sophie Bergerbrant to the "Textile revolution": in their opinion, what makes the theory of the Secondary Product Revolution (SPR from now on) still a useful model for research, despite the fact that analyses of lipid residues in the ceramics of many Neolithic cultures have shown, for example, that milk exploitation certainly predates Sherratt's hypothesis, is the fact that the formation of a product package has been recognised and its strong impact emphasised.
The aim of this paper is to suggest that the development of the population that the archaeological record gives us for the Po Valley at the beginning of the 2nd millenium BC might have benefited from such a product package and that the settlement dynamics themselves might correspond quite closely to what Sherratt hypothesised as a consequence of the SPR almost 40 years ago.
The theoretical framework of Sherratt's model and some of the misunderstandings it has suffered from will be outlined, the different items of the product package will be discussed, the chronological dating of an SPR in northern Italy will be considered, and finally an attempt will be made to identify those classes of materials in the archaeological record that can be used to verify the various hypotheses.

## THE THEORETICAL FRAMEWORK

SPR appeared in the scientific literature at the beginning of the 1980s (SHERRATT 1981; ID 1983): by it Sherratt proposes a theoretical model for the analysis of economic, political and social changes between the end of the Neolithic and the beginning of the Bronze Age in the Near East and in Europe. The engine of these changes is identified in a modified

approach of man towards the exploitation of the animal resource, no longer bred to be a source of primary products (meat, skin and bones) after the slaughter, but kept alive to provide a series of secondary products (milk, wool, labour power) that do not involve the killing of the animal and can be obtained in a repetitive manner for a certain period of time, at the end of which however it is still possible to make use of the primary products of the animals used.
If one considers that the labour force could be interpreted both as an aid in agricultural work (plough) and as a means of transport even over long distances (convoys of beasts of burden, caravans and wagons), one can easily imagine the repercussions, not only economic, of what cannot be reduced to a mere food strategy (Fig. 1).

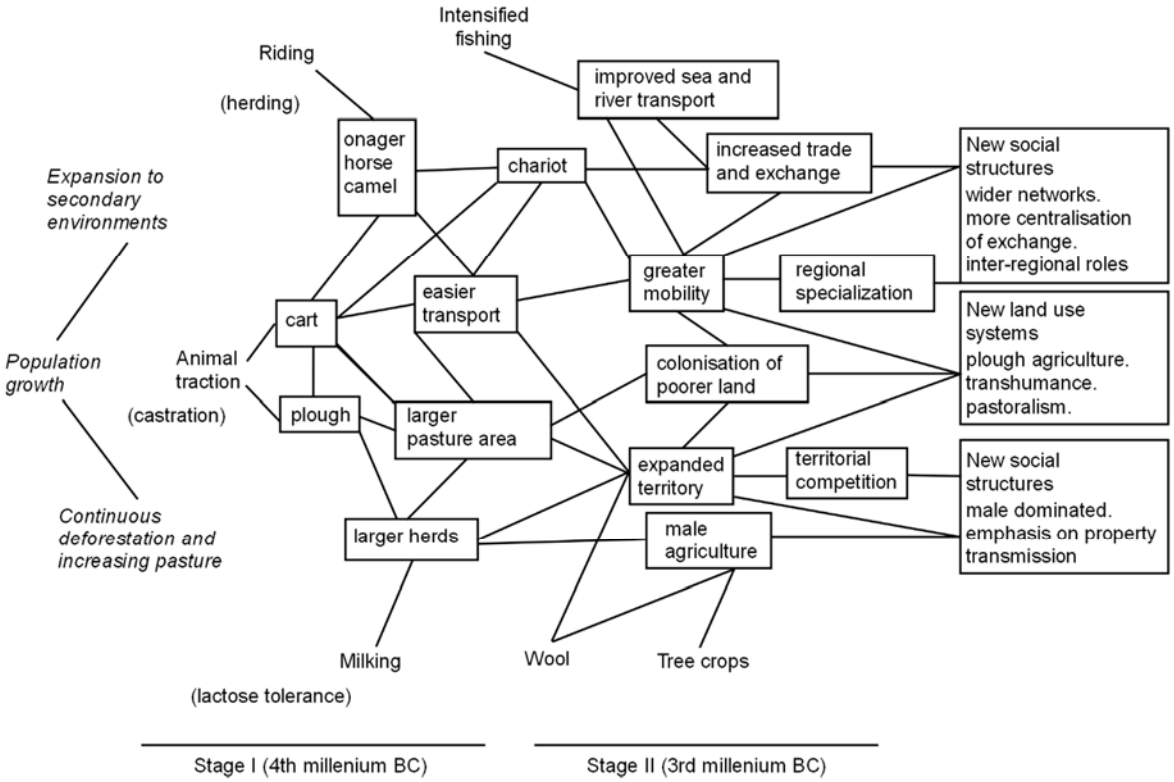


Fig. 1. The first logical model of the different interaction between the components of the secondary products complex (from SHERRATT 1981, p. 185, fig. 6.16).

The strength of Sherratt's paradigm lies in the fact that the series of innovations he considers in the SPR model "*spread and interacted with each other so as to cause major economic changes*" (SHERRATT 1981, p. 183). What makes the SPR a theoretical reference model for the evaluation of the socio-economic dynamics of populations scattered over a vast and diversified territory is precisely the fact that the interaction of the various factors involved has similar effects.
While acknowledging that, because of the extent of the area under consideration, there are some regions where this circulation and interaction of elements occurs earlier than in others[2], Sherratt points out that, for example, by focusing the attention on Central and Eastern Europe, it can be seen that these phenomena occurred in different territories within the same time span (SHERRATT 1981, p. 159; pp. 168-169, fig. 6.9) and he writes clearly that "*these developments were not accidentally coincident*" (SHERRATT 1981, p. 184).
The fact that in Mesopotamia this system began in a region split between different State entities, while in Europe the people were at most organised into chiefdoms, does not change the significance of the phenomenon (in this, in my opinion, lies the value of the SPR as a paradigm): in both macro-regions we can observe a drastic increase in population growth and simultaneously in territorial expansion, phenomena that had begun to emerge millennia earlier with the domestication of plants and animals, but which only now underwent a dramatic change in the scale.
In my opinion, the essence of the SPR lies precisely in this scale jump: although some scholars have pointed out that Sherratt avoided explicitly expressing his opinion on whether he wanted to consider the first use of secondary products or refer to a change in their importance in Near Eastern and European societies (GREENFIELD 2010, p. 33; SHIPMAN 2014, p. 41), I believe that what Sherratt himself wrote about the SPR as a phenomenon that "*marked the birth of kinds of societies characteristic of modern Eurasia*" (SHERRATT 1981, p. 161), cannot refer to other than their implementation into the system.

[2] Mesopotamia is presented as one of the areas in which this phenomenon occurs earlier than in other regions of Europe (SHERRATT 1983, pp. 98-100).

"*The essence of what Sherratt was trying to weave together in his Secondary Products Revolution model was that, while all these individual strands are important and significant (and early occurrences thus worth identifying), the real impact on cultures comes with the application of these innovations on a large scale at the same time*" (Greenfield 2010, p. 47).
The natural consequence of such an interpretation is that the SPR cannot be dated unambiguously, but may fluctuate in the different regions observed, depending on the diversified interaction between the elements involved.

