



Salt and pastoralism in the Protohistory of the Veneto

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ABSTRACT

The study examines for the first time the available archaeological data on salt production and use in Later Prehistory in the Veneto region and exploits the close connection between salt use and livestock keeping on which Veneto historically relied as a crucial resource during protohistoric and Roman times. The region was one of the most significant areas of the central Mediterranean during Later Prehistory, as it provides evidence of rich central places and long-distance trading between the Mediterranean and Northern Europe. Despite the absence of salt mines, this area had access to abundant sal marinus from its extensive lagoons, which were natural environments for salt production and winter pastures, as supported by archaeological evidence from the Bronze Age, Roman times, and late antiquity. Topographic, ethnographic, and historical data demonstrate that the pastoral routes from the mountains grazed the coastal lagoon areas, creating connections between diverse ecosystems within the region and its surrounding areas. While pinpointing the exact movement of salt remains speculative, considering the available data, this preliminary study suggests that during the Bronze Age, sea salt from the coast was the primary source of salt especially in eastern Veneto, whereas rock salt from the Alps' significant mines was likely to arrive in the western Venetian mountains from the Iron Age onwards. Thus, at least two distinct circuits for salt production, trade, and distribution likely coexisted in the region from the Iron Age.

1. Introduction

This contribution aims to investigate, for the first time, the production and use of salt and the potential connections between the archaeology of salt and the archaeology of pastoralism in Veneto, located in north-eastern Italy (Fig. 1), one of the most significant areas of the central Mediterranean during Later Prehistory, as it provides evidence of rich central places and long-distance trading between the Mediterranean and Northern Europe. It is important to note that the movement of salt in this context is speculative (Harding, 2021, p.20). Both the archaeology of pastoralism and the archaeology of salt have been described as "invisible" disciplines. Gordon Childe (1942) previously questioned whether pastoralism is an activity that remains unseen in archaeological terms, due to its widespread nature across large territories and the limited and easily perishable material culture associated with pastoralists. More recently (Brigand and Weller, 2015, p.10), it has been observed that common salt is an invisible object of archaeological research, despite the fascinating range of salt-related topics explored in archaeological studies and the impressive interdisciplinary approaches employed. Thus, the archaeology of pastoralism and the archaeology of salt share research methods that rely on both direct and indirect indicators. These methods include the analysis of geomorphological and

environmental characteristics, sedimentology and soil micromorphology, archaeozoology, ethnography, ethnohistory, literary sources, toponymic data, and material culture.

Despite its invisibility, ancient texts, history, ethnography, and our everyday lives all confirm that both humans and animals cannot live without salt (Brigand and Weller, 2015, p.10). In ancient times, salt served various purposes such as preserving perishable food, enhancing flavour, and supplementing the diet of livestock, particularly ruminants. Approximately 4–5 kg of salt per year is needed for a sheep, which translates to a minimum requirement of 500 quintals per year for an average flock of 500 animals (Bonetto, 1997, p.138). Cattle require around 11 kg of salt annually, while dairy cows need 26 kg, indicating a significant quantity. As documented by ancient authors like Varro, Pliny, and Columella, salt was also used in breeding practices to improve the taste of milk, prepare specific cheeses, treat animal hides, wash sheep after shearing, and even in fabric dyeing. It was also employed as a medicine for both animals and humans. Depriving animals of salt leads to adverse effects and compromised health (Harding, 2021, p.1).

The connection between salt production and animal husbandry has been documented in various regions across Europe and the Mediterranean. For instance, in Romania, evidence of this relationship can be seen at the Lunca salt spring in Poiana Slatinei (Brigand et al., 2018, p.247)

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and at the Tolici salt spring in Halabutoaia, where the presence of pollen from plants, weeds, and mushrooms specific to well-trodden areas and pastures has been found (Danu et al., 2010). The earliest signs of human activity, likely pastoral, have been dated between 7200 and 6750 years ago near the abundant salt deposits of Bisoca in Transilvania (Brigand et al., 2018, p.247). Similarly, in Maremma, southern Tuscany, the Prile Lake transformed into a salt lagoon between 8000 and 1000 BCE, which created favorable conditions for the presence of pastures (Citter, 1996, 13–23; Vanno, Cristoferi 2018, p.208). During medieval times in the routes from Provence to the southern Alps, stops were established to care for livestock, collect tolls, and provide salt (Burri et al., 2018, pp.143). In the 12th century, the distribution of hilltop villages in southern Tuscany was primarily driven by the exploitation of salt flats, forestry, animal husbandry, and control over major transhumance routes (Vanno and Cristoferi, 2018, p.202). In southern France during the 14th–15th centuries, documents related to seasonal pastoral migration required pasture owners to supply sufficient salt for the animals (Burri et al., 2018, pp.141–142). Ethnographic research from the 1980s highlights the practice of placing blocks of rock salt in resting pens, around sheepfolds, and even outside the pens in Moldavia, the Cicolano pastures in Central Italy, and the Lancashire grasslands (Migliavacca, 1991).

In Veneto, ethnographic sources reveal the significance of salt in the rearing of animals in the low Po plain of Veneto. The shepherds of the 20th century identified certain areas in the Valli Grandi Veronesi -Po lowlands as suitable for animals due to their salt content. When

interviewed, the shepherds from Torretta di Legnago, located in the Valli Grandi Veronesi between the River Adige to the North and the river Po to the South, explained that they would lead their sheep and goats to the best pastures known as "terre salate" (Fig. 1; Migliavacca, 1991). In the Veneto region, the presence of salt is higher in soils with a high organic matter content, particularly in the southern Po plain where the Adige and Po marsh areas have been reclaimed (ARPAV, 2020). Historical records demonstrate that specific laws were established from the 12th to the 16th century to guarantee the supply of salt to animals in the Veneto mountains, which lacked this resource. During the 12th to 13th centuries, inhabitants of the Lessini area were exempted from paying salt duty but had to obtain controlled supplies from Verona (Cangrande della Scala 1326: Cipolla, 1978, pp.61–63). The Republic of Venice confirmed these salt privileges through a deliberation of the College in Venice in 1406 (Cipolla, 1978, p.112). In 1509, mountain residents were allowed to obtain salt supplies from Vicenza, Padova, and Treviso without the obligation to record the number of reared animals (Caldogno, 1972, p.79; Cipolla, 1978, p.143). It is highly likely that the salt was sourced from the coastal lagoons.

