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Human Ecology, Economic Changes and Gastronomy in Central Sardinia between Neolithic and Iron Age. The Case Study of the Mogoro Territory (4th-1st Millennium BC)

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Abstract – Human Ecology, Economic Changes and Gastronomy in Central Sardinia Between Neolithic and Iron Age. The Case Study of the Mogoro Territory (4th-1st Millennium Bc). – Sardinia is a paradigmatic example of a large island environment that has changed through time influencing the ecological and economical strategies of human populations.
The central-western area of the island hosts a series of morphologies and ecosystems particularly rich in fundamental resources for prehistoric/protohistoric communities: extensive and productive coastal lagoons, a fertile agricultural plain with streams and ponds, forested terraces of the hilly strip, and the important obsidian deposits of Monte Arci. The Mogoro territory is a privileged observation point for understanding the ecological dynamics in prehistoric Sardinia, being located at the centre of these production areas and positioned along the preferential access routes connecting lowlands to highlands.
The main core of this paper is the reconstruction of the local economy in various phases ranging from the mid-4th to the beginning of the 1st millennium BC, through the analysis of faunal assemblages recovered from the excavation of prehistoric/protohistoric sites in the Mogoro territory. It revealed radical economical changes through time as a response to ecological evolution. Whereas during the 4th millennium, the Neolithic economy is focused on the exploitation of the Campidano plain resources with its pastures for cattle and coastal lagoons, during the 3rd millennium the Chalcolithic communities appear isolated from those ecosystems and they are instead projected towards the highlands, suggesting a resilient adaptation to new conditions. The Recent Bronze Age Nuragic economy appears wealthy and opened again to coastal ecosystems exploited with greater intensity. Despite the collapse and the un-inhabitability of the nuraghe during the Final Bronze Age, its ruins are used for ritualized banquets by a wealthy community that intensely exploits the best coastal, plain and plateau resources. Between Recent and Final Bronze Age there is a continuity both in terms of subsistence strategies and in terms of food preferences, confirmed by the constancy of the attested cooking techniques, attesting to a strong persistence of traditions.

Riassunto – Ecologia umana, cambiamenti economici e gastronomia nella Sardegna Centrale tra Neolitico ed Età del Ferro. Il caso studio del territorio di Mogoro (IV-I millennio A.C.) – La Sardegna è un esempio paradigmatico di un grande ambiente insulare che è cambiato nel tempo influenzando le strategie ecologiche ed economiche delle popolazioni umane.

L'area centro-occidentale dell'isola ospita una serie di morfologie ed ecosistemi particolarmente ricchi di risorse fondamentali per le comunità preistoriche/protostoriche: estese e produttive lagune costiere, una fertile pianura agricola con corsi d'acqua e stagni, terrazze boschive della fascia collinare e gli importanti giacimenti di ossidiana del Monte Arci. Il territorio di Mogoro è un punto di osservazione privilegiato per comprendere le dinamiche ecologiche nella Sardegna preistorica, essendo situato al centro di queste aree di produzione e posizionato lungo le vie di accesso preferenziali che collegano le pianure alle alture.
Il nucleo principale di questo articolo è la ricostruzione dell'economia locale in varie fasi che vanno dalla metà del IV all'inizio del I millennio a.C., attraverso l'analisi di associazioni faunistiche recuperate dallo scavo di siti preistorici/protostorici nel territorio di Mogoro. Lo studio ha rivelato radicali cambiamenti economici nel tempo come risposta all'evoluzione ecologica. Mentre nel IV millennio l'economia neolitica è incentrata sullo sfruttamento delle risorse della pianura del Campidano con i suoi pascoli per i bovini e le lagune costiere, nel III millennio le comunità calcolitiche appaiono isolate da quegli ecosistemi e sono invece proiettate verso gli altipiani, suggerendo un adattamento resiliente alle nuove condizioni. L'economia nuragica del Bronzo recente appare ricca e nuovamente aperta agli ecosistemi costieri sfruttati con maggiore intensità. Nonostante il crollo e l'inabitabilità del nuraghe durante il Bronzo finale, i suoi ruderi vengono utilizzati per banchetti ritualizzati da una comunità benestante che sfrutta intensamente le migliori risorse costiere, di pianura e di altopiano. Tra Bronzo recente e Bronzo finale si riscontra una continuità sia nelle strategie di sussistenza sia nelle preferenze alimentari, confermata dalla costanza delle tecniche di cottura attestate, attestante una forte persistenza delle tradizioni economiche e culinarie.

Parole chiave: Sardegna, Neolitico-età del Bronzo, Archeozoologia, Alimentazione antica, Economia preistorica.

Keywords: Sardinia, Neolithic-Bronze Age, Archaeozoology, Ancient Food, Prehistoric Economy.

INTRODUCTION (R.C.)

Covering a surface of around 24.000 sq km, Sardinia is the second largest island in the Mediterranean (fig. 1). The prehistoric cultures that followed one another in the region have left numerous settlement and funerary sites, often characterized by impressive megalithic developments.

After an intense neolithization period, the Chalcolithic culture of Monte Claro is characterized by the colonization of hilly areas and the construction of fortified sites with megalithic walls (Depalmas 1989; Moravetti 2004). In the Bronze Age, the Nuragic civilization covered the island with thousands of turreted structures (nuraghi) whose original role, function and intended use over time is still to be defined. At the end of the 2nd millennium BC the nuraghi are no longer built, but their frequentation continues in the following millennia (Vanzetti *et al.* 2013).

Despite there being thousands of prehistoric sites scattered throughout Sardinia, only a some of them have been thoroughly analysed to understand their economy and diachronic evolution (Wilkens 2012). Although numerous contexts, including different kinds of sites as settlements, ritual areas, open air and cave sites have been previously studied by different authors also from the Archaeozoology Laboratory of the University of Sassari, nevertheless none of them covers such a broad time span – almost three millennia – filling also the gap between Neolithic and Final Bronze Age. Moreover, most of the available data come from the Northern part of the island.

This work is the first documentation in Central and Southern Sardinia of the ecological and economical evolution – in the same geographic location – of a prehistoric population from the 4th to the beginning of the 1st millennium BC.

As part of the investigations carried out by the University of Cagliari at two sites in the Municipality of Mogoro (Puisteris and Cuccurada), the discovery of layers rich in faunal remains within well dated contexts required an in-depth archaeozoological analysis aimed at reconstructing fundamental aspects of the ecology and economy of the local human community and, most importantly, the exploitation of animal resources, diet, and food preparation and cooking techniques.

Preliminary analyses (Carannante and Chilardi 2015) revealed the exploitation of different resources at the sites, evidencing radical economical changes during the three millennia considered.

Fig. 1. The island of Sardinia and the Gulf of Oristano.
La Sardegna con il Golfo di Oristano.

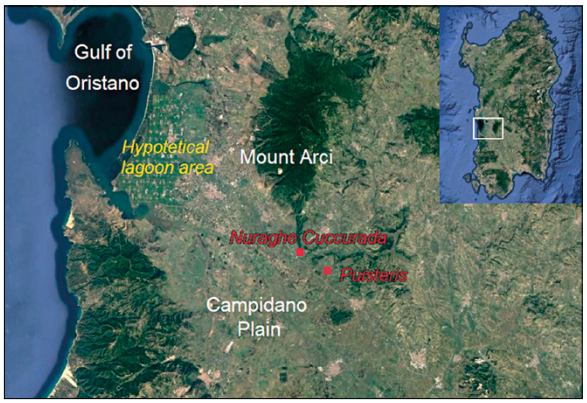

Fig. 2. The location of the archaeological sites cited in the text along with the position of Mount Arci and the ancient lagoon area.
Siti archeologici citati nel testo in relazione alla posizione di Monte Arci e alle antiche aree lagunari del Campidano.

The long duration of the periods explored and the archaeological complexity of the studied area, however, required further study in order to define some aspects in greater detail.

Therefore, the aims of this paper are:

– to define the role of the dominant animal resources in the different periods
– to evidence economical and social changes over the three millennia considered
– to identify changes in gastronomical traditions

1. THE ARCHAEOLOGICAL BACKGROUND OF THE MOGORO AREA (R.C.)

1.1 Regional setting

The region under study corresponds to the area of the Municipality of Mogoro, in central-western Sardinia, characterized by a great wealth of archaeological evidence, especially from the prehistoric and protohistoric periods, but also from the Punic, Roman and medieval age.

The Mogoro area is very important to study due to its location along one of the best transport routes between the vast Campidano plain and the volcanic highlands, just at the feet of Monte Arci. This volcano is one of the main and best obsidian sources in the Mediterranean (Tykot 1998). The river Rio Mogoro descends from Monte Arci carrying obsidian, and flows to the nearby coastal lagoons bordering the plain at north. Such a strategic location, between fertile plains, fishy lagoons, wooded plateaus and Monte Arci, offered a wide range of very different ecosystems with resources whose exploitation changed on the basis of human needs and social organization. This justifies the exceptional density of sites distributed in the Mogoro area starting from the Neolithic period (Atzeni *et al.* 2015). The two most representative sites for the prehistoric and protohistoric phases of the area are Puisteris and Cuccurada, which are also located in view of one another (about 1 km away). Recent archaeological investigations at both sites allow us to reconstruct, in a diachronic sense, the fundamental aspects of the ecology and economy of the local human community in the prehistoric and protohistoric periods (fig. 2).

1.2 Puisteris site setting, stratigraphy and chronology

Puisteris is a prehistoric hut village, located in an area of Miocene limestone deposits on the southwestern slopes of the basaltic plateau of Perdiana (fig. 3), adjacent to the course of the Rio Mogoro (Cicilloni 2017). Investigations carried out since the 1950s brought to light a vast housing settlement on the site, strongly linked to agricultural activities and to the processing of obsidian, which was easily obtainable, at a short distance, along the course of the river. The village

Fig. 3. View of the Nuraghe Cuccurada (in the foreground) and the basaltic plateau where the settlement of Puisteris was located (in the background).
Veduta del Nuraghe Cuccurada (in primo piano) e dell'altopiano basaltico su cui sorgeva l'insediamento di Puisteris (sullo sfondo).

was characterized by the presence of numerous circular or elliptical huts with stone wall bases on which probably rested a straw cover, with poles and branches. An excavation carried out in the south-western part of the settlement in the 2000s highlighted some cavities in the ground, containing pottery, lithic and food remains, pertinent to the most important phase of the village related to the Ozieri culture (Recent Neolithic: first half-third quarter of the 4th millennium BC).