## The products

Recalling Sherratt's words quoted above, in order to test the hypothesis of whether the SPR may underlie the settlement development recorded in northern Italy between the Eneolithic and Bronze Age, one will first trace the earliest occurrences of the different elements of the system and then look for evidence to identify when in late prehistory these "major economic changes" interacted in the Po Valley.

## Animal traction. A premise

In a paper recently published in Antiquity (Gaastra, Greenfield, Vander Linden 2018) the concept of "light traction" is defined, i.e. the use of cattle (of both sexes) for a non-exclusive but far from occasional motive activity, as would be demonstrated by the study of bone remains related to the legs of 12 bovines from 11 sites covering the entire Neolithic of the central-western Balkans (6100/6000-4500 cal BC) and showing signs of sub-pathological alterations (with alterations definable between 1 and 3 on the value scale of the system developed by Bartosiewicz *et alii* 1997). Although I personally have to remark that the statistical sample appears to be quite weak, the authors point out that what they define as "light traction" can be seen as the first evidence of the exploitation of cattle for traction activity, which will then become much more intense from the 4th millennium BC onwards with the plough and the cart.

## Animal traction. The plough

The oldest plough marks come from Susa A and date back to the first half of the 5th millennium BC (end of the Ubaid Culture). They appear in various areas of Europe characterised by the Funnel Beaker Culture (TRB from 4000 to 2700 cal BC) from the 4th millennium BC (Milisauskas, Kruk 2011b, p. 236-237 and related bibliography) and in many cases owe their preservation to the fact that they were subsequently buried by burial mounds. In Italy, too, at the megalithic site of Saint Martin de Corléans, ploughing have been found (between the end of the 5th and the beginning of the 4th millennium BC), some of them underneath some funerary platforms (Ferroni *et alii* 2018, p. 165). The coincidence between early ploughing and funerary monuments has led some scholars to hypothesise that these had a ritual or religious value (Rowley-Conwy 1987, p. 265; Thrane 1989, p. 116; Sherratt 1996), but it has to be said that, when Andersen (1993) analysed some of these soils buried by mounds, he found pollen spectra showing that these were soils cultivated with cereals before the funerary monument was erected.
Bogucki (1993) argues that from the middle of the 4th millennium BC in temperate Europe, with the emergence of animal traction (or, if considering the above, with the transition from a light traction to an exclusive activity of selected classes of cattle) male cattle become valuable even after the age of 4 years, which is the time threshold for reaching maximum meat yield. Together with the identification of pathological or sub-pathological stress modifications in cattle limb bones, a high presence of males over 4 years old in a herd could therefore be considered as an indicator of traction use.
Virtually at the same time as the first evidence of plough marks, there are also the earliest depictions of ploughs in some pictograms on 4th millennium BC Mesopotamian tablets from Uruk and Susa (Fig. 2).
Depictions of ploughs with "handlebar apertures" are also frequent on Akkadian seals from the second half of the III millenium BC (Sherratt 1981, p. 165, fig. 6.5), coinciding with the first depictions from Egypt.
Depictions of single-handled ploughs have been found from Valcamonica (Fedele 2012, pp. 58-62) and Monte Bego (De Lumley 1996, pp. 111-133). While some images in Valcamonica can be dated to the Eneolithic (Borno 1, Ossimo 8, Cemmo Boulder 2 and Ceresolo 2 to Copper Age 2[3], Ossimo 7 and Cemmo Boulder 1 to Copper Age 3), it is not possible to discriminate between the Eneolithic and the Early Bronze Age for the engravings on Monte Bego. Around the two Cemmo boulders the area seems to be delimited by three parallel curvilinear plough marks (Poggiani Keller 2006a, p. 257). Furthermore, at Canton (Trescore Balneario, Lombardy), two groups of plough marks were found associated with the setting up of two funerary-cultural monuments: a VBQ[4] mound and a Eneolithic platform (Poggiani Keller 2006b, pp. 181-182). Numerous traces of ploughing from two sites in the province of Forlì-Cesena, Provezza and Pievesestina, date to a period between the full Eneolithic and the beginning of the Bronze Age (2600-2200 cal BC) (Gasparini,

[3] The Copper Age in Northern Italy can be divided into: Copper Age 1 or I (3400 – 2900/2800 cal BC), Copper Age 2 or II (2900/2800 – 2400 cal BC) and Copper Age 3 or III (coincident with the Bell Beaker Culture thus, in the study area, 2500 – 2200 cal BC).
[4] VBQ stands for "Vasi a Bocca Quadrata" Square Mouth Vessels, a Neolithic Culture spread in Northern Italy between 5000 and 4000/3800 cal BC.

Milantoni 2020, p. 852-855). Finally, traces of ploughing dating to the Early Bronze Age have been found from two sites in Campania: Acerra (Langella 2003, p. 953) and Gricignano (Fugazzola Delpino, Salerno, Tinè 2007). The ploughs of European origin are of the 'Triptolemus' type and consist of a working body (the stump), which cuts into the ground and makes the drill, a short shaft mounted on the stump (the handle), which allows the plough to be guided, and a very long oblique shaft which starts from the stump and is hooked at the opposite end to the oxen by means of the yoke. The two oldest ploughs from the European continent date back to the Early Bronze Age and come from the pile-dwelling village of Lavagnone (Perini 1982) and from Walle, in Friesland (Jacob-Friesen 1934).

Fig. 2. Pictograms in Mesopotamian tablets about plough and ploughing: above from Uruk, below from Susa (from Sherratt 1981, p. 164, fig. 6.4).

The former has been dated to 2048-2010 cal BC (De Marinis 2000, pp. 195-195), while the second to 1870-1615 cal BC (Geyh, Rasmussen 1998, p. 115). There is no doubt that the gap between the first evidence of ploughing and the dating of the first ploughs must be explained by the very difficult preservation of wooden artefacts: in addition to the two ploughs already mentioned, practically all the other ploughs found in Europe come from wet environments: the pile dwellings at Lake Ledro (Battaglia 1943) and Fiavè (Perini 1987), the Noceto basin (Castiglioni *et alii* 2009, pp. 226-227), Vebbestrup and Hvorslev in Jutland (Glob 1951), Polessje, Tokari and Sergeiev in Ukraine (Shramko 1964; Id 1971).
From ethnographic data it can finally be assumed that, together with the plough, there must have been other wooden tools used to break up clods of earth, such as sticks and shovels. These were not represented in texts, in oriental art or in Eneolithic rock engravings, and only faint traces of them have survived in fragmentary objects from wetland sites (Harding 2000, pp. 124-126).

## Animal traction. The wagon

Direct or indirect evidences of wheeled vehicles can be found from the middle of the 4th millennium BC onwards from a wide area including different regions of Europe and Asia. In a recently published work, nine categories of evidence for wheeled vehicles are grouped together:

- wagon models[5],
- animal figurines with the representation of the harnessing mode,
- depictions/pictograms of wagons,
- clay wheels,
- wooden wheels,
- cart tracks, trackway remains,
- travois,
- wooden axles,
- wagon burials.

[5] Bondár 2018, p. 283 and pp. 285-292, tab. 1 and related bibliography.

As we have already seen for ploughs, pictographs are among the oldest evidence, but for wagons there is also a rich iconographic repertoire from the same period consisting of clay models and cattle figurines, some of which are also made of copper, such as the figurine from the Lisková Cave in Slovakia (Struhár 1999, tab. 2. 10; Bondár 2012, p. 50, fig. 17.7) and the pair from Bytyn in Poland (Šturms 1955, Abb. 1. 4; Bondár 2012, p. 50, fig. 17.8), underlining the value of such representations. As mentioned above for ploughs, the preservation of wood in archaeological deposits requires special conditions, and it is still wetland sites and peat bogs that have provided wheels: these are solid ones, consisting of wooden planks fixed by crosspieces, and the oldest date from the fourth quarter of the 4th millennium BC[6].