2. Regional Setting

Veneto is in northeastern Italy (Fig. 1). The region exhibits a diverse landscape, encompassing the Adriatic coast rich with lagoons, the wetlands of the Po plain, the drier flatlands to the north of the water springs line, the subalpine hill zone between 200 and 800 m above sea level, and

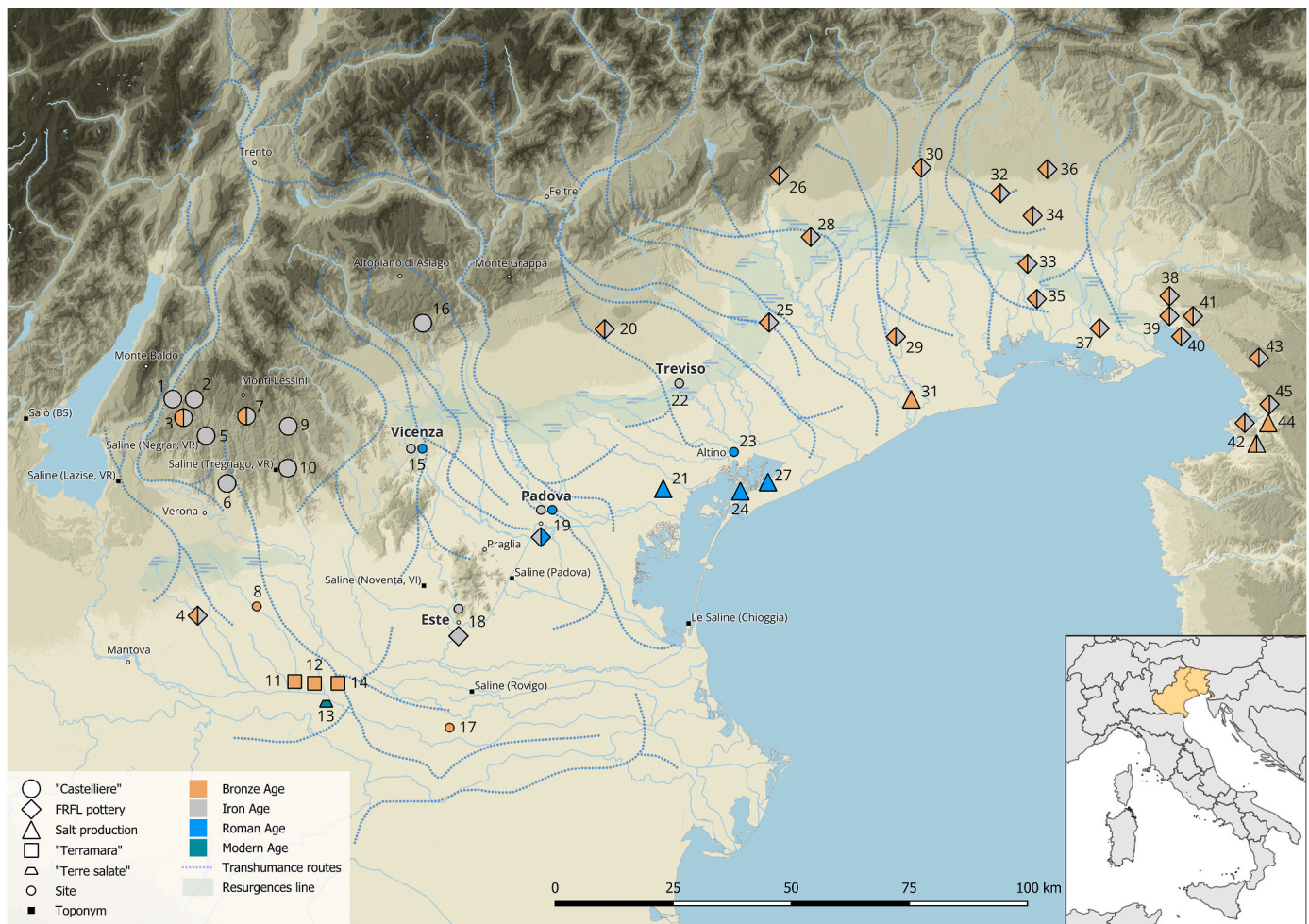


Fig. 1. The map indicates the location of the investigated area, and traces the pastoral movements attested in the Triveneto (from Malacarne, 2009). All sites considered in the study are indicated by a progressive number from west to east, which can be found in Table 1. The colours indicate the chronology of the archaeological data, the symbols indicate the function and characteristics attributable to the different sites. (drawn by Filippo Carraro).

Table 1

In the table the sites considered in the study are numbered; the function and the chronology are indicated (BA= Bronze age; IA= Iron age; RA = Roman age; MA = Modern age).