During the Chalcolithic period Puisteris was virtually abandoned, but a new village was built just on the top of Mogoro cliff in an easily defensible position.

1.3 Cuccurada site setting, stratigraphy and chronology

The Cuccurada-Mogoro site was first excavated in 1994 and continued until the present (Atzeni *et al.* 2015). It stands on the southern tip of the basalt plateau of Sa Struvina, dominating the Campidano plain, at the mouth of the Rio Mogoro valley (fig. 3). The investigations, still in progress, highlighted an important multi-layered settlement whose construction phases cover a period between the end of the Neolithic and the end of the Bronze Age. Sporadic finds dating back to the Recent Neolithic attest to close contacts with the nearby prehistoric settlement of Puisteris, located on the other bank of the Rio Mogoro but, during the 3rd millennium BC (Monte Claro culture), the area was occupied by an important Chalcolithic settlement surrounded by an imposing megalithic wall. During the Middle Bronze Age, a primitive "archaic nuraghe" was built on the top of the settlement. Later this structure was enlarged by adding a bastion, composed of four peripheral towers connected by rectilinear curtains reinforced by imposing walls. These surrounded a vast sub-trapezoidal courtyard, creating a multi-lobed complex nuraghe. The Nuragic complex was eventually completed by a hut village surrounding the nuraghe (fig. 4). The whole complex dates back to cultural horizons between the Middle and Recent Bronze Age, with sporadic occupation in the Final Bronze Age and in the First Iron Age (Atzeni *et al.* 2016).

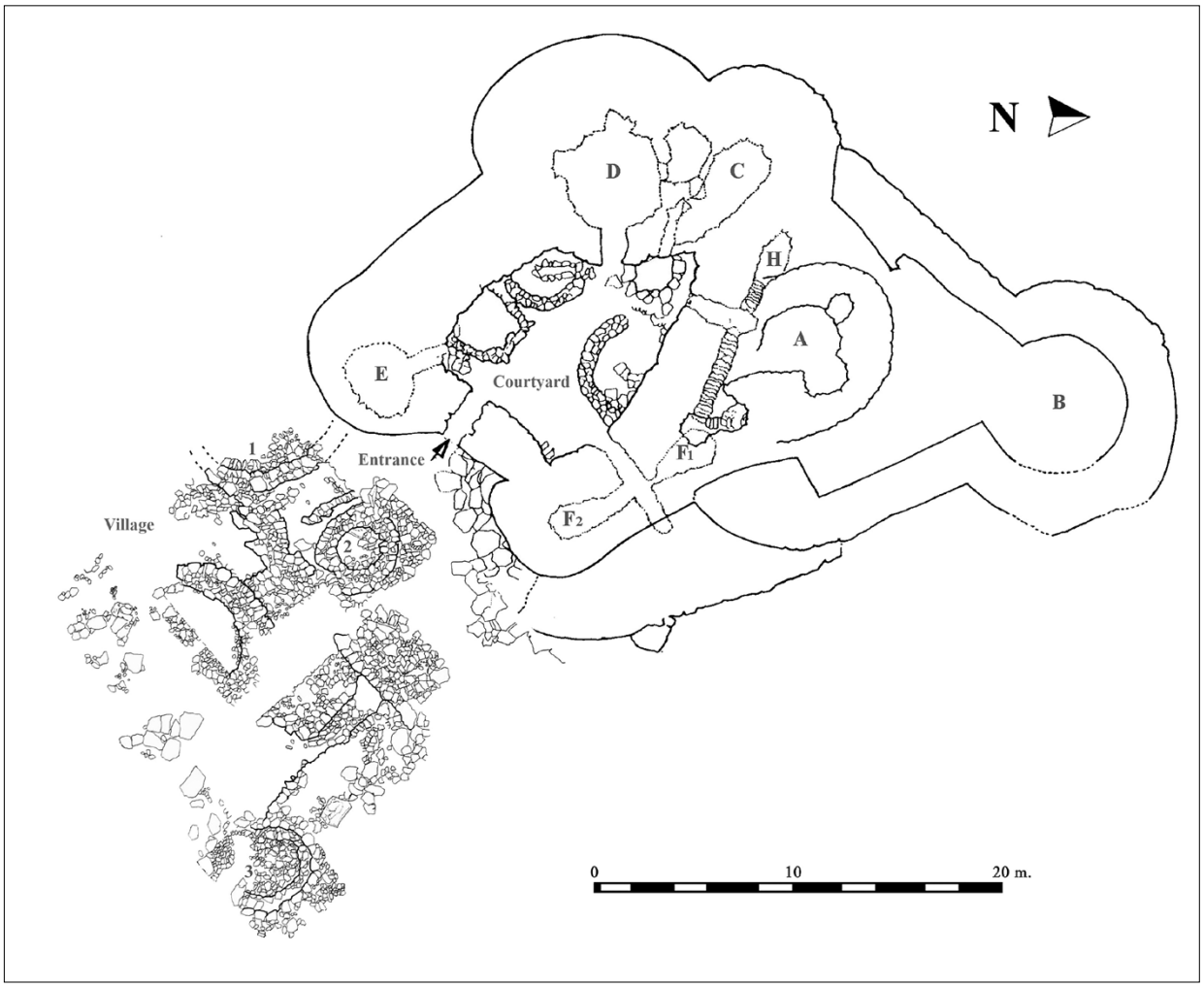

Fig. 4. Mogoro – Nuraghe Cuccurada. Plan of the Nuragic complex (A – E = towers).
Mogoro – Nuraghe Cuccurada. Pianta del complesso nuragico (A-E= torri)

Abundant food remains assemblages have been found in the strata dating to the three different phases of occupation in the nuraghe.

1.3.1 *Chalcolithic phase*

The Chalcolithic phase (3rd millennium BC) at the site was at first attested by relevant potsherds found on the surface. Excavations revealed that nuragic layers covered a previous Monte Claro settlement. Some trenches in the south-east area in front of the nuraghe entrance brought to light abundant ceramic and faunal remains pertinent to the Chalcolithic frequentation of the area. The monumental remains of the cyclopean wall (fig. 5) located south-west of the nuraghe complex, and an elliptical structure also in cyclopean work called "Cuccurada A", can be referred to this phase. Chalcolithic fortified villages, typical of Monte Claro culture, show several examples of these kinds of megalithic structures that are concentrated in the central-northern part of Sardinia anticipating those of the Bronze Age (nuraghi). The Sardinian Chalcolitic fortifications, often located on a perched position at the edge of hilltops, were certainly built as response to defence needs in possible tribal conflicts with other populations, according to Depalmas (1989).

Like many Monte Claro sites, Cuccurada became the centre of a territorial reorganization during the Bronze Age. As stated before, an archaic nuraghe was built on the top of the Chalcolithic settlement during the Middle Bronze Age. The intense megalithic reorganization of the subsequent phases has unfortunately erased the traces of frequentation connected to this period.

Fig. 5. Mogoro – Cuccurada. The megalithic wall of the Chalcolithic phase with the Bronze Age nuraghe in the background.
Mogoro – Nuraghe Cuccurada. La cinta megalitica della fase calcolitica con sullo sfondo il nuraghe dell'età del Bronzo.

1.3.2 *Recent Bronze Age phase.*

The Recent Bronze Age (1350-1150 BC) was a very important phase in the life of the site. During this period, the primitive archaic Middle Bronze nuraghe was incorporated into a more complex, "polylobed" structure (fig. 4) (Cicilloni 2018). Radiocarbon dates for the Recent Bronze Age have been obtained from Tower D (1420-1120 cal. BC) (Cicilloni 2018). In this period, the construction of some huts is also attested both outside and inside the courtyard of the nuraghe (Cicilloni 2017). During this period, Cuccurada becomes the main centre of an articulated territorial system including a rich network of monuments related to the Nuragic civilisation, such as nuraghi, giants' tombs and villages. A control system existed on the basaltic plateau consisting of Nuragic buildings located in strategic positions with visual connections between them, in order to defend the economic wealth of the region and to guard the access routes towards the interior (Cicilloni *et al.* 2015; 2016).

1.3.3 *Final Bronze Age phase.*

Between the Recent Bronze Age and the Final Bronze Age the nuraghe Cuccurada suffered severe collapses. The huts in the courtyard were abandoned and covered by a layer of collapsed building materials. In the Final Bronze Age (1150-850 BC), however, there still was a frequentation of the ruined monument, as attested mainly in the deposits of the Tower D and of the courtyard (fig. 6). Here, starting from the angle between the external face of tower C and the north front of the courtyard, two archaeological layers, SSUU 71 and 72, one superimposed on the other, were present underneath a substantial collapse layer, both characterized by potsherds dating to Final Bronze and, to a lesser extent, to the first phase of the Iron Age.

The partially collapsed walls and the beaten floors of three Nuragic huts dating to the Recent Bronze Age, located inside the courtyard, during the Final Bronze Age were covered by the conical fan (SU 72) gradually expanding downwards, from the height corresponding to the threshold of Tower C, to cover the entire area of the courtyard. This consisted of dark brown soil of medium compactness mixed with boulders of medium size and was likely created by the collapse of part of the northernmost wall and towers. In the Late Bronze Age, SU 72 was probably used as a ramp to access the upper chamber of Tower C among the rubble of the ruined nuraghe. In