One of these wheels comes from a pile-dwelling in the Ljubljana marsh (Stare Gmajne) dated to the end of the 4th millennium BC: from the same level of occupation where the wheel was found, a complete wagon axle was also found (Velušček 2006, pp. 41-42). Another wheel from the end of the 4th millennium BC was found on a timber trackway, a road built of logs placed perpendicular to the direction of travel. In wet settlements this type of solution is by no means surprising, but it is certain that with the rapid spread of wagon transport from the middle of the 4th millennium BC onwards this type of infrastructural construction became very important. One similar road, 31 Pr, dating from the second quarter of the 5th millennium BC, has been excavated near Campemoor in Lower Saxony (Bauerochse, Metzler 2001, pp. 113-120) testifying that these roads should not be considered as necessarily related to the use of carts, but anticipated wheeled transport by several centuries. Wagon tracks have been recognised at the Flintbek funerary monument in Germany (TRB) and have been dated, based on stratigraphic relationships with structures that have been 14C sampled, to 3423-3390 cal BC (Mischka 2011, tab. 3.2): the distance between the two grooves (between 1.10 and 1.20 m) corresponds to the measurements of the axis found at Stare Gmajne.

Moving on to the Italian peninsula, at the foot of a hill between the Berici Hills and the Eastern Monti Lessini in the municipality of Brendola (Vicenza), the discovery of a section of structured road with gullies on the sides and several packed floors, the oldest of which is dated to the Recent Neolithic (VBQ III, 4500 - 4000/3800 cal BC), should be noted (De Guio, Cattaneo 1997). Like the timber trackway 31 Pr at Campemoor, this find demonstrates, if proof were needed, how structured routes existed well before the appearance of wheeled wagons[7]. On the lower left corner of Boulder 2 from Cemmo in Valcamonica (Fedele 2012, p. 59, fig. 2) a very significant scene can be observed: two yoke couplings are represented, each with a pair of horn-bearing animals attached, the difference between the two scenes being what is attached to the yoke, i.e. a four-wheeled cart at the top and a plough at the bottom. Boulder 2 from Cemmo is dated by Fedele to Copper Age 2 and thus the earliest depictions of chariots from the Italian peninsula would be contemporary with those representing the use of the animal-drawn plough (Fig. 3).

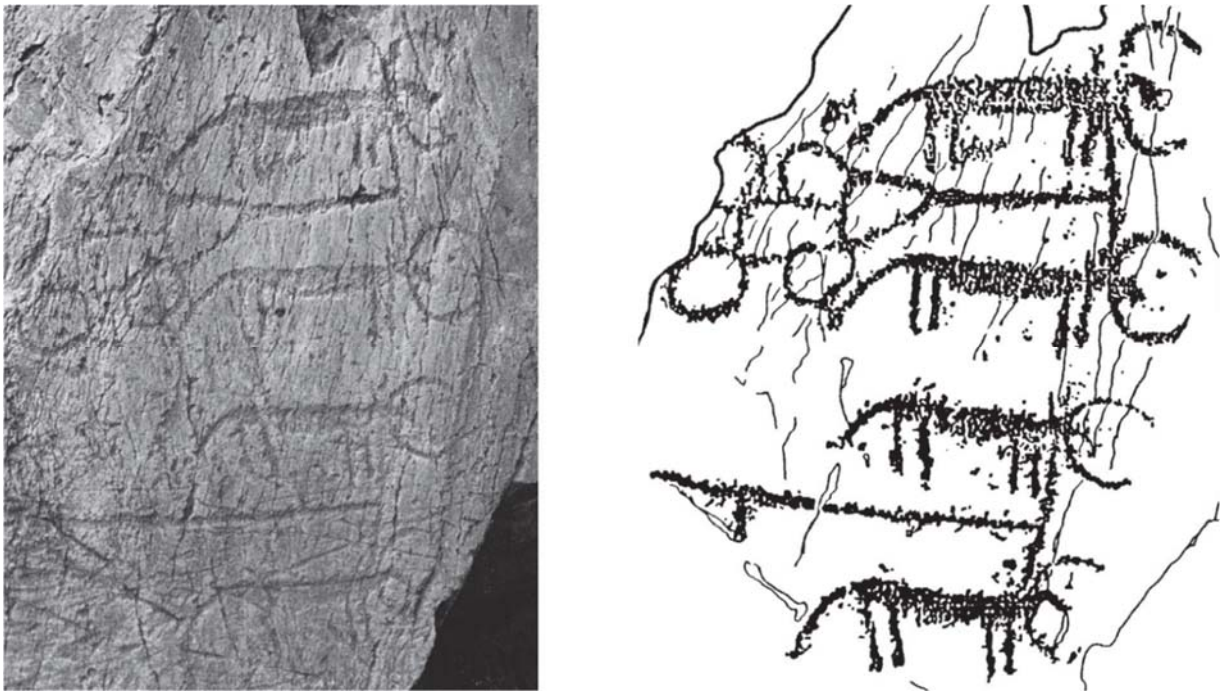

Fig. 3. Boulder 2 of Cemmo with the depiction of two pairs of cattle harnessed to a wagon (above) and a plough (below) (modified from Fedele 2012, p. 59, fig. 2).

[6] For a review of the chronologies of the 4th and 3rd millennium wooden wheels see Mischka 2011, tab. 3.

[7] A timber trackway dated to 4840-4710 BC cal 1 sigma was excavated by Daria Banchieri along the north shore of Isolino Virginia (Varese Lake, Lombardy: Cermesoni, pers. com.).

From an area adjacent to the site of the Varna-Circonvallazione cult site comes a dense pattern of traces interpreted mostly as ploughing or weeding marks and, in a couple of cases, as wagon tracks (Tecchiati 2014, pp. 103-104).
The stratigraphic relationship with the structures of the cult site, dated between 3650 and 3370 cal a 2 σ B.C., suggests at least the contemporaneity of this portion of the relict landscape, if not its anteriority, thus placing these traces between the end of the Neolithic and the beginning of the Eneolithic. Traces of ploughing also come from the Copper Age 3 cult area of Velturno (BZ), in the proximity of which rows of stones interpreted as part of a ceremonial road were later brought to light (Tecchiati 2013, p. 471).
Wagon tracks on a road preserved for a stretch of 16 m can be recognised in the Bell Beaker phase of the village of Canton (Trescore Balneario, Lombardy) where it runs NW-SE along a terrace at the edge of the hillside: the road, which runs straight, has a constant width of 1.60 to 1.70 m and has on its sides two 0.20 to 0.30 m wide gullies, with a semicircular section, which must have housed a system of posts for the containment of the gravel and small pebble embankment which in some fragments is still preserved (Poggiani Keller, Baioni 2014, p. 268). The tracks, visible on the surface of one of the road sectors, are compatible with the passage of a four-wheeled wagon such as those represented by the rock engravings.
Several evidences from Campania have been recently brought to light at Gricignano di Aversa U.S. Navy, Afragola, Acerra/Spiniello, Circumvesuviana Railways Lots C1 and C2, T.A.V. V/10 and V/11, Ottaviano Raggi, Palma Campania/Tirone, San Paolo Belsito/Montesano and Nola/Sarnella (Saccoccio, Marzocchella, Vanzetti 2021, pp. 244-248 and related bibliography) on horizons below the eruption of the Pomici di Avellino: these are windows onto the agrarian landscape of the Early Bronze Age (2200 – 1650 cal BC) Campanian plain with rich traces of fossil fields and, in many of the sites listed above, wagon tracks.
From the pile-dwelling of Lavagnone (BS) a timber trackway from the beginning of phase 2 (EBA IA, 2200 – 1985 cal BC[8]) and in use at least until the end of phase 3 (EBA IB, 1985 - 1900 cal BC[9]) has been excavated (De Marinis *et alii* 2015, p. 223).
To complete the overview of archaeological evidence for the use of wagons from the Italian peninsula, we must mention the wooden wheels[10]: a solid disc wheel from the basal layers of the terramara of Castione dei Marchesi dated to the Middle Bronze Age[11] (Mutti *et alii* 1988, p. 214), fragments of two wheels similar to the one from Castione dei Marchesi from Lagozzetta di Besnate and Isolone del Mincio (Cornaggia Castiglioni 1978), four wheels from Mercurago dated between Middle Bronze Age and Recent Bronze Age[12] (Gambari 1992, p. 324).