id	Site	Chronology	Type
1	Sottosengia	IA	castelliere
2	Monte S. Giovanni	IA	castelliere
3	Monte Loffa	BA, IA	castelliere
4	Castion d'Erbe	BA, IA	FRFL pottery
5	Rocca di Lugo	IA	castelliere
6	Monte Marseghina	IA	castelliere
7	Monte Purga	BA, IA	castelliere
8	Bovolone	BA	sito
9	Purga di Bolca	IA	castelliere
10	Tre Punte di Preatta	IA	castelliere
11	Castello del Tartaro	BA	sito terramara
12	Fondo Paviani	BA	sito terramara
13	Torretta di Legnago	MA	Terre salate
14	Fabbrica dei Soci	BA	sito terramara
15	Vicenza	IA, RA	sito
16	Monte Corgnon	IA	castelliere
17	Frattesina	BA	sito
18	Este	IA	sito; FRFL pottery
19	Padova	IA, RA	sito; FRFL pottery
20	Montebelluna	BA, IA	FRFL pottery
21	Ammiana	RA	Salt production
22	Treviso	IA	sito
23	Altino	RA	sito
24	S. Francesco del Deserto	RA	Salt production
25	Oderzo	BA, IA	FRFL pottery
26	San Tomè di Dardago	BA, IA	FRFL pottery
27	Lio Piccolo	RA	Salt production
28	Palse di Porcia	BA, IA	FRFL pottery
29	Concordia sagittaria	BA, IA	FRFL pottery
30	Gradisca di Spilimbergo	BA, IA	FRFL pottery
31	S. Gaetano Caorle	BA	Salt production
32	Variano, Basiliano	BA, IA	FRFL pottery
33	Castions di Strada	BA, IA	FRFL pottery
34	Pozzuolo del Friuli	BA, IA	FRFL pottery
35	S. Giorgio di Nogaro	BA, IA	FRFL pottery
36	Udine	BA, IA	FRFL pottery
37	Aquileia	BA, IA	FRFL pottery
38	S. Polo, Castellazzo di Doderbò	BA, IA	FRFL pottery
39	Terzo Ramo Timavo	BA, IA	FRFL pottery
40	Duino	BA, IA	FRFL pottery
41	Grotta del Mitreo	BA, IA	FRFL pottery
42	Elleri	BA, IA	FRFL pottery; Salt production
43	Monrupino	BA, IA	FRFL pottery
44	Stramare	BA	Salt production
45	Cattinara	BA, IA	FRFL pottery

the highlands of the Prealps and Alps, reaching elevations of up to 2000 m above sea level.

The region, situated between the lagoon fringe, expansive plains, and the pre-alpine hinterland, provided abundant resources for livestock farming. These resources included salt, winter pastures in the marshy lowlands, and summer pastures in the mountains. As a result of this favorable geographical context, livestock farming and sea salt production played a crucial role in the region from the Protohistoric period to the Roman age.

3. Salt production in the Veneto region during Roman times

The Veneto region did not have salt mines and was unable to provide *sal fossilis*, a mineral composed of sodium chloride, also known as rock salt. However, the region had ample access to *sal marinus*, or sea salt, due to its extensive lagoons which provided natural environments for salt production. Sea salt was obtained by evaporating seawater in shallow impermeable tanks. Various pieces of evidence suggest the existence of salt pans during Roman times.

Pliny (nat. Hist. 31, 88) emphasized the indispensability of salt for

civilized life, highlighting its significant role in Roman daily life during the 1st century AD. This era and subsequent centuries saw the operation of numerous salt production facilities, including well-known ones located near the mouth of the Tiber River, near present-day Fiumicino (the *Campus Salinarum Romanarum*), as well as recently discovered sites near Cervia (Morelli and Forte, 2014; Guarnieri, 2019). Excavations at both locations have revealed the presence of drying ponds and remnants of the channels that transported seawater for salt extraction.

In Veneto, a renowned source of late antique literature, Cassiodorus (var. 12, 24, 6–7), indirectly suggests salt production in the 6th century AD. He verifies that the inhabitants of the coastal areas of Veneto exploited salt, a vital natural resource that was even equated to gold. Recent studies conducted by the University of Venice in the northern part of the Venetian lagoon, specifically at Lio Piccolo, Scanello, Costanziano/Ammiana, and San Francesco del Deserto, provide direct evidence of salt production (Fig. 1). These investigations identify residential structures dating back to a substantial period between the 1st and 7th century AD, although the limited availability of stratigraphic excavations impedes precise dating (Calaon and Cipolato, 2019; Cottica and Goti Vola, 2019). These were villas with sections dedicated to the exploitation of a hybrid landscape between land and water, where fishing, hunting, and salt production took place. This is confirmed by numerous archival documents from the following centuries (Hocquet, 2003) and by the existence of locations with significant names like Saline. According to Hocquet, it is likely that salt production had previously occurred in the northern part of the lagoon, where it maintained an advantage over Chioggia and the southern sector until 1100. However, the situation began to change by the last quarter of the 11th century. In addition to these inhabited settlements, recent research in underwater archaeology has identified a few infrastructures previously referred to as 'road embankments'. These structures, consisting of wooden poles and planks filled with various materials such as building waste, mud, and fragmented amphorae, are approximately 2 m wide and vary in length. According to Calaon, their fragmented and scattered distribution, small size, and environmental context suggest that they were embankments designed to enclose, expand, and define specific bodies of water, primarily for productive purposes such as fishponds, inland valleys, and salt pans. The embankments also featured walkways on their tops, which served functional purposes for these activities. Additionally, underwater excavations have revealed wooden components associated with sluice gates, which were used to regulate the flow of water in fish-breeding and salt-drying tanks (Calaon and Cipolato, 2019, p. 30 and fig. p. 38).

Another indirect indication of salt production in Roman times in the Venetian lagoon area comes from the development of sheep and goat breeding practices, which, as previously mentioned, required a sufficient supply of salt. It is not a coincidence that cities such as Altinum (Fig. 1, located in the northern part of the Venice lagoon) or Patavium, whose agricultural land extended towards the sea, are recognized as significant centers of wool production according to literary and epigraphic sources (Bonetto, 1997, p. 138). Padova, mentioned by Strabo as the second wealthiest city in the Empire, owed its prosperity to the production of *gausapae*, which were heavy fabrics used for making carpets, clothing for harsh climates, and military attire. These goods were then sent to the market in Rome (5.1.7). Altino, as documented in literary sources, was known for cattle breeding and for its production of *ceva*, a large milk-producing cattle breed (Columella 6.24.5).