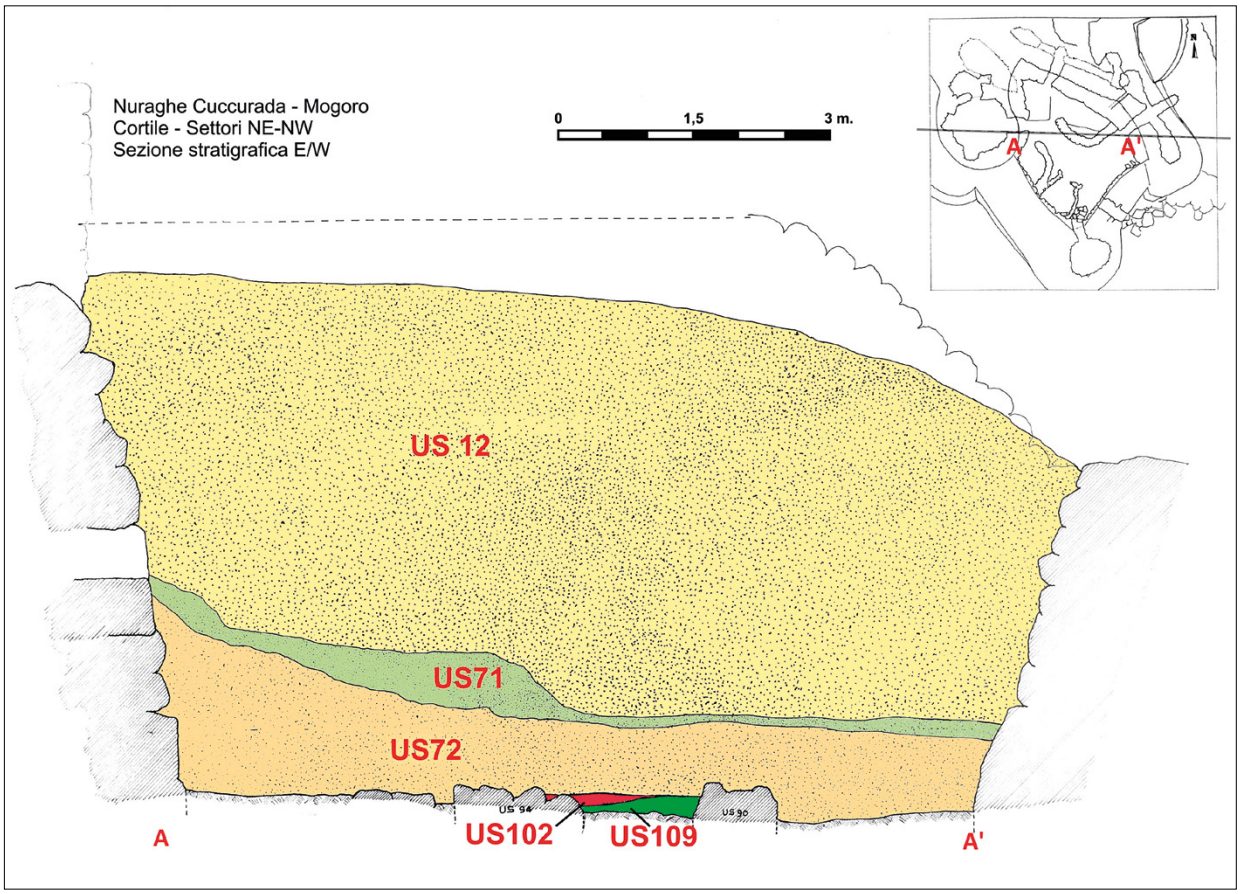

Fig. 6. Mogoro – Nuraghe Cuccurada. Stratigraphic section of the courtyard.
Mogoro – Nuraghe Cuccurada. Sezione stratigrafica del cortile.

fact, the top layers of SU 72 were characterized by abundant archaeological material: large quantities of coal fragments, abundant bivalve shells, poorly preserved animal bone fragments, potsherds, lithic finds (millstones and grinders), and bronze remains. Such remains presumably thrown from the elevated entrance of Tower C probably infiltrated the collapsed medium-sized boulders deposits.

The SU 72 was covered by a thinner SU71, with an average thickness of approx. 25 cm, made up of small, crushed stone mixed with dark brown soil of medium compactness, very rich in animal bones, mollusc shells, coal fragments and potsherds. This deposit, similar to the previous one for chronology and content, was likely an arrangement of the materials unloaded on the fan, to facilitate access and passage to the Tower C, suggesting that in the final stages of the Bronze Age the ruins of the collapsed and no longer inhabitable nuraghe were at the centre of non-sporadic activities involving the consumption/offering of mammals and molluscs.

After a rather sporadic occupation in the Iron Age, the monument was definitively abandoned and suffered a final series of collapses.

2. MATERIALS AND METHODS (S.C.)

The examined faunal assemblage includes 3.426 finds from the various excavation sectors. The materials present a fairly high degree of fragmentation, although inhomogeneous and variable, which has obviously influenced their identification.

All the finds analysed come from sealed contexts corresponding to chronologically well-defined phases.

In order to delineate the diachronic evolution of the local economy, the data have been grouped into four large groups corresponding to at least four phases of life in the territory:

1. Recent Neolithic phase characterized by finds from the Puisteris site pertinent to the Ozieri culture (4th millennium BC).
2. Late Chalcolithic (3rd millennium BC). Archaeozoological remains from Cuccurada associated with materials pertinent to the Monte Claro culture.
3. Recent Bronze Age (1350-1150 BC). Archaeozoological remains from the huts built in the courtyard of the Cuccurada Nuraghe.
4. Final Bronze/Early Iron Age (1150-850 BC). Archaeozoological remains from the collapse deposits of the same nuraghe that had partially covered the courtyard containing the huts.

3. RESULTS

3.1 Final Neolithic phase of the Puisteris village (Ozieri facies) (A.C.)

The oldest examined sample is the result of a limited excavation test carried out in the large village of Puisteris and characterized by materials pertinent to the facies of Ozieri of the Final Neolithic. Although limited to only 506 finds, it provides an interesting picture of the exploitation of animal resources in this phase of occupation of the Mogoro territory.

Table 1 summarizes, for each identified taxon, the Number of Remains (NR) and the relative percentage with respect to the faunal assemblage of the Neolithic phase, in addition to the corresponding Minimum Number of Individuals (MNI). The Percentage Number of Remains (NR%) was calculated only for the taxa identified to genus level and, furthermore, given the small size of the sample, the data relating to the Minimum Number of Individuals is purely indicative.

More than half of the archaeozoological remains from the Neolithic Puisteris village are represented by marine molluscs (265 remains, 52.4%). Almost all of them (213 remains) are lagoon-cockle valves (*Cerastoderma glaucum*) and clams (*Ruditapes decussatus*). For both species, the large size of the specimens found should be noted. Today, in fact, the species *Cerastoderma glaucum* has a variable length between 20 mm and 35 mm and only rare specimens can reach 50 mm (Poppe and Goto 1993: 95). In Puisteris, however, the dimensional range of the valves ranges from 33 mm to 54 mm with a peak around 47 mm, exceeding the maximum limits indicated for many specimens. Even the valves of *Ruditapes* found in Puisteris have a variable length between 48 mm and 75 mm reaching the maximum size (76 mm) of the species.

Taxon	NR	NR%	MNI
Bos taurus	25	7.4%	2
Ovis/Capra	26	7.7%	2
Sus domesticus	10	3.0%	2
Canis familiaris	2	0.6%	1
Vulpes sp.	1	0.3%	1
Large size Mammals	25	-	-
Medium size Mammals	138	-	-
Cerastoderma glaucum	110	32.8%	45
Ruditapes decussatus	103	30.7%	39
Mytilus galloprovincialis	38	11.2%	20
Ostrea edulis	10	3.0%	5
Glycymeris glycymeris	1	0.3%	1
Patella ulyssiponensis	2	0.6%	2
Patella depressa	1	0.3%	1
Cornu aspersum	3	0.9%	3
Helix sp.	6	1.8%	6
Rumina decollata	5	1.0%	5
Total	*506*	*100*	*135*

Table 1. Puisteris Village – Composition of the faunal assemblage during the Neolithic (Ozieri culture).
Villaggio di Puisteris – Composizione dell'insieme faunistico durante il Neolitico (cultura di Ozieri).

Much less abundant are the remains of mussel (*Mytilus galloprovincialis*) and Mediterranean oyster (*Ostrea edulis*). A single valve of *Glycymeris glycymeris* – highly eroded by wave motion and collected for non-food purposes – is also present in the bivalve assemblage.

The marine archeomalacological assemblage is completed by three patella shells (*Patella ulysseponensis* and *Patella depressa*), which represent the only remains of marine gastropods.

All identified species, except the rare patella, are characteristic of the Mediterranean lagoons with variable salinity and, in particular, the abundance of large lagoon-cockles indicates a habitual collection in the lagoon environment.

Traces of forced anthropogenic opening of the valves found on the scutellum area of five heart-cockle valves indicate that, at least sporadically, these molluscs were eaten raw.

Fourteen shells of gastropods belonging to three terrestrial species (*Helix* sp., *Cornu aspersum*, *Rumina decollata*) could also attest to the rare consumption of snails.

Another half of the finds identified in Neolithic Puisteris (226 remains, 44.7%) belong to mammals, the only class of vertebrates present in the sample examined. However, of these, only 64 were identified taxonomically and anatomically. The remaining 162 fragments were divided, according to dimensional criteria, as belonging to large or medium-sized mammals.

Even though the limited sample size requires some caution in the interpretation of the data, it is still possible to elaborate upon some considerations. As far as terrestrial tetrapods are concerned, the fauna as a whole consists almost exclusively of domestic mammals; the only wild species definitely present is the fox, and both birds and reptiles are missing.

The percentage occurrence of cattle remains is practically equivalent to that of sheep and goats, highlighting how the economy of the settlement, with regard to animal resources, was not mainly based on small scale herding.

The low occurrence of wild mammals is not a surprise if we compare the data obtained for other Ozieri culture sites. The fauna groups related to the coeval villages (Wilkens 2012) of Pabaranca – where wild mammals are totally absent – and of Contraguda – in which only *Prolagus sardus* is present with a percentage equal to 2.8% of the identified remains – show how the neolithization process was now fully accomplished and how breeding was one of the fundamental pillars of the productive economy of the villages. The considerable balance between cattle and sheep and goats is also found in the aforementioned inhabited area of Pabaranca, where they are represented by 40.7% and 49.7% of the remains respectively.

With regards to the age of death, the data available are rather limited, however it is worth noting that all the remains of the postcranial skeleton attributable to *Bos taurus* show fused epiphyses typical of animals that had exceeded 30-36 months and the teeth (all permanent) show medium advanced wear, while among the remains of *Ovis/Capra* at least two remains belong to rather young individuals.

Taxon	NR	NR%	MNI
Bos taurus	11	17.7%	2
Ovis/Capra	27	43.6%	4
Sus domesticus	14	22.7%	2
Canis familiaris	1	1.6%	1
Cervus elaphus	4	6.4%	3
Ovis cfr. *O. musimon*	4	6.4%	2
Large size Mammals	3	-	-
Medium size Mammals	87	-	-
Cornu aspersum	1	1.6%	1
Total	*122*	*100*	*15*

Table 2. Mogoro – Cuccurada. Composition of the faunal assemblage during the Chalcolithic phase (Monte Claro culture).