## Transport. Equids

A further human-animal interaction that Sherratt assigns to the 4th millennium BC is the domestication of "four of five species of animals which, although hunted in earlier periods, had not been economical to domesticate" (Sherratt 1981, p. 170): these animals, the equids (horse, onager and donkey) and the camelids (camel and dromedary), could be either mounted and provided a means of transport over long distances or used to carry objects directly on their backs. Given the geographical focus of this work on northern Italy, only equids will be discussed below.
A premise that must be made before analysing this issue is related to the difficulty encountered in the determination of the species on the basis of morphological elements of the skull and dental enamel (Hanot, Bochaton 2018, pp. 12-13). Certainly, the problem of recognition of different species does not exist in terms of DNA analysis, but it must be borne in mind that for all studies prior to the archaeological and archaeozoological application of this methodology, the entry of equids in faunal counts conceals this degree of indeterminacy. A second aspect of uncertainty when it comes to horses is the possibility of distinguishing between wild and domesticated horses: Bendrey (2012, pp. 135-136) notes that "*During the Late Pleistocene, wild horses (Equus ferus) were common across Europe, only to wane in numbers in the earlier Holocene, perhaps disappearing entirely from some areas. By the Bronze Age, domestic horses (Equus caballus) were in use throughout Europe. [...] This transition is still poorly understood*".
A first indication of this transition could be considered the evidence of the use of the bit on some horse teeth and the simultaneous presence of lipids from mare's milk in some ceramic fragments of the Eneolithic culture of Botai (Kazakhstan): the archaeological association of the two different evidences is dated to the middle of the 4th millennium BC (Outram *et alii* 2009). Milisauskas and Kruk (2011, pp. 235-236) provide a summary (with extensive bibliography) of the various hypotheses about the locations and dates of this transition, but what is clear is that although, for example, horse faunas from the Bronocice site in Poland (2900-2700 BC) certainly pertain to domestic

[8] See De Marinis 1999, p. 33, fig. 8.
[9] See De Marinis 1999, p. 33, fig. 8.
[10] All the examples come from wet sites in Northern Italy
[11] After Bernabò Brea, Cardarelli, Cremaschi 2018, the Terramare Culture Middle Bronze Age covers a period between 1650 and 1325/1300 cal BC.
[12] After Del Lucchese *et alii* cds, in North-western Italy the Middle Bronze Age covers a period between 1650/1625 and 1325/1300 cal BC and the Recent Bronze Age a period between 1325/1300 and 1175/1150.

horses (Milisauskas, Kruk, Makowicz-Poliszot 2006), in general "*the frequencies of horse remains are low in central and western Europe prior to the Bronze Age*" (Milisauskas, Kruk 2011a, p. 236).
Representations of horses pulling chariots or being ridden are dated to the 2nd millennium BC from various parts of Europe: from shaft graves Circle A at Mycenae come three funerary stelae with representations of horses pulling chariots (c. 1600 BC) (Fig. 4) while a figurine of a horseman dates from a few centuries later (c. 1300 BC). From Scandinavia come the famous sun chariot from Trundholm (c. 1450 BC) and a depiction of a chariot from the Kivik cairn in Sweden (c. 1500-1300 BC) (Kristiansen, Larsson 2005, pp. 186-193 and 294-296), and the examples of horse depictions in Spanish rock art date back to the 2nd millennium BC (Arbogast *et alii* 2002, p. 21).

Fig. 4. A horse carrying a chariot on a Funerary stele found on Grave Circle A, Mycenae (Archaeological Museum, Athens).

The horse appears in the archaeological record of the Italian peninsula at the site of Le Quercete - Fianello in Maccarese (Latium), with the discovery in a pit of an almost complete specimen of *Equus caballus* and two dogs (Curci, Tagliacozzo 1994, p. 299). The bones were found chaotically scattered within the pit, although some anatomical connections could be observed, such as those between the long bones of three limbs, one of some vertebrae and one of some ribs. The absence of complete bone districts (e.g. the fourth limb or the skull) in a pit that was sealed by a layer of sterile clay, and the simultaneous presence of two dogs, suggest a ritual deposition. Le Quercete is dated to the early Eneolithic, and in particular to phase C of Conelle di Arcevia, dated between 3250 and 2890 cal BC, while the horse bones recovered from the village of Querciola near Sesto Fiorentino (Tuscany) date to the late Eneolithic (Corridi 1997).
Few remains from Sonnenburg (Riedel 1984), Barche di Solferino (Riedel 1976) and the EBA 2 phases of Lavagnone (1800 – 1600 cal BC[13]) can be dated to the Early Bronze Age (De Grossi Mazzorin, Solinas 2013), while the discovery of horse bones become far from exceptional from the Middle Bronze Age onwards, both north and south of the Po (respectively De Grossi Mazzorin 2013a and De Grossi Mazzorin 2013b and related bibliographical references). In a paper on the faunal remains from sectors A and E of the Lavagnone pile-dwelling it is remarked that "*although there are sporadic reports of the presence of this quadruped in Italy since the final phases of the Eneolithic, it would seem, from the greater number of evidences, that the real "cultural acquisition" of horse breeding by Italic communities should be placed in the early phases of the Middle Bronze Age*" (De Grossi Mazzorin, Solinas 2013; English translation by the author). Tecchiati (Gambari, Tecchiati 2004, p. 234) points out that the exponential increase in evidence from the Po Valley in the early Middle Bronze Age probably benefited from an environment favourable to the breeding of this species.