Recent studies conducted by researchers from the University of Padua have revealed the presence of Roman farms in the Altinum area, dating from the 1st to the 5th century A.D. These farms consisted of either large, squared structures measuring 12 × 12 m or rectangular structures measuring 33 × 9 m, which were separate from the main building. Interestingly, no evidence of a prepared floor was found, and the walls were partially constructed using wood, indicating a relatively simple architectural design. It was hypothesized that these structures may have served as enclosures or stables for breeding animals. To

further investigate the nature of these structures, the researchers conducted analyses on the soil's phosphorus (P), carbon (C), and nitrogen (N) content, as well as elemental ratios. The results revealed exceptionally high levels of total P at the site. Additionally, high levels of inorganic P (IP) were detected along the walls of the buildings, suggesting the mineralization of organic P (OP). This organic P had become trapped within inorganic compounds, specifically calcium carbonate, enabling its preservation over time. When examining the elemental ratios, the organic C/total C (OC/TC) and C/N ratios indicated the presence of organic matter originating from animals rather than plants. Moreover, the OC/OP and N/OP ratios provided further evidence supporting the anthropogenic origin of the site.

These findings strongly support the conclusion that the remains discovered in the Altinum area are indeed the remains of Roman rural buildings, specifically functioning as stables for breeding cattle or sheepfolds (Busana et al., 2012; Migliavacca et al., 2012). Archaeozoological studies have documented the presence of cattle, pigs, and sheep on some farms, indicating an integrated economy that encompassed both agriculture and breeding. On other farms, there was a significant predominance of sheep, suggesting the practice of intensive sheep breeding (Busana et al., 2016). In the latter case, it is highly likely that transhumance was practiced, with the animals grazing in the mountainous areas abundant in excellent fodder during the hot season, and wintering on the plains during the cold season. The Roman age herding roads that connected Altinum to the foothill area and Piave valley provide topographical evidence of transhumance and can be seen as a link between coastal and higher pastures of great interest (Rosada, 2004). Additionally, the herding road known as "Arzeron della Regina" directed from Padova to the upper Po plain in the Vicenza area and eventually to the mountains of the Asiago plateau (Bonetto, 1997, 2004).

Hence, the specific geographical location of the territory under scrutiny in this study, situated between the lagoon periphery and the mountainous regions, proved conducive to successful livestock farming, along with the processing of raw materials derived from it. While the mountain pastures provided the herds with a nourishing summer diet, it was the coastal areas that supplied the indispensable salt as a vital supplement to this diet.

4. Salt production in the Veneto region during the Protohistory

While salt marshes are credited to the Roman period (Weller, 2015), it is widely recognized that different salt extraction methods were employed in the prehistoric era (Harding, 2021). Evidence of briquetage has been discovered along the northern Italian coast in Friuli, specifically at the Castelliere di Elleri, located less than 1 km from the Muggia Bay coastline (Montagnari Kokelj, 2007, Fig. 1). The Castelliere dates back from the middle Bronze Age to the Late Iron Age, and a network of sites within the area, including Stramare (Fig. 1), suggests the significant role the region played in salt production centered around the Muggia Bay.

Sea salt was also produced along the Venetian coast, which was rich in lagoons, and then transported to market centers. The Caorle San Gaetano site, dating back to the Recent/Final Bronze Age and the Early Iron Age phases (XIII-XI BCE; IX-VIII BCE: Bianchin and Martinelli, 2004; Bianchin Citton, 2007; Cupitò and Leonardi, 2015), was located on the edge of a lagoon and separated from the sea by sandy cords (Fig. 1). The reclamation structures, directly in contact with the underlying brackish mud, consisted of sparse and makeshift planks, upon which small structures for decantation/evaporation, as well as pits and fire installations for pyro-technological activities, were built. The archaeological findings consist mainly of pottery artifacts, which are highly fragmented and rarely able to be reconstructed. They often show clear signs of colour alteration and surface abrasion due to exposure to fire. These artifacts include atypical container walls, which can be attributed to the category of large *ollae* or jar-silos made of impure

mixture and roughly smoothed surfaces. There are also truncated pyramidal clay pillars without suspension holes, which suggests the use of the boiling method for salt production from seawater (Harding, 2013, pp.17-18).

Other intriguing data emerged in 1969 with the discovery of a deposit of ceramic materials at the mouth of the Timavo River (Fig. 1). Covering approximately 150 square meters and submerged at a depth of around 7 m, this site, located along the Trieste coastline, is of significant importance in the context of salt exploitation during prehistoric and protohistoric periods. The deposit consisted of roughly a hundred specimens of a distinct type of jars, commonly known as "Timavo type," characterized by their flared rims and flat lips (FRFL). These *ollae*, although of little value, were subjected to archaeometric analysis, revealing a mixture that included degreasing speleothems, which are concretions typically found in caves affected by karst phenomena (Prosdocimi and Tenconi, 2015; Tenconi et al., 2013). The deliberate focus on a single ceramic form led to the interpretation of this accumulation as either a production area or a storage/loading point for vessels used in transportation. The distribution of such vessels (Fig. 1) extended during the Late Bronze Age and Early Iron Age in the region of Friuli Venezia Giulia, and later expanded to encompass select Early Iron Age sites in Veneto (Prosdocimi and Tenconi, 2015). The study conducted by Prosdocimi et al. (2021) utilized technological details and analysis of distribution and chronology to determine that the *ollae* vessels were imported to Veneto from Friuli. Consequently, the low intrinsic value of these vessels raises the question of their possible contents. The discovery near the Timavo River mouth suggested a connection between the flattened rim *ollae* and the utilization of marine resources. Given that there was no need to import salt to the Veneto region, which possessed an ample supply of coastal lagoons suitable for salt production (as evidenced by the discovery in Caorle), it was speculated that the Timavo-type *ollae* were employed to transport a valuable commodity produced near the Karst over a medium-to-long distance. This commodity could potentially be a perishable fish product that was treated with salt.

A proposed distribution network for salt and related products produced along the coast during the protohistoric period can be observed through the distribution of "flared rim and flat lip" pottery (Fig. 1). This type of pottery is typically associated with the exchange of salt products along the coast, and interestingly, seems to exclude the western Venetian Mountain area. Thus, how was salt distributed in the region of Venetia during the last two millennia before Christ?