Mogoro – Cuccurada. Composizione dell'insieme faunistico durante la fase Calcolitica (cultura di Monte Claro).

Diagenetic processes, strongly influenced by the acidity of the soil and by the marly-calcareous substrate, have evidently altered the bone surfaces, making it difficult to observe cut marks that would allow to reconstruct, even partially, the transformation phases of the carcass to create resources useful to the village economy. Burnt traces are also very rare, limiting themselves to a completely carbonized bovine metapodial trochlea and a medium-sized charred mammalian diaphysis fragment, too little to form hypotheses about food preparation methods in Puisteris.

A fragment of the diaphysis of a bovine ulna shows clear signs of gnawing probably attributable to dogs, whose presence in the inhabited area is, however, attested by two teeth hypothetically attributable to a single adult individual.

3.2 Chalcolithic phase of the Cuccurada-Mogoro village (Monte Claro facies) (S.C.)

The second analysed sample comes from sealed contexts characterized by materials pertinent to the Monte Claro culture and relating to the remains of a village dating back to the late Chalcolithic period underneath the Nuragic village of Cuccurada.

This sample is small in size, consisting of only 152 identified remains. 62 of these were identified

to genus or species level, whereas the remaining 90 are attributable to various portions of the skeleton of medium and large mammals.

The data obtained are summarized in table 2, following the same criteria used for materials from the Neolithic village of Puisteris. However, given the small size of the sample, the frequency percentages obtained must be considered purely indicative.

What is immediately striking, comparing the composition of the fauna with that obtained for the settlement of Puisteris, is the total lack of molluscs from marine / lagoon environments and the presence of wild mammals species such as red deer (*Cervus elaphus*) and mouflon (*Ovis musimon*) totally absent in the context previously examined.

Among the domestic taxa identified, *Ovis/Capra* are the most represented, followed by pigs and cattle, whereas only one element is attributable to dog. Red deer is represented by three teeth, all belonging to adult or young/adult individuals, while four other bone fragments, one tooth, one tarsal and two metapodials, can be compared with skeletal elements of mouflon allowing their attribution, even if not totally certain.

The wild taxa are completed by a shell of *Cornu aspersum*: this species of terrestrial pulmonate gastropod is the only mollusc in the sample, in stark contrast to what was found in Puisteris.

The data relating to the ages of death are not very indicative since the number of individuals identified is very low; it is worthwhile, however, to report among the individuals of *Ovis/Capra* the presence of a specimen whose age must certainly have been less than twelve months and, among the three deer individuals, a large adult specimen. Two fragments of adult bovine metatarsals with small dimensions also indicate the presence at this stage of a select smaller variety of cattle.

From a taphonomic point of view, the finds from the Chalcolithic settlement are better preserved than those of Puisteris. The difference in substrate and lower acidity of the soil have better preserved the bone surfaces, therefore, despite the smaller number of finds available, traces of anthropogenic modification appear more frequently. It was thus possible to observe some traces of butchery which include a slash on a bovine scapula – connected to the de-segmentation of the corresponding anatomical element – and some cut marks on a *Ovis/Capra* atlas, located near the articular facets with the skull, likely caused by the detachment of the head from the rest of the carcass.

Burnt traces are present on six bone fragments pertinent to medium-sized mammals; these are carbonizations with a characteristic black colour; however, they can tell us little about any method of cooking food.

Finally, a fragment of a medium-sized mammalian tibia diaphysis was worked to obtain, probably, an awl.

3.3 Recent Bronze Age phase of the Cuccurada-Mogoro Nuraghe (S.C.)

The examined Bronze Age contexts pertain to the Cuccurada Nuraghe, partially built by concealing the remains of the previous fortified Chalcolithic village.

The analysed materials come from several Stratigraphic Units referable to two occupation phases of the structure, datable respectively to the Recent Bronze Age and the Final Bronze Age. A total of 2768 fragments have been identified, attributable to at least 25 different taxa comprising mammals, birds, reptiles, fish and molluscs, highlighting an extraordinary taxonomic variety of fauna.

In light of this, and in order to highlight any differences in the calculated quantitative parameters, the detailed examination and the display of the data obtained from the two chronological phases were treated separately.

The first archaeozoological sample of the Cuccurada Nuraghe comes from several Stratigraphic Units pertaining to the occupation and filling of a Recent Bronze Age hut built inside the courtyard of the nuraghe, close to the northern bastion. The context is sealed by the Final Bronze Age collapse of the hut itself, and of the nuraghe towers. This sample consists of 763 identified fragments, of which 688 were taxonomically determined to at least at the family level. The faunal assemblage consists of 16 different taxa, including mammals, birds, fish, and molluscs.

The quantitative data, obtained using the same calculation criteria of the previous contexts, are summarized in table 3.

The vertebrate faunal assemblage is heavily dominated by domestic *taxa* which alone account for just over 92% of the determined remains. The economy of the community, in light of the clear

Taxon	NR	NR%	MNI
Bos taurus	90	13.0%	4
Ovis/Capra	426	61.8%	13
Sus domesticus	120	17.3%	4
Canis familiaris	1	0.1%	1
Sus scrofa	1	0.1%	1
Cervus elaphus	11	1.5%	2
Prolagus sardus	3	0.4%	2
Large size Mammals	8	-	-
Medium size Mammals	59	-	-
Small size Mammals	1	-	-
Indet. Birds	1	0.1%	1
Mugil cephalus	2	0.3%	1
Sparus aurata	2	0.3%	1
Indet. Sparidae	2	0.3%	-
Cerastoderma glaucum	10	1.3%	5
Glycymeris glycymeris	1	0.1%	1
Mytilus galloprovincialis	4	0.6%	4
Ostrea edulis	10	1.3%	5
Eobania vermiculata	4	0.6%	4
Rumina decollata	1	0.1%	1
Indet. Pulmonata	6	0.8%	-
Total	*763*	*100%*	

Table 3. Mogoro – Nuraghe Cuccurada. Composition of the faunal assemblage during the Recent Bronze Age phase.

Mogoro – Nuraghe Cuccurada. Composizione dell'insieme faunistico durante la fase del Bronzo recente.

prevalence of *Ovis/Capra*, seems to be based essentially on small-scale sheep farming to which are added, in order of importance, pigs and cattle. Wild mammals are represented by a few remains pertaining to at least two individuals of red deer (*Cervus elaphus*), two individuals of prolagus (*Prolagus sardus*), and a partially preserved male wild boar canine (*Sus scrofa*). The rare game remains suggest that hunting played a marginal role in the economy of the Nuragic community of Cuccurada. Particularly noteworthy is the fact that the deer remains include isolated teeth, portions of the axial skeleton and limbs, but not fragments of the skull. The assemblage of mammals is completed by a single fragment attributable to a dog: a portion of the tibia, belonging to an individual under the age of 10 months (Silver 1969).

Among the *Ovis/Capra*, at first glance, sheep prevail with a ratio of 4 to 1. The animals were rather small; on the basis of osteometric data, obtained from radii, metacarpals, tibias, calcaneus and whole metatarsals, it was possible to reconstruct, applying the Teichert coefficients (1975), ten withers heights with an average of 51.8 cm, a maximum of approximately 59 cm obtained from an *Ovis* metacarpal and a minimum of just 45 cm obtained from a complete radius with distal fused epiphysis and therefore over 36 months of age (Silver 1969). The small size of sheep finds a close parallel in those of the Middle Bronze Age studied at the site of the Nuraghe Madonna del Rimedio in Oristano where the heights at the withers correspond well (Santoni and Wilkens 1996: 31). The same correspondence between the two sites is found with regards to the size of the pigs.

Cuccurada pig had an average withers height of 68.6 cm calculated (Teichert 1969) using three measurements taken from metacarpals and metatarsals, while in terms of cattle, it was possible to calculate (Matolcsi 1970) a single withers height obtained from an adult metacarpal, which returned a value of 104.6 cm. The mortality curve obtained for sheep and goats, calculated according to the method proposed by Payne (1973), highlights a high percentage of kills between 6 and 12 months of age. This percentage remains high until the fourth year of life of the animals, beyond which only 32.9% of the flock survive. Such a trend reflects a fairly complex exploitation focused on meat production, but in which milk and its derivatives also constituted an important resource, with wool having a minor, although not entirely secondary, role. Pigs were typically slaughtered between 18 and 36 months of life, *i.e.* when the maximum meat yield was reached, though at least one child / neonatal age was present. The cattle were mainly adult individuals; the deciduous teeth are totally missing and in only one case there is certainly an age of less than 36 months.

2.2% of mammal remains have traces of butchery, affecting all domestic species – except the dog – and, in one case, deer. In most cases these are traces of disarticulation represented by short and thin cut marks, but it is interesting how two remains of bovine are, on the contrary, affected by tools of a certain weight that have caused evident truncations.

In terms of the butchering process, the beheading of the animal is the most attested procedure. It is recorded in as many as seven cases, five of which are on specimens of *Ovis/Capra*, and the remaining two on individuals of pig and deer. Of particular interest is the presence of cut marks on a specimen of hyoid bovine bone (fig. 7), aimed at removing the tongue, as well as the attestation of a cut mark from skinning observed on a first phalanx, once again of *Bos taurus*, and attributable to a use of cowhide (fig. 8).

Just under 7% of the osteological material shows traces of combustion of various degrees, sometimes connected with the preparation of food. In this case, brown or blackish halos can be seen on the exposed parts of the joints and bony portions protruding from the flesh. Furthermore, in some cases calcination or total carbonization can be seen, related to the throwing of meal remains into hearths and to the fact that bones are good fuel sources due to their fat content.

In the Recent Bronze Age, the exploitation – albeit moderate – of lagoon resources resumes. Lagoon – cockle (*Cerastoderma glaucum*), oyster (*Ostrea edulis*) and mussel (*Mytilus galloprovincialis*) are characteristic of the Mediterranean lagoons as well as the only fish species present in the sample: the gilt-head bream (*Sparus aurata*) and the grey mullet (*Mugil cephalus*).

Also worth mentioning are a bream dental bone with a marked black combustion halo on the cranial margin, indicating rapid cooking of the specimen on embers, and two oyster valves with traces of forced opening on the posterior margin, attesting to the consumption of raw molluscs.