## Milk

The recent development of lipid analyses in ceramics has proven that milking is a regular activity since at least the Neolithic period (Charlton *et alii* 2019, p. 6184; Copley *et alii* 2003, pp. 1527-1529; Copley *et alii* 2005a; Copley *et alii* 2005b; Craig *et alii* 2005; Salque *et alii* 2012; Salque *et alii* 2013; Cramp *et alii* 2014a; Cramp *et alii* 2014b; Smyth, Evershed 2015). The first evidences from Europe date from the early 6th millennium BC from Hungary (Greenfield 2010, p. 34)

[13] See De Marinis 1999, p. 33, fig. 8.

and from the middle of the 6th millennium BC from Pokrovnik in northern Dalmatia (McLure *et alii* 2018) and Mala Triglavca in Slovenia (Šoberl *et alii* 2014, pp. 151-152), close to the Italian border: it is not possible however to define the role of milk consumption in the human diet at this early stage.
From some caves in the Karst near Trieste come 14 clay spoons (several of which from levels containing Vlaška material consistent with that from Mala Triglavca and therefore from the Early Neolithic) that have shown traces of protein derived from goat's milk (Montagnari Kokelj *et alii* 2012, p. 35-37). Archaeozoological analyses of kill-off patterns (Legge 2005; Mulville *et alii* 2005; Vigne 2008; Greenfield, Arnold 2015) also indicate that ruminant milk has started to be consumed shortly after domestication. According to a model proposed by Payne (Payne 1973) the management of goat and sheep flocks varies according to the final use of the animal resource (meat, milk or wool). Payne proposes three models of culling profiles depending on whether the flock is intended to produce meat (Model A), milk (Model B) or wool (Model C): in the first case most animals are culled between 18 and 30 months, when the animal reaches maximum body yield, in the second case all lambs that do not contribute to maintaining a constant number of animals in the flock are culled and in the third case most animals are kept alive until at least 6 years of age. Payne's undeniable contribution has been to propose a key for the interpretation of what are undoubtedly reflections of economic choices in the archaeozoological record, but subsequent literature has highlighted the theoretical nature of schemes in which only one of the three resources is the objective of breeding and the need to subject this type of data to statistical analysis (Greenfield 1988; Id 2005; Halstead 1998; Munson 2000; Helmer, Gourichon, Vila 2007; Vigne, Helmer 2007; Greenfield, Arnold 2014; Gerbault *et alii* 2016).
The recent discovery (Warinner *et alii* 2014) of the milk protein β-lactoglobulin (BLG) in the dental tartar of ancient human samples potentially opens the way to a new means of investigating the origins of human consumption of ruminant milk and dairy products: BLG is in fact not contained in human milk and therefore its presence in dental tartar can only be explained through diet, furthermore the amino acid sequence of BLG differs between different species and can be used as a species-specific indicator (Charlton *et alii* 2019, p. 6185). At the moment, this approach is not yet widely used and, with the exception of a single individual, buried near Stonehenge, dated to 3245-3110 (cal. 2 σ) and thus ascribable to the Neolithic period (Mays *et alii* 2018, p. 699), the oldest group of individuals in which BLG has been detected date to the Bronze Age (Warinner *et alii* 2014, p. 4). Greenfield and Arnold (2015, p. 794) interpret this fact as evidence of a considerable intensification in dairy production during the Bronze Age.
In terms of material culture, the archaeological record includes ceramic objects and potsherds with numerous small holes ("vasi cribrati" in Italian) that in literature are commonly associated with milk processing (kettle lids, strainers, milk savers, etc., Di Fraia 2021). Although the oldest fragments found in Italy date from the Neolithic period, most of these materials are from the Bronze Age: an analytical study of lipid traces in these ceramic classes from northern Italian contexts is, however, lacking. By the way, it should be noted that when these analyses were carried out it was noted that the link with dairy production was not always exclusive, and in some cases it was possible to exclude any connection with milk processing (Salque *et alii* 2012, p. 58). Finally, a recent study on traces of ruminant lipids from Neolithic pottery from sites on the Atlantic coast of northern Europe shows that the presence of lipids from dairy products increases with a latitudinal gradient in a north-west direction (Cubas *et alii* 2020).

## Wool

The oldest Eurasian textile fragments date back to the 7th/6th millennium BC and were made of plant fibres (Sabatini, Bergenbrant 2020b, p. 2 and bibliography), but it is not until the last centuries of the 3rd millennium BC that the first fragments of woollen fabric can be found. Although the Ötzi find clearly shows that goat and sheep skins were used at least as early as the end of the Neolithic (Fleckinger, Putzer, Zink 2013, pp. 237-239), there is no evidence of wool production in Neolithic Central and Western Europe.
Two sites that could provide an early example of wool yarn production as early as the 4th millennium BC are a kurgan of the Majkop culture, which flourished in the North Caucasus (in the south-western corner of present-day Russia) between 3700 and 3200 cal BC (Trifonov 2000), and a settlement of TRB in Bronocice (present-day Poland), which can be dated to between 3650 and 3100 cal BC. From Kurgan 2 in Novosvobodnaya comes a fragment (N1) of woollen fabric (Shishlina, Orfinskaya, Golikov 2003, pp. 333-334) (Fig. 5), while for the village of Bronocice, although no woollen textile fragment is found, a transition to wool production around 3650 cal BC is assumed, based on a number of concomitant factors such as kill-off patterns, isotopic analyses indicating an increasing number of sheep from outside the village micro-region, a greater production of plant fibre textiles, and an upscaling in the production of spindle whorls and loom weights (Pipes, Kruk, Milisauskas 2014, p. 98).
The production of woollen textiles was certainly an economic activity of great importance in the ancient world, and it is not surprising that its earliest evidence comes from Mesopotamian texts from the 4th millennium BC (Barber 1991; for the following millennium, see also Kawami 2014).

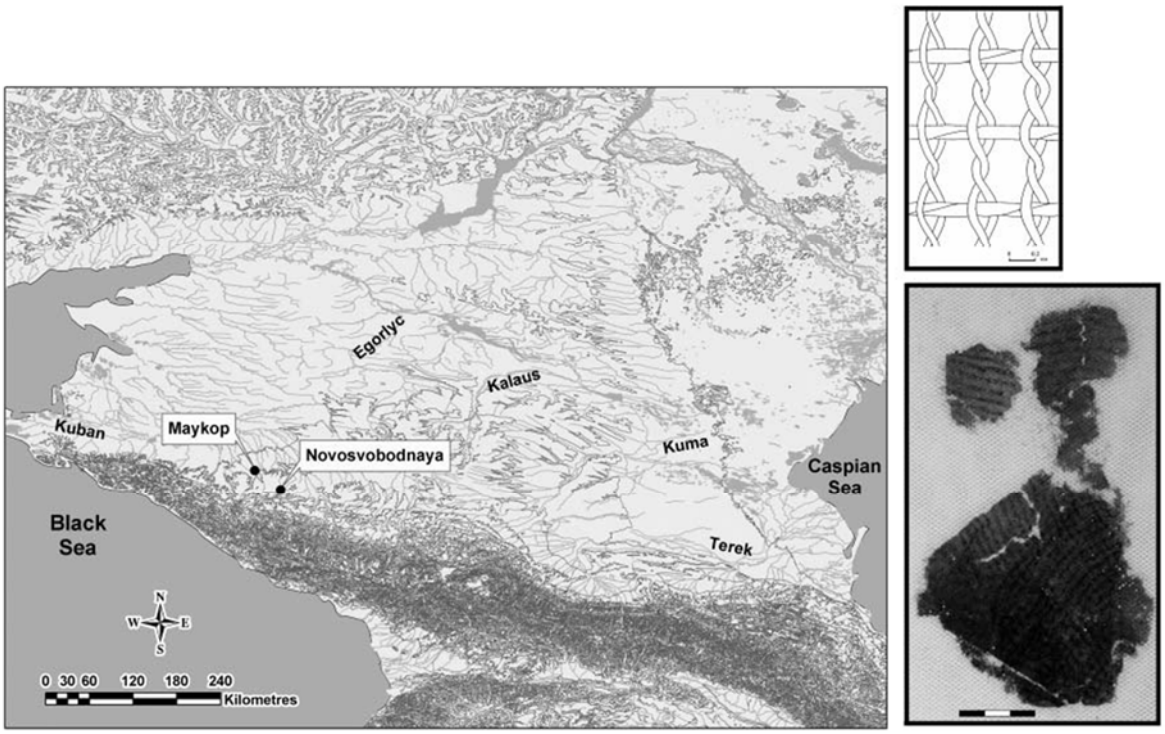


Fig. 5. Left: Novosvobodnaya; bottom right: wool fragment N1; top right: weaving diagram of N1 (modified from Shishlina, Orfinskaya, Golikov 2003, pp. 333-334).