During historical times, the presence of numerous place names suggests the extraction, trade, sale, and distribution of salt in the Veneto region. This distribution spanned from the current coastline, with notable locations such as Le Saline in Chioggia, province of Venezia, through the Venetian plains (Saline in Rovigo province and Saline-Due Carrare in Padova province), considering that the ancient coastline was situated farther inland compared to its present location. Furthermore, the distribution network reached into the inner Veneto region, extending towards the western Prealps with sites such as Saline in Vicenza province, Saline in Verona province, and Saline-Negrar in the province of Verona. Additionally, the distribution network extended to Lake Garda with sites near Lazise and Salò. It is worth noting that salt distribution may have also catered to animal needs, as suggested by Kübler in 1926. Therefore, during historical periods, a portion of salt was likely transported via the river Adige. This practice of transporting salt through rivers is indeed well-documented in central and eastern Europe during historical times (Marc, 2006).

Additionally, in conjunction with shepherds, pack animals have accompanied them since ancient times as they migrated within the Veneto region, moving between summer pastures in the mountains and winter pastures on the plains and coastal areas. Could the paths taken by these shepherds provide insights into the salt distribution network?

5. Pastoral movements in the Veneto region

The study of pastoralism in the Veneto region began in the 1980s and focused on the archaeology of the phenomenon during the Protohistoric and Roman periods. This research was preceded by thorough investigations in geography, ethnography, and history (Migliavacca, 1985, 1991; Bonetto, 1997).

The ethnographic study played a crucial role in identifying various forms of pastoral activities, ranging from sedentary shepherds to mobile ones. In the Veneto region, pastoral movements (Fig. 1) occurred between winter pastures along the seaside, in lowland areas, and at the bottom of valleys, with summer grazing areas in the mountains, in line with the typical Mediterranean pattern. Additionally, the wetlands of the low Po plain were exploited by different groups of shepherds originating not only from the Alps and Prealps in the Veneto region but also from the Apennines to the south of the river Po (fig. 8; Migliavacca, 1991; Carrer and Migliavacca, 2020).

Historical data has demonstrated that throughout different historical conditions, various pastoral movements have continuously exploited all vegetation belts since the 9th century AD. These movements have skillfully utilized the available resources in five distinct grazing areas: the wetlands of the low Po plain, the drier pastures of the high Po plain, the Brometum of the hillzone, the Trisetum of the prealpine zone, and the summer Seslerieto-Semperviretum of the calcareous highlands. In addition to the summer pastures in the highlands and the winter pastures in the lowlands, intermediate grazing areas, known as stavoli, masi, and tede, played a crucial role. In western Veneto, enduring and close connections have consistently linked the water spring winter grasslands in the Verona and Mantua lowlands to the summer pastures in the highlands of Monte Baldo and Lessini. These links have been further substantiated by the Cerea Statutes dating back to 1304 (Rossini and Fernell-Mazzaoui, 1975, p.11). Further east, the Vicenza Prealps served as summer pastures for shepherds who came from the high and low plains around Vicenza and Padova. Medieval documents preserved in the archives of Praglia Abbey provide explanations of the routes followed by these shepherds to reach the Altopiano di Asiago, following the herding road named "Arzeron della Regina" along the right bank of the Brenta River. On the other hand, shepherds from Padova reached the Grappa plateaux along the left bank of the Brenta River and continued towards the Feltrina and Trento territories. Moving even further east, pastoral movements connected the winter pastures along the coastal area with the summer pastures in the Bellunese Prealps and beyond in the northern regions (Bonetto, 1997, pp.157-158; Pracchi, 1943; Malacarne, 2009).

6. Discussion

6.1. Salt and pastoralism in Veneto during the Bronze Age

During the Middle Bronze Age (Bronzo Medio or BM, from the seventeenth to the fourteenth century BCE) and the early phases of the Late Bronze Age (Bronzo Recente or BR, from the fourteenth to the twelfth century BCE), a new type of settlement known as terramara emerges in the plain (Cupitò and Leonardi, 2015). The terramare are central places situated on fluvial terraces, surrounded by canals and embankments that serve both defensive purposes and the control of water drainage (Bernabò Brea et al., 1997). The terramara of Castello del Tartaro (Fig. 1), constructed on a natural mound along the bed of the river Tregnone in the Po lowland, was the focal point of a prehistoric rural landscape where three concentric drainage systems, connected by transverse drains, likely facilitated irrigation of the surrounding fields and meadows (Cima, 2012). Soil chemistry analyses in this sophisticated landscape organization have revealed the presence of a Bronze Age embankment road, specifically used for herds, located among the three major terramare of Fondo Paviani, Castello del Tartaro, and Fabbrica dei Soci (Fig. 1; Migliavacca et al., 2023). Micromorphological analyses of

the soils at Santa Rosa di Poviglio provide evidence suggesting the importance of animal husbandry in the economy of the terramara settlement. Zooarchaeological studies (De Grossi Mazzorin, 2015; De Grossi Mazzorin and Riedel, 1997; Riedel, 1994) have revealed that sheep and goats were the predominant livestock, with a scarcity of cattle, a moderate number of pigs, and a notable presence of dogs (which may be relevant to pastoral activities) in the terramare settlements located south of the Po River (Montale, Tabina di Magreta, and Poviglio). In contrast, the terramare settlements north of the Po River (Fondo Paviani, Fig. 1) showed a prevalence of sheep and a shortage of goats. Additionally, horse faunal remains, carriage wheels, and bridles have been documented in the Terramare region and the Veneto region as early as the mid-seventeenth century BCE (De Grossi Mazzorin, 2015; De Grossi Mazzorin and Riedel, 1997; De Grossi Mazzorin and Solinas, 2013).