Some finds attest to the use of animal hard materials to make commonly used objects and ornaments. A 66 mm long *Glycymeris glycymeris* valve shows artificially smoothed edges and an ellipsoidal hole smoothed on the umbo with internal friction erosion (fig. 9); this type of finding indicates the use of these valves as concave pallets to be handled for the production of spoons intended for the consumption of hot liquid or semi-liquid food. With regards to mammal bones, a fragment of bovine diaphysis appears worked to create a sharp point, whilst a sheep/goat metatarsal diaphysis fragment appears carefully worked and polished to create a cylindrical bead, probably intended for ornamental use.

Fig. 7. Mogoro – Nuraghe Cuccurada. Bovine hyoid bone with cut marks.

Mogoro – Nuraghe Cuccurada. Osso ioide bovino con tracce di macellazione.

Fig. 8. Mogoro – Nuraghe Cuccurada. Bos taurus first phalanx with cut marks.

Mogoro – Nuraghe Cuccurada. Prima falange di Bos taurus con cut mark.

Fig. 9. Mogoro – Nuraghe Cuccurada. Shell of Glycymeris sp. with a drilled hole in the umbonal area.

Mogoro – Nuraghe Cuccurada. Conchiglia di Glycymeris forata all'umbone.

3.4 Final Bronze Age phase of the Cuccurada-Mogoro Nuraghe (A.C)

The last sample examined includes 2009 fragments of which 1900 have been taxonomically identified to at least at the family level, demonstrating a total of at least 22 different taxa including seven of mammals, two of birds, one of reptiles, two of fish and ten of molluscs. This sample is statistically representative of a larger fauna set of some thousands of finds characterized by a high degree of fragmentation.

The sample comes from Stratigraphic Unit 72 in the courtyard of the Cuccurada Nuraghe which cover the chaotic collapses of the towers and correspond to continued use of the structures despite the loss of functions of the nuraghe itself. These deposits are sealed by subsequent Iron Age collapses which led to the final abandonment of the structure.

The quantitative data relating to this last phase are summarized in table 4.

Over half of the finds from this phase are represented by marine mollusc remains (1072, 53.4%) of which almost all (969 remains) are lagoon-cockle valves (*Cerastoderma glaucum*). These percentages resemble the situation already found for Neolithic Puisteris. However, the dimensional range of the valves from the Final Bronze Age goes from 23 mm to 36 mm, with a peak around 27 mm, placing these specimens in the current norm of the species in contrast of what recorded in the Neolithic Puisteris shell assemblage.

Much less abundant are the remains of clams (*Ruditapes decussatus*), Mediterranean oysters (*Ostrea edulis*) and mussels (*Mytilus galloprovincialis*) which – like the heart-cockle typical of transitional environments – confirm a collection of molluscs focused on the exploitation of coastal lagoons.

The grey-mullet (*Mugil cephalus*) and the gilthead bream (*Sparus aurata*) were the only species of fish identified in the Recent Bronze Age and, as habitual frequenters of the Mediterranean lagoons, also confirm the exploitation of these environments for fishing activities.

The bivalve remains are completed by two fragments of *Pinna nobilis* (the large noble pen shell), and by a 61 mm long *Glycymeris glycymeris* valve with artificially smoothed edges and an ellipsoidal hole smoothed on the umbo with internal rubbing erosion confirming the use of this species to make spoons also in the Final Bronze Age. The marine archaeomalacological assemblage is completed by three murex specimens (*Truncullariopsis trunculus* and *Bolinus brandaris*) which are the only remains of marine gastropods.

A single lagoon-cockle valve shows traces of shellfish opening attesting they were sometimes eaten raw.

Sixty shells of Pulmonate gastropods belonging to at least three terrestrial species (*Helix* sp.,

Taxon	NR	NR%	MNI
Bos taurus	204	10.70%	6
Ovis/Capra	376	19.70%	23
Sus domesticus	154	8.00%	9
Sus scrofa	1	0.05%	1
Cervus elaphus	21	1.10%	2
Lepus sp.	1	0.05%	1
Prolagus sardus	12	0.60%	2
Indet. Rodents	1	-	-
Large size Mammals	15	-	-
Medium size Mammals	78	-	-
Passeriformes	1	0.05%	1
Indet. Birds	8	0.40%	-
Emys orbicularis	1	0.05%	1
Mugil cephalus	3	0.15%	1
Sparus aurata	1	0.05%	1
Cerastoderma glaucum	969	51.00%	437
Mytilus galloprovincialis	8	0.40%	4
Pinna nobilis	2	0.10%	1
Ostrea edulis	33	1.70%	14
Ruditapes decussatus	56	2.90%	5
Glycymeris glycymeris	1	0.05%	1
Truncullariopsis trunculus	2	0.10%	1
Bolinus brandaris	1	0.05%	1
Eobania vermiculata	48	2.50%	48
Helix sp.	2	0.10%	2
Rumina decollata	4	0.20%	4
Indet. Pulmonata	6	-	-
Total	*2009*	*100%*	

Table 4. Mogoro – Nuraghe Cuccurada. Composition of the faunal assemblage during the Final Bronze Age.
Mogoro – Nuraghe Cuccurada. Composizione dell'insieme faunistico durante la fase del Bronzo finale.

Eobania vermiculata, *Rumina decollata*) may also attest to the rare consumption of snails.

The other half of the finds identified in the Late Bronze Age phase pertain to mammals, among which sheep and goats are the most represented taxon, followed by cattle and pigs. The wild species are mainly represented by deer (*Cervus elaphus*) followed by endemic sardinian rodent the prolagus (*Prolagus sardus*), while hare (*Lepus* sp.) and wild boar (*Sus scrofa*) are represented by only one fragment each. A fragment of a *plastron* of an adult marsh turtle (*Emys orbicularis*) and nine remains attributable to birds – including a passerine –, these not certainly attributable to an anthropic transport, complete the list of terrestrial tetrapods.

Of particular interest in this context is the presence of the hare – an animal certainly introduced on the island and rather rare among the Bronze Age assemblages – and of the prolagus, a species which, in the period under consideration, was close to extinction (Wilkens 2012).

From a morphological point of view, the presence of a fragment of hornless sheep skull, probably female, and of relatively curved but not twisted goat-shaped horn is reported. Five heights at the withers were calculated for the sheep/goats, one on the metacarpus and four on the talus which returned an average height of 52.2 cm, with a minimum value of 50.3 cm and a maximum of 54 cm, confirming their rather small size in the Sardinian Bronze Age.

For pigs, it was possible to calculate four measures, all on astragali; the average withers height obtained is 64.5 cm, with minimum and maximum values of 63.3 cm and 65.2 cm, respectively.

Among the cattle remains, no skeletal elements were useful for the reconstruction of their withers heights. However, the concomitant presence of relatively small sized cattle remains, and elements attributable to large individuals, including a fragment of the frontal bone, stands out with part of a particularly imposing horn core indicating the coexistence of two races of remarkably different sizes. A first phalanx with pathological exostoses testifies to the use of cattle as working animals.

The sheep and goats have a highly concentrated age of death between 12 and 24 months, an interval in which almost 50% of the specimens were killed. This data suggests that their presence in the Stratigraphic Units dating back to the Final Bronze Age is primarily linked to the consumption of meat, even if some very immature or elderly individuals are present.

Among the pigs, the presence of five remains pertaining to at least two piglets is reported, accompanied by older individuals generally under the age of 36 months. The male / female ratio obtained from the lower canines is 4 to 1.

The cattle remains belong, as in the previous phase, mainly to adult individuals. Only an unerupted third definitive premolar testifies to the presence of an individual under 18-30 months (Grant 1975), whose presence seems confirmed by a second phalanx with an unfused distal epiphysis that suggests an age less than about 18 months (Silver 1969).

Traces of butchery are rather rare: only thirty fragments – less than 1.5% of the total – have cut marks of some kind. As already noted for the materials dating back to the Recent Bronze Age phase, there are thin cuts, often located on the atlas or the cervical vertebrae, and there are some examples of chops and dismemberment of the bones of large mammals.

Only 1.6% of the bone remains show burnt traces.

Also of note is a *Ovis/Capra* astragalus with its cranial surface clearly abraded and smoothed, as well as smooth edges of enigmatic function.

4. DISCUSSION (A.C. and S.C.)

Considering the data obtained for the different phases of protohistoric occupation of the territory of Mogoro, it is possible to reconstruct, also in a diachronic sense, fundamental aspects of the ecology and economy of the local human community, but also the exploitation of animal resources, nutrition, and food preparation with cooking techniques.

Taxonomical data, kill-off patterns, ecology of the species involved were crossed together and aggregated according to the different phases depicting the complex framework of the human ecology dynamics through time. On the other hand, the same data crossed with taphonomic ones about butchering and burnt traces, give a picture of the local gastronomy in the various prehistoric phases.

4.1 Ecology and economy of protohistoric communities in the Mogoro area

4.1.1 *Seafood Harvesting and Cattle Breeding in Neolithic Puisteris*

Despite its small size, the Puisteris sample highlights interesting aspects of the economy of the large Neolithic village. First, shellfish gathering from coastal lagoons clearly emerges as a prominent economic activity at the site. The same economic importance of lagoon molluscs is attested in several contemporary sites throughout Sardinia. A review of such mollusc exploitation in Sardinian prehistory is beyond the scope of this work but a valid discussion of this topic can be found in Masala and Wilkens (2015). Currently, the lagoons closest to Puisteris are those of Santa Maria di Neapolis, San Giovanni and Marceddì, in the southern part of the Gulf of Oristano, which are about 20 km away. However, the geomorphological nature of the coastal lagoons – ephemeral and in constant evolution – allows us to hypothesize that in the 4th millennium BC, the coastline was located further back towards the east, and that lagoons were located at a much shorter distance from the site. To fully understand the ecological significance of the economic / ecological role of shellfish harvesting, it will therefore be essential in future researches to investigate the actual extension of the lagoon areas in the Final Neolithic through a comparison with the available geoarchaeological data.

The very large dimensions of the bivalves harvested in this phase could reflect a different ecological condition of the lagoons during this time, as well as a reduced occurrence of mollusc gathering activity up to that time. The dimensional variation of the molluscs over the millennia and the evolution of the coastal lagoons in the area will be however the subject of future work.