An even greater quantity of texts provides us with invaluable information on the breeding strategies and yields of flocks and individual animals in the state economies of the 3rd millennium BC Near East and the Aegean palatial economies of the 2nd millennium BC (Breniquet, Michel 2014 and bibliography). Considering the fact that only a few fabric fragments from these regions have survived, mostly all of which are plant fibres (Skals *et alii* 2015), we should be aware of the distortions in our knowledge base caused by the difficulty of preserving textiles in general and wool textiles in particular. The oldest fragment of wool fibre from the European continent, which has been preserved carbonized, comes from the perilacustrine settlement of Clairvaux-les-Lacs in Switzerland and has been dated to between 3000 and 2900 cal BC (Schibler 2004). It is no coincidence that the most significant *corpora* of woollen fabric fragments come from two "special" environmental contexts such as the Danish peat bogs (Mannering, Gleba, Bloch Hansen 2012, pp. 97-102) or the Austrian salt mines (Grömer 2012, pp. 30-42). A number of incredibly well-preserved Bronze Age burials come from Denmark: in wooden coffins made from a carved half-trunk (usually oak), the bodies of the deceased, dressed in woollen cloth and animal skins, have been preserved in exceptional condition by being quickly buried in peat. A second group of textiles (111 fragments almost all of wool of various sizes corresponding to at least 58 distinct artefacts (Grömer 2012, p. 30)) comes from the Austrian Hallstatt salt mine, where the bactericidal properties of salt and an anaerobic environment with a constant climate have not only preserved the colour of many of the fragments found but also their elasticity. The Hallstatt textiles date from the transition period between the Early and Middle Bronze Age (in Austria around 1600 cal BC).

From the Italian peninsula, is worth mentioning a linen belt from the Polada Culture pile-dwelling of Molina di Ledro (Trentino), in which a wool thread was used to sew a buttonhole and a fringe: the find would date back to the early phases of the Early Bronze Age (Bazzanella, Mayr 2009). The oldest fragment of fabric made entirely of wool fibres from Italy is, however, several centuries later and comes from the nineteenth-century excavations of the terramara in Castione de' Marchesi (Bazzanella 2012, p. 209). The fragment has been found in relatively basal layers and can therefore be dated to the first phases of occupation of the site, around the middle of the 2nd millennium BC, at the same time as the extraordinary Danish discoveries and the textiles found in the Hallstatt salt mines.

Weaving can be detected in the material culture through a series of objects (mainly spindle whorls, loom weights and needles) related to the different phases of processing: the difficult question is whether they were used for the production of textiles from plant or animal fibres. Grömer's observation that, at least for Central Europe, terracotta spindle whorls would have been widespread from the Bronze Age onwards (Grömer 2012, p. 41) is very interesting for the analysis of the archaeological record of ancient wool production: these, usually smaller and lighter and with a "*completely different appearance*" from Neolithic spindle whorls (Grömer 2006), would be directly linked to the spread of finer yarns such as those of animal origin (wool). Bazzanella even more explicitly says that "*wool makes its appearence during the Bronze Age, accompanied by a progressive reduction in dimensions and weight of the spindle*

*whorls*" (Bazzanella 2012, p. 211). It should be stressed, however, that the trend towards a reduction in weight and size of spindle whorls is not an absolute phenomenon: Neolithic spindle whorls in Greece, for example, are smaller than those from Early Bronze Age I and II (Anderson Strand, Nosch 2020, p. 28).
A second class of objects related to spinning, very frequent also in Italian sites, is the loom weights: often the discovery of these objects in neat rows within houses has allowed us to hypothesise the dimensions and also the type of loom used (Bazzanella 2012, p. 211 and related bibliography; Sabatini 2020a, pp. 59-65 and related bibliography), but there seems to be no evidence to indicate a particular type of weights or a certain size class for a particular type of fibre.
The analysis of loom weights from the taxonomic point of view in a Central European context (Kneisel, Schaefer-Di Maida 2020) and in the Terramare site of Montale (Sabatini 2020a) is the subject of two recent papers. A series of representations of upright looms with loom weights comes from the "Grande Roccia di Naquane" in Valcamonica, whose engravings have been dated, based on stilistic criteria, to the 14th century BC (Anati 1959).
A further reflection can be made on the possible use of shearing tools: there are no tools that could have been used for shearing before the iron scissors attested from the middle of the third century onwards in several northern Italian graveyards (for the Bologna area Vitali 1992, p. 399; Ortalli 2008, p. 308; for Liguria Durante 2004, p. 419). It must be emphasised that all the shears from the late La Tene period come from graves and that the picture does not change much even for the centuries between the 1st BC and the 2nd AD if, for example from the area of the present-day province of Brescia (Lombardy), of the 18 shears found two come from high-ranking residential contexts (domus), one from a sanctuary and the rest from funerary contexts (Busana, Cottica, Basso 2012, p. 415). Rosselli (2013, p. 375) suggests that the presence of such objects in the late La Tene burials could refer to a certain socio-economic status of the deceased, somehow linked to the world of sheep farming.
It is difficult to establish whether the appearance of shears only from the middle of the 1st millennium BC is to be related solely to the increasingly widespread use of iron, a much more elastic material than bronze (Forbes 1956, p. 8; Barber 1991, p. 29), or whether this is also due to the appearance of sheep species with continuously growing wool (Ciani *et alii* 2015).
The newly domesticated sheep must have had an annually shedding coat, and domestication and subsequent selective action by humans (which has now led to the existence of over 1600 types of sheep) would lead to the emergence of continuously growing sheep with ever finer fibres (Jackson *et alii* 2020, p. 2). As long as the sheep's fleece was moulting, it is not necessary to assume the existence of shearing tools, but the removal of fibre could be done by simply plucking the sheep fleece, as attested for example still in Roman times by Pliny in his *Naturalis Historia* (8, 73): "*oves non ubique tondentur, durat quibusdam in locis vellendi mos*".
We can assume, however, that other cutting tools such as knives (Gleba, Mannering 2012b, p. 7), razors or even flint blades (Massussi, Tucci 2019) were used before the introduction of shears. Nonetheless, in the absence of traceological analyses, it is difficult to go beyond a purely hypothetical level. As suggested for milk exploitation and dairy production interesting can be the analysis of kill-off patterns (see above): an increased number of surviving adult male sheeps can in fact be explained with an interest in wool production (Arbuckle 2012).