In the recent Bronze Age, two polities emerged in the Veneto low Po plain: Bovolone and, particularly, Fondo Paviani (Fig. 1). These polities developed connections with the Adriatic and Aegean regions, as evidenced by the presence of luxurious pottery, glass, and ivory artifacts. Furthermore, the discovery of the oldest donkey faunal remains in Italy indicates early trade contacts with the eastern Aegean areas, where the donkey was native (De Grossi Mazzorin, 2015). Donkey bones dating back to the second half of the twelfth century are documented at Frattesina (Fig. 1). Notably, Mycenaean pottery has been found at both Frattesina and Fondo Paviani (Cupitò and Leonardi, 2015). Therefore, there is direct evidence that, during the Bronze Age in the Veneto plain, the terramare were agricultural and commercial centers, also engaging in significant animal farming. The presence of exotic items from the Aegean region suggests a strong connection between the terramare and the Adriatic coastline, which housed productive sites with pyro-technological activities, decanting/evaporation structures, and sumps (as mentioned earlier in San Gaetano Caorle). The existence of donkey and horse breeding implies their potential role as pack animals, both in the mobility of shepherds (as extensively utilized by traditional pastoral groups in modern and pre-modern times) and in the transport of salt (as described by Harding and Kavruk, 2013, pp.212 ff.; Harding, 2021, pp.70-72). The same routes used by traders were also traversed by shepherds, satisfying the undeniable need for salt for both livestock and the central locations in the plain.

6.2. Salt and pastoralism in Veneto during the Iron Age

During the Iron Age, there was a significant surge in salt production across Central and Western Europe (Harding, 2021). Extensive networks of salterns were established along the Mediterranean coastlines, and the salt mines at Hallstatt experienced their peak development in the early Iron Age. Similarly, the salt mines at Durrnberg were utilized from the fifth century BCE onwards. These two mining regions together would have generated vast amounts of rock salt, which undoubtedly would have been transported extensively, both to the north and south of the Alps.

In Veneto, during the 8th-7th centuries B.C., the mountain and hill regions in the west experienced significant abandonment, while the newly established Venetic cities in the plain developed a complex economy. Stock raising, which was practiced in the high plain, played a prominent role in conjunction with the growth of handicraft industries. These cities were not only engaged in commercial activities with the areas north of the Alps but also maintained close connections with the coast through a network of navigable rivers. Este was connected to the Adige River, Padua to the Brenta River, Vicenza to the Bacchiglione River, Treviso to the Sile River, and Altino, which also had access to the sea through the lagoon, was situated in an area rich in evidence of salt production since the Bronze Age. Located amidst the lagoons and mountains, the Venetic cities emerged as centers of political and territorial control over transhumant farming, extending their influence to the eastern Veneto mountains where all settlements were of Venetic origin

(Bonetto, 1997, p.153).

In the Western Veneto mountains, significant settlements emerged from the late 6th century B.C. It is important to highlight the presence of fortified sites ("castellieri") on the outskirts of permanent settlements, which aimed to exploit the abundant resources of the highlands, particularly rich in pastures. The available evidence suggests that these hillforts were closely connected with the Rhaetian Alpine region situated further north (Marzatico, 2015). Consequently, the Western Veneto mountains were part of a network of exchanges that involved traversing the Alps, also to obtain their salt supply. This is supported by the distribution of "flared rim and flat lip" pottery, which can be linked to the coastal trade of salt products, seemingly excluding the Venetian Mountain area.

7. Conclusion

In conclusion, the protohistoric Veneto region shows promising evidence of sea salt production in lagoon areas along the coast since the Recent Bronze Age, according to the broader evidence that the establishment of salt production as an industry can be traced back to at least the Bronze Age and possibly even earlier (Harding, 2021, p.72). Through the analysis of geographical, historical, ethnographic, and archaeological data, it has become apparent that the routes of pastoralism from the mountains grazed the coastal lagoon areas, creating connections between diverse ecosystems within the region and its surrounding areas. While pinpointing the exact movement of salt remains speculative, considering the available data, this preliminary study suggests that during the Bronze Age, sea salt from the coast was the primary source of salt especially in eastern Veneto, whereas rock salt from the Alps' significant mines was likely to arrive in the western Venetian mountains from the Iron Age onwards. In this period, while lowland urban centers were closely connected to coastal productive areas, the western mountains are quite far from the coast. The data collected in this paper suggest the existence of two circuits of salt exchange and trade: a confirmed circuit of sea salt from the coast to urban centers, and a probable circuit of rock salt from the significant mines in the Alps to settlements in the western Venetian mountains.

The sources of salt supply can be either marine salt from the coast or rock salt from the significant mines in the Alps. For future research, it should be considered whether the supply and trade routes of sea salt and rock salt in Protohistory were distinct (one for lowland centers and the other for the mountain area) or coexisted.

Author statement

M. M. conceptualisation, methodology, investigation, writing - original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