Alongside the mollusc gathering in the lagoons, cattle, sheep and goat breeding represented another pillar of the Neolithic economy at Puisteris. In particular, cattle were an asset to the village, being used as a workforce and slaughtered only in old age. According to Perra (2018), slaughtering of juvenile cattle is typical in Neolithic sites of Sardinia. Slaughter of adult cattle instead becomes systematic and widespread starting from the 3rd millennium and even more so in the Nuragic phases of the Bronze Age. The data from Puisteris therefore represents an anomaly in the Sardinian Neolithic economy. The Puisteris situation reflects the full accomplishment of the neolithization process confirmed also by the insignificant role of hunting in the economy of Puisteris, attested by the almost total absence, at this stage, of wild animals.

Both the economic role of lagoon resources and the breeding of cattle indicate a community that was part of an ecosystem projected essentially towards the lowland and coastal areas, with little interest in the resources found in the interior of the territory.

4.1.2 *Hunting and caprovine and pig breeding in Chalcolithic Cuccurada*

This economic / ecological framework seems to completely overturn in the subsequent Chalcolithic phase of the village of Cuccurada, despite the fact that it is located very close to Puisteris. Marine and lagoon resources lose any role in this period, whereas deer and mouflon hunting assumes a considerably important part in the economy. The breeding strategies also change; sheep, goats and pigs now acquire a more important role than cattle.

Wild animals of large size – as in the case of deer and mouflon – could have been hunted both as a primary resource for subsistence, as well as part of hunting activities related to the onset of warrior elites who affirmed their role in the community also through these practices. The latter hypothesis is supported by the age at death of sheep and goats slaughtered in this phase indicating optimal meat yield. This suggests that the demand for quality meat was of greater importance than the need for milk and dairy products or wool.

4.1.3 *The Diversified economy at Nuraghe Cuccurada*

The economic / ecological framework obtained for the fully Nuragic phase of the Recent Bronze Age does not appear in stark contrast to the Chalcolitic phase. The economy of the community is still based essentially on the small herding of sheep and goats – especially sheep – to which pigs and cattle are added, with all the domestic individuals appearing to be small in size. The mortality curves of the sheep and goats show that their breeding is oriented towards the best meat yield but also towards the production

of milk, given that this probably reflects an increasing importance of the production of dairy and cheese, probably started in the previous Middle Bronze Age as attested by the neat increase in milk-boilers in this period (Depalmas and Melis 2010: 184). Pig breeding also appears to be oriented towards achieving maximum meat yield, although the consumption of suckling piglets is attested, while cattle continue to be slaughtered in old age. The traces of skinning on some remains also attest to the exploitation of cowhides.

Hunting has a marginal role in this phase and is oriented towards deer, wild boar and prolagus. A similar role of hunting is attested in the Nuraghe Arrubiu-Orroli in South East Sardinia (Fonzo 2008). On the other hand, occasional exploitation of lagoon resources resumes, both in the form of bivalve gathering, and fishing for lagoon species, such as grey-mullet and gilt-head bream. The data appears even more significant if we consider that only three remains of the estuarine species *Cerastoderma* sp. were found in the Nuraghe Madonna del Rimedio which stands close to the lagoon area (Santoni and Wilkens 1996).

Hard materials of animal origin are sporadically worked to create bone ornamental tips, beads and shell spoons.

The ecological framework that emerges from the Recent Bronze Age is that of a community part of a larger ecosystem, capable of exploiting coastal resources in addition to mountain ones, and of diversifying and optimising animal production and derived products.

4.1.4 *The Rich Economy and Wide Ecosystem of Final Bronze Cuccurada*

The last phase of the Cuccurada Nuraghe poses greater problems for interpretation than those previous. Several data point out that continuous occupation and visitation were not possible in the ruined building. First of all, during the Final Bronze Age, the towers of the nuraghe were partially collapsed and their deposits covered most of the courtyard, burying access to many of the rooms. Moreover, the food remains deposits in the nuraghe are very abundant – more than expected either for an inhabited area or an uninhabited one. Last fact: mollusc remains are relatively abundant (fig. 10) despite their accumulation in residential areas is not admissible.

Nevertheless, the food remains in the Final Bronze Age Stratigraphic Units (SSUU71 and 72) have been disposed mixed to potsherds and charcoals on a steep slope starting from the access to the higher room of the tower C, thus suggesting that this space had a role in the preparation and consumption of food. All these data strongly suggest that the Final Bronze Age partially collapsed nuraghe was not habitually frequented, but was not only the place where food remains were discarded but also where meals were periodically consumed. In detail, the geometry of the SSUU71 and 72 suggests that they were created by throwing away the rubbish produced by abundant meals outside the upper chamber of tower C, whose entrance emerged from the rubble of the collapsed nuraghe. However, the rich deposits of meal remains dated to this stage and covering the collapses do not suggest a squatter occupation. On the contrary, the huge amount of distant lagoon resources, prestigious game remains and the presence of valuable specimens such as very young sheep/goats and suckling piglets suggests a periodic attendance of the disused structure by a rich community that was part of an extensive and prosperous economy stretching from coastal lagoons to hilly areas.

The exploitation of very young sheep/goats and piglets also suggest an increasing role of milk and dairy products as well as a better management of pig farming such that cull piglets become necessary due to the high fertility of the species.

During the Final Bronze phase, the sharp increase in marine and lagoon resources explotation, which had been lost after the Neolithic phase, suggests a prestigious role for fishing and shellfish gathering products. This hypothesis is confirmed by the presence of fish and shellfish even in contemporary nuraghi located in positions much further from the coast such as Arrubiu, where the exploitation of marine resources, far from a consumption linked to necessity, represented an expression of gastronomic luxury (Carannante and Chilardi 2020).

The slaughtering of very young caprovines and piglets, attested in other contemporary sites such as Nuraghe Arrubiu, is to correlate not only with an optimisation of breeding and with a production focused on the production of sheep and goat milk and dairy products (Fonzo 2008: 33),

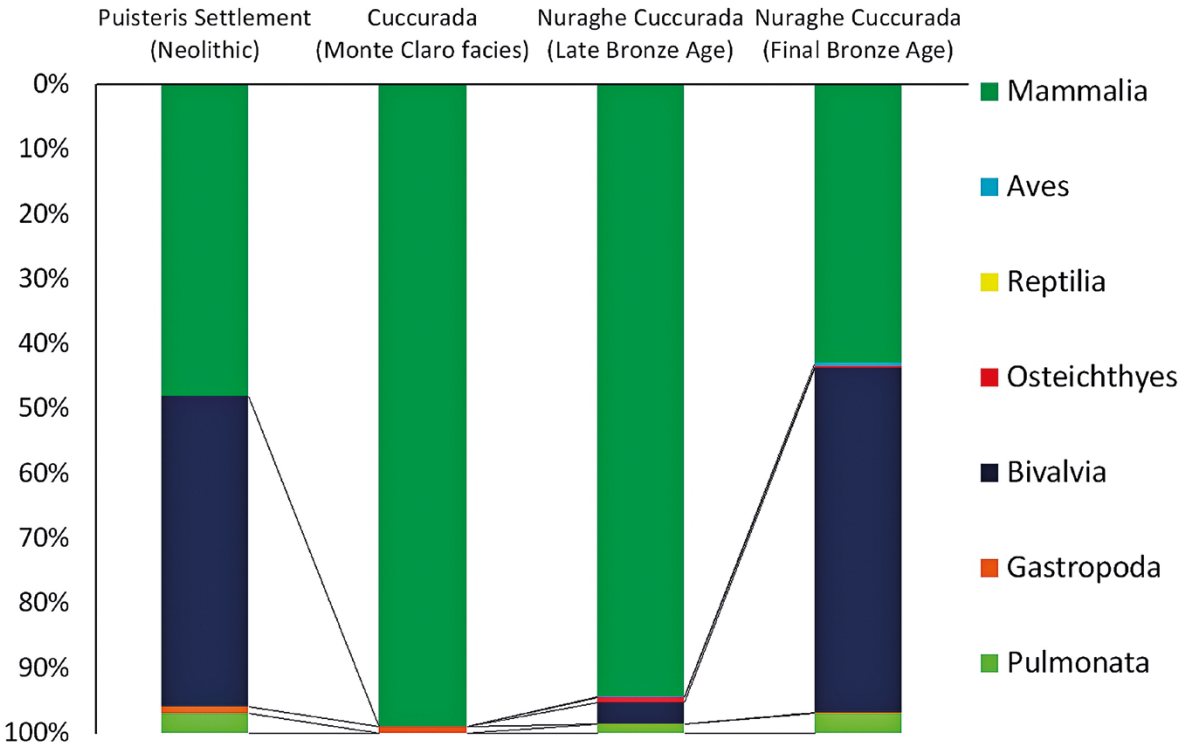

Fig. 10. Mogoro – Puisteris and Cuccurada. Comparison of the composition of the faunal assemblages in the different phases.

Mogoro – Puisteris and Cuccurada. Confronto della composizione degli insiemi faunistici nelle diverse fasi.

but also with a flourishing economy. Hunting, in particular, now seems to play an important social role as attested by the presence of deer, hare, prolagus and wild boar, confirming what was observed for this period by Depalmas and Melis (2010: 185) and Fonzo (2008: 33). This hypothesis is supported also by the discovery of a bronze statuette inside the Tower D, dating to the end of Final Bronze/beginning of Iron Age, and depicting a hunting scene with a man piercing a mouflon with a spear and a dog biting the prey at the throat (Atzeni 2015: 389).

This may suggest the collapsed, uninhabited Final Bronze Age nuraghe was still the centre of luxurious community banquets with ritual implications. According to Perra (2018: 106), several spaces inside nuraghes and "meeting huts" of the Sardinian Final Bronze Age were intended to host the banquets of small group of the local elite. The present study of the Cuccurada deposits reveals that the local elite feastings took place among the ruins of the uninhabitable nuraghe, highlighting the cultural centrality that the monument had in the Sardinian society of the Final Bronze Age. Such a religious reuse of the ruins by a flourishing society is also reported by Depalmas and Melis (2010: 185).