## Was there a SPR in northern Italy?

The question is far from being rhetorical: if Sherratt's intellectual challenge is to be accepted, we must ask ourselves whether the different elements that make up the 'package' really "*spread and interacted with each other so as to cause major economic changes*" (Sherratt 1981, p. 183): the fact that individual "secondary products" are attested from northern Italy in late prehistory is not necessarily, in my opinion, a sufficient evidence for SPR.
The elements analysed above are presented in the following chronological order from the earliest to the latest evidence in northern Italy[14]:

**milk and dairy production:**

a) clay spoons with traces of milk fat from some caves in the Trieste Karst (mid-6th millennium BC levels);

**animal-drawn plough:**

a) oldest plough marks from Saint-Martin-de-Corléans (early 4th millennium BC),

b) representations of ploughs pulled by oxen in rock engravings in Valcamonica from the Eneolithic 2;

**animal transport (horse):**

b) horse bones from several sites in the Po Valley (Middle Bronze Age);

**wool:**

a) wool yarn from Molina di Ledro (beginning of Early BronzeAge).

From this chronological framework we are going to argue that the SPR can be a useful model to study the Po Valley between the Eneolithic and the Bronze Age, and that the interaction dynamics between its different elements could be observed there in the first half of the 2nd millennium BC.

[14] Where present a) corresponds to the oldest occurrence, b) to a moment of growth in the number of evidences.

In this regard, two works that have questioned the value of the SPR as a model for the understanding of Italian late prehistory are discussed below.
When questioning a possible definition of the Eneolithic, Guidi (Cazzella, Guidi 2011, pp. 29-30) used the same logic as above, but came to a different conclusion: he attributed to the Late Neolithic a specialised production of milk and wool "*as archaeozoological data and the presence of a rich repertoire of spindles in the material culture of the time would suggest*" (Cazzella, Guidi 2011, p. 29; English translation by the author) and mentioning the horse from Maccarese, he concluded that "*it seems difficult to deny that a "plough-wheel-horse" complex distinguishes the Italian Copper Age*" (Cazzella, Guidi 2011, p. 30; English translation by the author).
While recent works, published after 2011, seem to agree in recognizing the widespread use of wool and woollen fabrics, at least for Central-Western Europe[15], starting only from the Bronze Age (Gleba, Mannering 2012a; Sabatini, Bergenbrant 2020a), when considering horses in Italy Guidi expressly states that "*it is known that the **first certain evidences** are all in the Eneolithic: we are talking about the famous specimen from Maccarese, datable to around the second half of the 3rd millennium BC and, perhaps, the one attested (now no longer preserved, however) in an Eneolithic burial in Cantalupo Mandela*" (Cazzella, Guidi 2011, p. 30; English translation and boldface by the author). As already mentioned above, I personally believe that it is more important to recognise a framework of reciprocal interactions between the different elements rather than the earliest attestations. Therefore, while I agree with the exceptionality of the presence of a horse in a cultic context such as Maccarese, I think it is precisely the exceptionality of this context that prompts us to look for the SPR in later periods.
In this context, we would like to recall what Rapi wrote about the preconditions of the Polada culture:
"*The gap is enormous when compared to the late Neolithic groups [...] and it was achieved because of the technological advances made between the late Neolithic and the Copper Age; the development of early metallurgy, the adoption of the plough and the wheel were fundamental, but the great driving force behind this process was certainly the so-called secondary products revolution […]. From this point of view, we could think of the Copper Age as a sort of "big workshop" where the first experiments were carried out with those technologies and practices that were later perfected and used in the Bronze Age with a scale jump*" (Rapi 2013, p. 526; English translation by the author).
In Rapi's reconstruction, too, it is said that the Eneolithic saw the appearance of individual elements of the system, but here everything remained at an "experimental" level during the Eneolithic and it was only in the following Bronze Age that the various elements were brought together and the above mentioned scale jump, that is characteristic of the SPR model, was achieved.
The change of scale in the exploitation of the animal resource led to a strong intensification of agricultural production and similarly of the mobility of goods and people: the animal-drawn plough made sustainable the cultivation of a series of lands previously considered too poor and thus led to an expansion of the occupied areas. At the same time the adoption of the wagon or of pack-animals facilitated the reaching of previously unimaginable areas and the establishment of a long-range exchange system for specialised productions such as woollen textiles (which joined those of vegetable fibres, above all linen and cotton) or metallurgy (Fig. 6).
A further consideration to be made about the use of the animal-drawn plough is linked to the fact that, as the range of cultivated land increases (it is no longer only the most fertile land that is worked), a lower longevity of the settlements begins to be noticed, as they no longer arise only in the best areas from an agricultural point of view. The faster cycle of utilisation of agricultural areas also leaves sufficient fallow land available for pastoralism, which is becoming increasingly important.
A different scale jump is suggested by Carrer and Migliavacca (2020, p. 231) for the passage of the Po Valley from a short-range transhumance (which began in the Early Neolithic and gradually intensified until the Late Neolithic) to a long-range transhumance which they suggest begins with the Bronze Age, in a territory in which villages that had become central places ensured control over communication routes and exploited the sheep and goat resource to produce surplus (woollen clothes and dairy products) that could be easily moved by wagon transport.
A preliminary look at the faunal remains reveals two aspects that should be emphasised here: a trend towards selection of smaller cattle breeds and a general increase in the average number of individuals of domestic pigs between the Early Bronze and later Bronze Ages.
A study showing the appearance of smaller cattle species compared to Neolithic cattle in the central sector of the Po Valley north of the Po River has just been presented at the AIAZ Conference by Fapanni, Salvagno and Tecchiati (2021) who relate this decrease in cattle size to a selection by man to have animals better adapted to the changed human-animal interactions[16].

[15] See above the reference to the wool fragment from Kurgan 2 of the necropolis of Novosvobodnaya.
[16] A similar observation can be found in De Grossi Mazzorin 2013a.

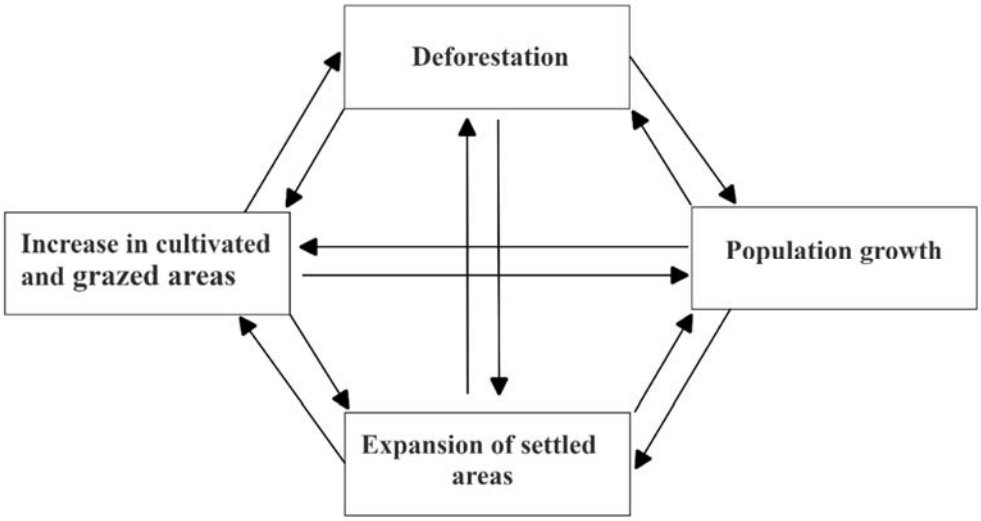


Fig. 6. Diagram of the biunivocal relationships between the different processes involved in the SPR.