- ARPAV, 2020. Carta della reazione (pH) e carta della salinità dei suoli della Regione Veneto. In: Regione del Veneto. Venezia.
- Bernabò Brea, M., Cardarelli, A., Cremaschi, M. (Eds.), 1997. *Le Terramare. La Più Antica Civiltà Padana*. Electa, Milan.
- Bianchin, E., Martinelli, N., 2004. Cronologia relativa e assoluta di alcuni contesti veneti dell'età del Bronzo recente, finale e degli inizi dell'età del Ferro. Nota preliminare. In: Bartoloni, G., Delpino, F. (Eds.), *Oriente e occidente: metodi e discipline a*
- confronto. Riflessioni sulla cronologia dell'età del ferro in Italia, Atti dell'incontro di studi. Istituti Editoriali e Poligrafici Internazionali, Pisa- Roma, pp. 239–253.
- Bianchin Citton, E., 2007. Il sito di S. Gaetano di Caorle: un approdo adriatico della tarda età del Bronzo. In: Fozzati, L. (Ed.), *Caorle Archeologica, Memorie Mediterranee* 3, Marsilio, Venezia.
- Bonetto, J., 1997. *Le vie armentarie tra Patavium e la montagna*, Zoppelli Ed. Dosson (Treviso).
- Bonetto, J., 2004. Agricoltura e allevamento in Cisalpina. Alcuni spunti per una riflessione. In: Santillo Frizell, B. (Ed.), *PECUS. Man and Animal in Antiquity, Proceedings of the Conference at the Swedish Institute (Rome, 9-12 September 2002)*, pp. 57–66. Rome.
- Brigand, R., Weller, O. (Eds.), 2015. *Archaeology of Salt. Approaching an Invisible Past*. Sidestone Press, Leiden.
- Brigand, R., Weller, O., Tencariu, F.A., Alexianu, M., Asandulesci, A., 2018. Ovine pastoralism and mobility systems in Romania: an ethnoarchaeological approach. In: Costello, E., Svensson, E. (Eds.), *Historical Archaeologies of Transhumance across Europe, Themes in Contemporary Archaeology*, 6, EAA Edition. Routledge, London and New York, pp. 245–263.
- Burri, S., Py-Saragaglia, V., Cesarini, R., 2018. Moving up and down throughout the seasons: winter and summer grazing between Provence and the southern Alps (France) AD 1100. In: Costello, E., Svensson, E. (Eds.), *Historical Archaeologies of Transhumance across Europe, Themes in Contemporary Archaeology*, 6, EAA Edition. Routledge, London and New York, pp. 135–154.
- Busana, M.S., et al., 2012. Agricoltura e allevamento nell'agro orientale di Altinum: il caso di Ca' Tron. In: Busana, M.S., Basso, P. (Eds.), *La Lana Nella Cisalpina Romana, Economia e società, Antenor Quaderni* 27. Padova University Press, Padova, pp. 127–170.
- Busana, M.S., et al., 2016. Edifici per animali di età romana: tra fonti, archeologia e scienza/Roman buildings for animals: between sources, archeology and science. In: Basso, P., Zanini, E. (Eds.), *Statio Amoena. Sostare e vivere lungo le strade romane*. Archaeopress Archaeology, Oxford, pp. 111–120.
- Calaon, D., Cipolato, A., 2019. La laguna nord di Venezia in età romana e tardoantica. In: Bressan, M., Calaon, D., Cottica, D. (Eds.), *Vivere d'acqua. Archeologie tra Lio Piccolo e Altino, Quaderni del Polo museale del Veneto* 3, Crocetta del Montello (Treviso), pp. 40–59.
- Caldogno, F., 1972. *Relazione delle Alpi vicentine e dei Passi e Popoli loro*, 1598. Istituto di Cultura Cimbra, Roana.
- Carrer, F., Migliavacca, M., 2020. Prehistoric transhumance in the northern Mediterranean. In: Sabatini, S., Bergerbrant, S. (Eds.), *The Textile Revolution in Bronze Age Europe*. Cambridge University Press, Cambridge, pp. 217–238.
- Childe, G., 1942. *What Happened in History*, Harmondsworth and New York. Penguin Books, Ltd.
- Cima, P., 2012. Fossil landscapes: alcune linee sperimentali di remote sensing e simulazione nel progetto AMPBN (Alto- medio Polesine- Bassa Veronese). In: Brogiolo, G.P., Angelucci, D.E., Colecchia, A., Romedino, F. (Eds.), *APSAT 1. Teoria e metodi della ricerca sui paesaggi d'altura. All'Insegna del Giglio*, Mantua, pp. 117–131.
- Cipolla, C., 1978. *Le popolazioni dei XIII Comuni veronesi*, vol. 1882 Giazza.
- Citter, C., 1996. Grosseto, Roselle e il Prile. Note per la storia di una città e del territorio circostante. In: Società Archeologica Padana, vol. 8.
- Cottica, D., Goti Vola, V., 2019. La villa romana di Lio Piccolo. In: Bressan, M., Calaon, D., Cottica, D. (Eds.), *Vivere d'acqua. Archeologie tra Lio Piccolo e Altino, Quaderni del Polo museale del Veneto* 3, Crocetta del Montello (Treviso), pp. 27–39.
- Cupitò, M., Leonardi, G., 2015. Il Veneto tra Bronzo antico e Bronzo recente. In: Leonardi, G., Tiné, V. (Eds.), *Preistoria e Protostoria del Veneto*. Istituto Italiano Preistoria e Protostoria, Firenze, pp. 201–239.
- Danu, M., Gauthier, E., Weller, O. (Eds.), 2010. *Human Impact and Vegetation History on Salt Spring Exploitation (Halabutoaia-Tolici, Petricani, Neamt, Romania)*. International Journal of Conservation Science, vol. 1, pp. 167–173.
- De Grossi Mazzorin, J., 2015. Fondo Paviani e Frattesina: economia animale di due central places della tarda età del Bronzo veneta. In: Leonardi, G., Tiné, V. (Eds.), *Preistoria e Protostoria del Veneto*. Istituto Italiano Preistoria e Protostoria, Firenze, pp. 389–400.
- De Grossi Mazzorin, J., Riedel, A., 1997. La fauna delle terramare. In: Bernabò Brea, M., Cardarelli, A., Cremaschi, M. (Eds.), 1997. *Le Terramare. La Più Antica Civiltà Padana*. Electa, Milan, pp. 475–480.
- De Grossi Mazzorin, J., Solinas, A.M., 2013. L'analisi dei resti faunistici provenienti dai settori A e D della palafitta del Lavagnone. In: De Grossi Mazzorin, J., Curci, A., Giacobini, G. (Eds.), *Economia e ambiente nell'Italia padana nell'età del Bronzo*. Le indagini bioarcheologiche, Edipuglia, Bari, pp. 21–102.
- Guarnieri, C., 2019. *Le saline romane e il territorio di Cervia. Aspetti ambientali e infrastrutture storiche*, Edipuglia, Bologna.
- Harding, A., 2013. *Salt in Prehistoric Europe*. Sidestone Press, Leiden.
- Harding, A., 2021. *Salt. White Gold in Early Europe*. Cambridge University Press, Cambridge.
- Harding, A., Kavruk, V. (Eds.), 2013. *Explorations in Salt Archaeology in the Carpathian Zone*, Archaeolingua, Budapest, pp. 185–192.
- Hocquet, J.-C., 2003. *Le saline dei Veneziani e la crisi del tramonto del medioevo*. Roma.
- Kübler, A., 1926. Die romanischen und deutschen Örtlichkeitsnamen des Kantons Graubünden. In: Von August Kübler (= Sammlung romanischer Elementar und Handbücher, Reihe 3: Wörterbücher, Band 4), Heidelberg.
- Malacarne, A., 2009. *Transumanze. Sulle tracce degli ultimi pastori del Triveneto*. In: Agora Libreria Editrice, Feltrè.
- Marc, D., 2006. *Sisteme de transport și de comercializare tradițională a sării*. In: Cavruc, V., Chiricescu, A. (Eds.), *Sarea, Timpul Și Omul, Sfântu Gheorghe*. Editura Angustia, pp. 152–157.