4.2 Chalcolitic socio-economic change as possible response to a climate event

The bioarchaeological analyses revealed marked changes in the Mogoro area's economy-ecology over the millennia. If, during the 4th millennium BC, the Neolithic village is focused on the exploitation of the resources of the Campidano plain with its pastures for cattle and coastal lagoons rich in molluscs, during the 3rd millennium the Chalcolithic village appears isolated from those ecosystems and is instead projected towards the highlands. The reason for this ecological change is yet to be determined, but probably related to social and / or climatic transformations that further bioarchaeological, geoarchaeological and isotopic research will help to clarify. Nevertheless, considering climatic

causes, the socio-economic change highlighted by our analyses can find a possible explanation. This change occurred between the end of the Ozieri phase (3300 BC) and the beginning of the Monte Claro phase (2700 BC), thus overlapping chronologically with the global climatic crisis dated between 5300 and 5000 BP (Holzhauser 2009; Burga 2020). This climatic 5.2 ky event (also known as Piora II oscillation or Bond 4B) marked the beginning of the cold and dry sub-boreal phase. This substantial transition marked the end of the Holocene thermal maximum, a warm period with temperatures markedly higher than those of pre-industrial era. During such climatic event, widespread abrupt cooling was accompanied by drier conditions in central and eastern Asia, Africa, the Mediterranean and parts of North America, associated with considerable societal disruption (Magny *et al.* 2006; Roland *et al.* 2015).

Recent geoarchaeological papers (Pascucci *et al.* 2018; De Falco *et al.* 2022) involving one of the present authors seem to support this hypothesis in Western Sardinia. Sedimentological and palaeoecological analyses carried out on sediment cores taken in the Mistras (Pascucci *et al.* 2018) and Santa Giusta lagoons, as well as at the mouth of the river Tirso (De Falco *et al.* 2022), have confirmed, also for Western Sardinia, the climatic and depositional trends found in other regions of the Mediterranean. According to geoarchaeological results, the barrier-lagoon systems in the Oristano Gulf developed in the period between 4100 and 2600 BC. This expansion of the Sardinian lagoon ecosystems probably favored the economy based on lagoon resources attested in Puisteris as in other coeval sites. Geoarchaeological analyses have also shown that a phase of sea-level still stand (or possible drop) correlated with a cold phase affected the area of the Gulf of Oristano during the second half of the 3rd millennium inducing coastal progradation and putting the lagoon ecosystems in crisis.

The warm-wet conditions of the Holocene thermal maximum with higher sea and groundwater levels may have played a significant role in the expansion of the coastal lagoons and in the Campidano plain water availability during the Neolithic phases, favouring the economic model recorded in Puisteris. On the contrary, at the end of the 4th millennium, a reduction in global temperatures with consequent lowering of sea levels had as consequence a reduction and displacement of the coastal lagoons. The increase in the distance and contraction of the lagoons, and the reduction in their productivity, together with the lower availability of water in the Campidano caused by the lowering of the aquifers, could be influential ecological factors in the dramatic socio-economic change of the Sardinian Chalcolithic.

4.3 Food preparation practices and gastronomy of the protohistoric communities at Mogoro

The taphonomic analyses also revealed information about the gastronomic habits of the protohistoric communities and about culinary changes over time.

Few data are available for the Neolithic Puisteris due to the low number of finds and the poor state of conservation. Nevertheless, we can reiterate the preference of the Neolithic community for large specimens of lagoon molluscs such as heart-cockles and clams sometimes eaten raw, as evidenced by traces of forced opening of the valves.

Even less archaeo-gastronomic information is available for the Chalcolithic phase of Cuccurada. We can only reiterate the consumption of game such as deer and mouflons, young / adult sheep and goats and report a couple of finds that attest to the detachment of the head of sheep and goats as unique butchery traces related perhaps to a cooking of the whole animals after their beheading.

However, much important information was deduced from the Recent Bronze Age samples.

In terms of the butchering processes, the data are very scarce, but five atlases and occipital remains attest that the decapitation of sheep and goats was a habitual action. The taphonomic study revealed that the blade penetrated the ventral side of the neck, throat-cutting the animal, until it was beheaded. Once detached, the heads of the sheep and goats were sometimes roasted separately. This is attested by brown halos derived from slow combustion identified on the posterior fragment of an occipital, on an orbit and on three jaws.

Seven pig and sheep /goat humeri show a similar enigmatic trace: a partial detachment of the distal epiphysis on the side of the condyle. This

trace can be related to a forced bending of the animal's elbow connected to the dismembering process, or to cooking processes to keep the front limb in an obligatory contracted position during a long roasting process.

Reddish brown combustion halos – indicative of slow and prolonged cooking and probably connected to flame roasting – are present on the distal portion of two humeri, on an astragalus and on the surface of some ribs of sheep and goats. This suggests that, after beheading and evisceration, the animals, sometimes deprived of the extremity of the legs, were cooked whole; this hypothesis is also supported by the scarcity of further traces of butchery on the postcranial skeleton.

Traces of an even slower and prolonged cooking have been observed on some bovine remains such as a truncated rib and a fragment of acetabulum, which probably remained connected to a disjointed thigh and then roasted, thus suggesting that an entire leg of beef, or a large part of it, was cooked slowly near a reverberating flame.

A *Ovis/Capra* vertebra and a rib, on the other hand, show traces of a slight hot absorption of fats that could be derived from cooking in a skillet or in an oven at high temperatures.

Few archaeo-gastronomic data are available for pigs, but it is worth highlighting the presence of at least one piglet among the remains of this phase.

A trace of combustion on a gilt-head bream dental bone attests that even fish were sometimes roasted during this phase, while traces of forced opening of an oyster valve attest to the consumption of raw molluscs.

The same poor attestation of butchering traces is found in the Nuraghe Madonna del Rimedio in Oristano where light scratches only testify to the disarticulation of the carcass of goats and pigs. For the latter, however, the division of the skull into two mirrored halves to remove the brain and work to remove the tongue are attested (Santoni, Wilkens 1996: 33).

The detailed taphonomic study carried out by Fonzo (2003: 124) on the coeval bones from Nuraghe Arrubiu confirms that pigs and piglets were roasted whole as attested at Cuccurada, but suggests a different slaughtering for the caprovines. At Arrubiu, cut marks on goat and sheep bones are more abundant. Here, in addition to decapitation and removal of the feet as at Cuccurada, the limbs were detached and divided into large portions, the neck was detached in correspondence with the last cervical vertebrae and the thoracic part of the trunk was separated from the posterior one.

In the Final Bronze Age phase, butchering traces increase sharply. Seven of the cervical vertebrae and especially two atlas vertebrae of *Ovis/Capra* carry cut marks on the ventral surface, confirming that throat-cutting and beheading were the first and most frequent butchering process.

Two teeth and a cranial fragment of *Ovis/Capra* with burnt traces limited to the exposed surfaces attest to the roasting of the heads. Brown halos on the exposed surfaces of three pig teeth indicate that even pig heads were sometimes roasted whole.

Twelve finds are attributable to several individuals of sheep and goats between neonatal and infant age, suggesting considerable interest in younger specimens. This interest appears confirmed by the seven remains of suckling piglets found in this phase.

Several *Ovis/Capra* bones – two cervical vertebrae, one thoracic, one lumbar, two ribs – that carry transverse cut marks indicate that the butchering processes had become more frequent in the Late Bronze Age, and this figure is confirmed by several traces of disarticulation present on a sheep / goat radius, on a pig humerus and ulna, and on some ribs.

These taphonomic data suggest that caprovine slaughtering at Nuraghe Cuccurada during the Final Bronze Age had become more complex and very similar to that practiced in the Nuraghe Arrubiu already in the Middle/Recent Bronze Age (*cfr*. Fonzo 2003).

Red-brown halos on the distal end of a tibia and on the most exposed surface of a sheep / goat calcaneus attest that, even in this phase, slow and prolonged roasting at some distance from the flame of entire parts of the animal or whole animal was one of the favourite cooking techniques. These data admirably agree with those found by the taphonomic analyses carried out by the present authors on the Final Bronze Age bone remains from Nuraghe Arrubiu (Carannante and Chilardi 2020: 124). They suggest that in the Final Bronze Age, in addition to the butchering techniques, the

cooking techniques also became very similar in the two sites.

Cut marks are attested also on *Bos taurus* hyoid bones, probably made during the removal of the tongue to cook it separately.

Two oyster valves with traces of combustion only on the external surface, attest that sometimes the opening of these molluscs was facilitated by rapid exposure of the bivalves to the heat on a bed of embers.

The future comparison of these preliminary data, obtained from the taphonomic analysis of the archaeozoological finds, with the archaeobotanical data and the data on the pottery and metallic objects connected to the preparation and cooking of the foods found in the examined sites will lead to a better definition of the gastronomy in the Mogoro territory.

CONCLUSIONS

The territory of Mogoro is a case-study area of great significance. The intensity of the population in this region starting from the Neolithic is justified by the diverse economic value offered by the different types of environments – coastal lagoons, fertile plains, and wooded highlands – which humans have been able to use in the various historical periods based on need, productive capacities and social organization.

From this point of view, the archaeozoological data from the Neolithic village of Puisteris and the multi-layered site of the Nuraghe Cuccurada, are of extreme importance. On the one hand, they have helped reconstruct the diet of the prehistoric and protohistoric populations who lived in the hut village of Puisteris and who built and used the Nuraghe Cuccurada and, on the other hand, they have shed light on the economy-ecology of the groups that frequented this area from the Neolithic to the Iron Age. The fortunate circumstance of being able to reconstruct, in a diachronic sense, the processes involved in meat production and consumption by the prehistoric and protohistoric populations of the area, offers us a unique and unprecedented path to analyse how they have changed during the various chrono-cultural phases, including the exploitation of animal resources, nutrition, and food preparation and cooking techniques.

Moreover, the data from the Neolithic and Chalcolithic phases of the area have recorded a dramatic socio-economic change around the end of the 4th millennium. This change, also characterized by displacement of settlements from the plains to the protected areas of the plateau has already been highlighted by other scholars (Depalmas 1989) and correlated to defensive needs. The archaeozoological data here presented combines this possible cause (instability and conflicts) with reasons connected to climate change with ecological consequences determining a different availability of resources previously at the centre of the Neolithic economy.

Future geoarchaeological and paleoclimatological analyses will allow to define the extent and distance of lagoons from the sites under examination and the possible effects of climate change on the drastic change in the economy between the Neolithic and Chalcolithic periods.

In the nuraghe of the Recent Bronze Age we can read a rich economy that opens up again to coastal ecosystems, whose resources appear to be exploited with greater intensity. Of particular interest is the data from the Final Bronze Age, in which the ruins of the nuraghe are used for feasting; probably rituals by a rich community that intensely exploits the best coastal, plain and plateau resources celebrating the cultural centrality of the collapsed monument. Despite the collapse of the nuraghe and, consequently, the radical change in the functions of the structure, the archaeozoological data reveals that the population of the Final Bronze Age had a flourishing economy and continued the same traditions of food preparation, farming, and consumption of lagoon resources from the previous phase. This excludes, for the Recent Bronze Age-Final Bronze Age transition, an economic crisis or a clear change of traditions at the Cuccurada site. The collapsed and no longer inhabited nuraghe during the Final Bronze Age, became a place for rich ceremonial feastings for a population that continued the economy and the traditions of the previous phase without discontinuity.