On the increase in the number of pigs observed in northern Italy from Early Bronze Age onwards (De Grossi Mazzorin 2013a) it can be underlined that this could well be explained by an economic choice aimed at mitigating the loss of meat due to the changed slaughtering strategies of cattle and sheep and goats, which had become increasingly important alive and exploited for their secondary products. It is important to consider that in an increasingly densely occupied territory such as the Po Valley in the Bronze Age, the pig requires considerably less land for its nutrition, as it does not need the extensive meadows on which cattle and sheep and goats fed. At the same time, it is also a species with multiple offspring, thus making it possible to compensate quickly and cheaply for a decreasing meat supply from other species.

This framework of interactions between the different elements also perfectly fits the picture that Sabatini draws for the Terramare settlement of Montale, which suggests that the village was a centre of specialised production of woollen textiles (Sabatini 2020b, pp. 198-200) judging by the high presence of sheep in the faunal assemblages (which rises from the high 40% of Middle Bronze 2 and 3 to 48% of Recent Bronze 1 out of the total count) and by the contemporary massive presence of spindle whorls and loom weights (more than 4000 spindle whorls and 127 loom weights just from the 19th century excavations).

Assuming an economy of specialised production of wool presupposes that the village is located in an area with ample land available for sheep farming and the settlement system is capable of supporting, in terms of agricultural production, the large number of people who have been absorbed into wool production[17], and this is precisely the kind of environment that is created when the various innovations introduced between the end of the Neolithic and the Eneolithic "*spread and interacted with each other so as to cause major economic changes*" (Sherratt 1981, p. 183).

## Looking for SPR evidence in the archaeological record

Finally, we would like to consider which elements of the archaeological record we should focus on, and from which type of analysis we should try to obtain data that would allow us to interpret the "scale jump" in the use of secondary products.

On the question of the contribution of the biosciences, the following list is intended more as a starting point for discussion than to set out a roadmap to be followed. Nonetheless, I strongly believe that it is important for an archaeologist who deals with the landscape and the environmental resources to be able to ask the right questions, and only by it can he intercept the attention of other scholars interested in sharing parts of his research path.

**1) Milk**

For milk both as a direct nutrient and as a basis for dairy production it would be useful to:

a) search for the milk protein β-lactoglobulin (BLG) in dental calculus of ancient human samples to investigate the origins of human consumption of milk and dairy products. As BLG is species-specific, it might also be interesting to

[17] Cardarelli (1997, p. 654) describes the Terramare society of the mid-2nd millennium BC., which Montale belonged to, as "a community-based society, but already organised on a regional basis, thus with a "political system" *that unites a certain number of villages but which, judging by the apparent homogeneity of the settlements, would not appear to be related to a hierarchical territorial organisation, even if, as will be discussed below, it is possible that some villages begin to assume a particular role due to the presence of specialised or semi-specialised crafts in other settlements that are scarcely attested*" (English translation by the author).

distinguish the type of milk that was used by different human groups and possibly compare this with archaeozoological data;
b) lipid analysis on potsherds from the Neolithic period onwards in order to first detect dairy production and possibly to recognise the type of milk used;
c) the implementation of a RDBMS to record the different ceramic forms that are found to be associated with dairy production.

**2) Wool**

For the breeding of sheep and wool production, it would be useful to perform:
a) ZooMS analysis (Buckley *et alii* 2009) on sheep and goat faunal remains to distinguish between the two and to be able to correctly identify variations in the occurrence of sheep within faunal collections;
b) Isotope analysis on sheep to assess the mobility (Sabatini 2020b, pp. 192-193) of flocks within a territory and recognise episodes of transhumance;
c) paleo-diet analysis on sheep to assess possible change in foraging strategies: the shift to a wool-based economy certainly leads to a significant increase in the number of animals, and this could result in a change in the diet of the animals themselves, not necessarily an impoverishment, but perhaps a widening of the fodder supply basin and thus possibly the introduction of new plant species;
d) traceology analysis on spindles whorls and loom weights to try to differentiate between tools used for vegetable fibres and tools used for wool.

**3) Kill-off patterns**

a) search for the most convincing statistical method for the evaluation of kill-off patterns and updating of the already published ones according to the newly identified parameters;
b) isotope analysis in order to detect variations on the weaning age of calves and lambes that can affect kill-off patterns and be related to dairy production (Balasse, Tresset 2002).

## Conclusion

Before the end, it is important to highlight the peculiar nature of agro-pastoral production in the Po Valley in the second millennium BC: the importance of sheep breeding on one hand, and therefore the production of wool mentioned above (with the fascinating idea of recognising in this area, together with Sabatini, one of the key centres for continental Europe and therefore to assume the production of enormous volumes of wool), and on the other hand the extraordinary control of the agricultural landscape that the Terramare people applied through hydraulic systems that served both the villages and the surrounding farmland in an integrated framework.
In both cases, however, these phenomena can be found in societies (contemporary or even more ancient, such as those from the Aegean for the former and those from the Near East for the latter) which are always characterised by a greater social complexity.
The hydraulic systems of the Terramare (and of the Friulian Castellieri), which in the interpretation of the irrigation systems given by Wittfogel (1957) for the Near East, may seem "*not of great importance*" or "*of modest dimensions*", if compared to the political reality of a chiefdom such as the Terramare one, must be taken into serious consideration.
Surely those works required the intervention and commitment of the entire community and therefore, from this point of view, the organisational effort required is certainly to be considered of great importance.
Before the introduction of mechanized agriculture, any society by simply choosing irrigated agriculture has to adopt mass work, which in turn involves planning and management skills. Before dealing with agriculture itself, a preparatory infrastructure made of channels, ditches, embankments which required a considerable effort in terms of time and energy involving the entire community is necessary: the digging of ditches and external irrigation channels had to engage teams of workers made up of most of the male population, then there were other teams to supply timber or other building materials that must have been employed, and the food preparation and administration of drinks in all likelihood were probably carried out by women and children. Closely related to the excavation works was the raising of the perimeter embankments using the huge amount of earth dug up during the realization of the channels. The apparent lack of leader figures in egalitarian societies such as those living in Northern Italy could be explained by a social organisation that Cattani (see his contribution in this volume) defines as Polyarchy, i.e. a system where for each village (or presumably also forms of alliances between villages) the power was not entrusted to a big man, but it is more likely that the decision-making aspect was held by many (representatives of extended family groups). There is no doubt that a community mobilization was necessary to organize the teamwork and to manage the building of the structures: and the same must be postulated for the managing of the entire wool production operational chain too.
In contemporary Aegean palatial societies, the management of the resource "wool" was under the strict control of the rulers: the proof that this type of product was considered very valuable can be found in the numerous administrative texts that regulated its production and taxation (Rougemont 2014). In the Po plain both the hydraulic managing of the landscape and the production of wool lead probably the society to a Polyarchic paradigm (Cattani *sensu*) or some

capable men to some kind of leadership role that does not make them excel as prominent figures within the village, as it can be inferred from the quite regular and egalitarian aspect of Terramare villages house plans[18], highlighting the communitarian character of Terramare society.

**Acknowledgements**
For my first thoughts about SPR in northern Italy, I would like to thank Francesca Romana Del Fattore and Umberto Tecchiati. The patience of the volume editors and the helpful comments of Maurizio Cattani and one anonymous reviewer are also gratefully acknowledged.

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[18] The presence of an elite group of some kind could maybe be observed in the necropolis with the sword bearers from Olmo di Nogara (Salzani 2005; Cupitò 2006) or the elaborate rituals of scattering fragmented weapons at Casinalbo (Cardarelli 2014).

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