- Marzatico, F., 2015. Vicini e lontani: rapporti culturali fra mondo alpino orientale e Veneto nella prima Età del ferro. In: Leonardi, G., Tiné, V. (Eds.), *Preistoria e Protostoria del Veneto*. Istituto Italiano Preistoria e Protostoria, Firenze, pp. 487–499.
- Migliavacca, M., 1985. Pastorizia e uso del territorio nel Vicentino e nel veronese nelle età del Bronzo e del Ferro, vol. III. *Archeologia Veneta*, pp. 27–62.
- Migliavacca, M., 1991. Pastorizia e uso del territorio nell'età del Bronzo nel Veneto: linee di approccio al caso della bassa pianura veronese- altopolesana. In: Maggi, R., Nisbet, R., Barker, G. (Eds.), *Archeologia del Pastoralismo in Europa meridionale: atti della Tavola Rotonda Internazionale, Rivista di Studi Liguri*, A. LVI, vol. 1990. Istituto Internazionale di Studi Liguri, Bordighera, pp. 315–328.
- Migliavacca, M., Pizzeghello, D., Busana, M.S., Nardi, S., 2012. Soil chemical analysis supports the identification of ancient breeding structures: the case-study of Cà Tron (Venice, Italy). *Quat. Int.* 275, 128–136.
- Migliavacca, M., et al., 2023. Phosphorus, stable isotopes and fatty acids of soils as tools for recognizing a Bronze Age droveway in the Valli Grandi Veronesi (North Italy). *J. Archaeol. Sci.: Report*. <https://doi.org/10.1016/j.jasrep.2022.103729>.
- Montagnari Kokelj, E., 2007. Salt and the Trieste Karst (North-Eastern Italy) in prehistory: some consideration. In: Monah, D., Dumitroaia, G., Weller, O., Chapman, J. (Eds.), *L'exploitation du sel à travers le temps*, Editura „Constantin Matasă” Salt and the Trieste Karst (North-Eastern Italy) in Prehistory: Some Considerations. Piatra-Neamt, pp. 161–187.
- Morelli, C., Forte, C., 2014. Il Campus Salinarum Romanarum e l'epigrafe dei conductores. In: *MEFRA*, 126.1. <https://doi.org/10.4000/mefra.2059>, 2014.
- Pracchi, R., 1943. Aspetti della vita pastorale nelle Alpi italiane. In: *Boll. Soc. Geogr. Ital.* VII, p. 131 ff.
- Prosdocimi, B., Tenconi, M., 2015. Le olle ad orlo appiattito in Veneto nella prima Età del ferro nel contesto dei rapporti con il Friuli-Venezia Giulia. *Studio archeologico e archeometrico*. In: Leonardi, G., Tiné, V. (Eds.), *Preistoria e Protostoria del Veneto*. Istituto Italiano Preistoria e Protostoria, Firenze, pp. 938–942.
- Prosdocimi, B., Leonardi, G., Montagnari Kokelj, M., 2021. Terzo Ramo del Timavo (Duino-TS): santuario o sito per "l'industria alimentare". In: Damiani, I., Cazzella, A., Copat, V. (Eds.), *Preistoria del cibo*. Istituto Italiano Preistoria e Protostoria, Firenze, pp. 595–602.
- Riedel, A., 1994. Archaeozoological investigations in north-eastern Italy: the exploitation of animals since the Neolithic. *Preistoria Alp.* 30, 43–94.
- Rosada, G., 2004. Altino e la via della transumanza nella Venetia centrale. In: Santillo Frizell, B. (Ed.), *PECUS. Man and Animal in Antiquity, Proceedings of the Conference at the Swedish Institute (Rome, 9-12 September 2002)*, Rome, pp. 67–79.
- Rossini, E., Fernell-Mazzaoui, M., 1975. La lana come materia prima del Veneto sud-occidentale. In: *Vita di Giazza e Roana*. VI, pp. 5–18. Vicenza.
- Tenconi, M., Maritan, L., Leonardi, G., Prosdocimi, B., Mazzoli, C., 2013. Ceramic production and distribution in North-East Italy: study of a possible trade network between Friuli Venezia Giulia and Veneto regions during the final Bronze Age and early Iron Age through analysis of peculiar "flared rim and flat lip" pottery. *Appl. Clay Sci.* 82, 121–134.
- Vanno, E., Cristoferi, D., 2018. The role of marginal landscapes in understanding transhumance in southern Tuscany (twelfth–twentieth centuries ad): a reverse perspective integrating ethnoarchaeological and historical approaches. In: Costello, E., Svensson, E. (Eds.), *Historical Archaeologies of Transhumance across Europe, Themes in Contemporary Archaeology*, 6, EAA Edition. Routledge, London and New York, pp. 197–218.
- Weller, O., 2015. First salt making in Europe: a global overview from Neolithic times. In: Brigand, R., Weller, O. (Eds.), *Archaeology of Salt. Approaching an Invisible Past*. Sidestone Press, Leiden, pp. 67–82.