The archaeo-gastronomic data is also interesting. They are scarce for the Neolithic phase – for which we can only reiterate the consumption of clams, lagoon-cockles and cattle – and chalcolithic, in which game plays an important role. For the Bronze Age, on the other hand, in addition to a re-

turn to the consumption of molluscs (sometimes eaten raw) and roasted fish, one can also see the beginning of an important gastronomic tradition including sheep, goats and pigs, sometimes headless, and likely slowly cooked whole, spit-roasted, beside an open fire. The interest in young lambs and suckling piglets cooked whole with the same technique should be highlighted, as it is one of the most typical recipes of the current Sardinian gastronomic tradition: an exceptional attestation of cultural preservation in culinary traditions.

The completion of archaeobotanical analyses will be able to offer a more complete overview. Preliminary archaeobotanical analyses, however, speak of an intense agricultural exploitation of the territory, with the use of areas for cultivation and especially cereal growing, probably practiced in the alluvial plain area south of the Nuraghe Cuccurada (Cicilloni and Ucchesu 2015). For the populations who lived in the area during the Bronze Age up to the threshold of the Iron Age, the presence of numerous millstones and grinders recovered during excavations confirms the importance of an economy deeply dependent on agricultural practices (Matta and Cicilloni 2019).

Finally, the territorial analyses carried out in the area show how there was, especially during the Middle and Late Bronze Age, a capillary distribution of sites, which highlights a need to search for a systematic control of the entire territory – testimony of the will of the prehistoric and protohistoric populations to keep all the most economically important areas under strict surveillance, such as transit routes, pastures, arable areas, and wooded areas used for timber harvesting and hunting (Cicilloni 2019).

REFERENCES

Atzeni E. (2015) – Il bronzetto con scena di caccia, in Cicilloni R., ed. – *Ricerche archeologiche a Cuccurada-Mogoro (Sardegna centro-occidentale),* Vol. 1. Perugia: Morlacchi: 389-391.

Atzeni E., Carta S., Cicilloni R., Ragucci G., Usai E. (2015) – *Il Nuraghe Cuccurada di Mogoro*. Sassari: Carlo Delfino Editore.

Atzeni E., Cicilloni R., Marini S., Ragucci G., Usai E. (2016) – Fasi finali e riutilizzo di età storica nel Nuraghe Cuccurada di Mogoro (OR), *Layers. Archeologia Territorio Contesti* 1: 192-228.

Burga C.A. (2020) – Holozäne Klimaänderungen und Waldgrenzschwankungen in den Alpen, in Lozán J.L., Breckle S.W., Escher-vetter H., Grabssl H., Kasang D., Paul F., Schickhoff U., eds. – *Warnsignal Klima: Hochgebirge im Wandel*, Wissenschaftliche Auswertungen Hamburg: 103-108.

Carannante A., Chilardi S. (2015) – L'alimentazione e lo sfruttamento delle risorse animali nell'area di Mogoro tra il III e il II millennio a.C. I dati archeozoologici dai siti di Puisteris e Cuccurada, in Cicilloni R. ed. – *Ricerche archeologiche a Cuccurada-Mogoro (Sardegna centro-occidentale)* Vol. 1. Perugia: Morlacchi: 422-447.

Carannante A., Chilardi S. (2020) – Reperti archeozoologici dalla Torre D, in Perra M., Lo Schiavo F. eds. – *Il Nuraghe Arrubiu di Orroli* Vol. 3. Cagliari: Arkadia: 117-126.

Cicilloni, R. (2017) – Pozzetti neolitici nel sito di Serra Neula/Puisteris – Mogoro (Sardegna centro-occidentale), in Lugliè C., Beeching A., Muntoni I.M. eds. – *Small pits, digs, holes, silos… Neolithic small dug-out structures: research methods and interpretative issues*. Abstract Book, Terzo Incontro Annuale di Preistoria e Protostoria (Firenze 2017), Incontri Annuali di Preistoria e Protostoria 3. Firenze: Istituto Italiano di Preistoria e Protostoria: 37-40.

Cicilloni (2018) – Un village de l'âge du Bronze près du Nuraghe «Cuccurada» de Mogoro (Sardaigne – Italie), in Lemercier O., Senepart I., Besse M., Mordant C. eds. – *Habitations et habitat du Néolithique à l'âge du Bronze en France et ses marges*. *Actes des IIe Rencontres Nord/Sud de Préhistoire récente (Dijon, 19-21 novembre 2015)*. Toulouse: Éditions Archives d'Écologie Préhistorique: 443-446.

Cicilloni (2019) – Siti fortificati e di controllo territoriale dell'Età del Bronzo nel Mediterraneo occidentale: il caso del nuraghe Cuccurada di Mogoro (Sardegna centro-occidentale), in Floris A., Lecis L., Macchiarella I., Tasca C. eds. – *Sguardi contemporanei. Studi multidisciplinari in onore di Francesco Atzeni.* Perugia: Morlacchi Editore: 57-65.

Cicilloni R., Ucchesu M. (2015) – Controllo del territorio e sfruttamento delle risorse ambientali tra il Bronzo Medio e il Bronzo Finale nell'area di Mogoro (Sardegna centro-occidentale). Paper Presented at the *50th Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria*, Rome, 5–9 October 2015.

Cicilloni R., Cabras M., Mossa A. (2015) – Studio dell'insediamento protostorico in un'area della Sardegna centro-occidentale tramite strumenti Gis ed analisi multivariate. *Archeologia e Calcolatori* 26: 129-148.

Cicilloni R., Ragucci G., Cabras M., Mossa A. (2016) – New Approaches in Landscape Analysis of the Bronze Age in Central-Western Sardinia: the Area of Mogoro (Oristano – Italy), in Burgers G.J., Tetteroo C., Pelgrom J., Mcgrath M. eds. – *Multi-, inter- and transdisciplinary research in landscape archaeology, LAC2014. Proceedings 3rd International Landscape Archaeology Conference (Roma 17-20 Settembre 2014).* Amsterdam: University Library, Vrije Universiteit: 1-12.

De Falco G., Carannante A., Del Vais C., Gasperini L., Pascucci V., Sanna I., Simeone S., Conforti A. (2022) – Evolution of a single incised valley related to inherited geology, sea level rise and climate changes during the Holocene (Tirso river, Sardinia, western Mediter-

ranean Sea), *Marine Geology* 451. Doi: https://dx.doi.org/10.1016/j.margeo.2022.106885.

Depalmas A. (1989) – La Cultura di Monte Claro: considerazioni e aspetti tipologici, *Antichità Sarde* 2: 5-62.

Depalmas A., Melis R.T. (2010) – The Nuragic People: Their Settlements, Economic Activities and Use of the Land, Sardinia, Italy, in Martini I.P., Chesworth W. eds. – *Landscapes and Societies: Selected Cases*. New York: Springer: 167-86.

Fonzo O. (2003) – L'ambiente e le sue risorse: la caccia e l'allevamento del bestiame, in Cossu T., Campus F., Leonelli V., Perra M., Sanges M. eds. – *La vita nel Nuraghe Arrubiu.* Orroli: Comune di Orroli: 113-133.

Fonzo O. (2008) – Evoluzione della composizione della fauna in relazione ai cambiamenti dell'ambiente, in Campus F., Cossu T., Leonelli V., Lo Schiavo F., Perra M., Sanges M. eds. – *Il paesaggio nuragico sull'altopiano di Pran 'e muru.* Orroli: Comune di Orroli: 27-35.

Grant A. (1975) – Appendix B. The use of tooth wear as a guide to the age of domestic animals. In Cunliffe B. ed. – *Excavations at Portchester Castle: I, Roman. Reports of the Research Committee of the Society of Antiquaries of London* 32. London: Thames and Hudson: 437-450.

Holzhauser H. (2009) – Auf dem Holzweg zur Gletschergeschichte, in Naturforschende Gesellschaft In Bern ed. – *Hallers Landschaften und Gletscher. Beiträge zu den Veranstaltungen der Akademien Schweiz 2008 zum Jubiläumsjahr „Haller 300". Sonderdruck aus den Mitteilungen der Naturforschenden Gesellschaft in Bern, Neue Folge* 66. Bern: Paul Haupt Verlag: 173-208.

Matta V., Cicilloni R. (2019) – Bronze Age stone tools in Nuragic Sardinia: the case of the ground-stone tools from Nuraghe Cuccurada-Mogoro (Sardinia, Italy), *Journal of Archaeological Sciences, Reports* 27: 1-18.

Magny M., Leuzinger U., Bortenschlager S., Haas J.S. (2006) – Tripartite climate reversal in Central Europe 5600-5300 years ago, *Quaternary Research* 65: 3-19.

Moravetti A. (2004) – *Monte Baranta e la cultura di Monte Claro*. Sassari: Carlo Delfino Editore.

Masala S., Wilkens B. (2015) – Lo sfruttamento dei molluschi marini in Sardegna, in Girod A. ed. – *Appunti di archeomalacologia*. Sesto Fiorentino: All'Insegna del Giglio: 179-197.

Matolcsi J. (1970) – Historische Erforschung der Körpergröbe des Rindes auf Grund von ungarischem Knochenmaterial, *Zeitschrift für Tierzüchtung und Züchtungsbiologie* 87 (2): 89-137.

Pascucci V. De Falco G., Del Vais C., Sanna I., Melis R.T., Andreucci S. (2018) – Climate changes and human impact on the Mistras coastal barrier system (W Sardinia, Italy), *Marine Geology* 395: 271-284.

Payne S. (1973) – Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale, *Anatolian Studies* 23: 281-303.

Perra M. (2018) – *Alla mensa dei Nuragici*. Sassari: Carlo Delfino Editore.

Poppe G.T., Goto Y. (1993) – *European Seashells. Volume II*. Wiesbaden: Christa Hemmen Verlag.

Roland T.P., Daley T.J., Caseldine C.J., Charman D.J., Turney C.S.M., Amesbury M.J., Thompson G.J., Woodley E.J. (2015) – The 5.2 ka climate event: Evidence from stable isotope and multi-proxy palaeoecological peatland records in Ireland, *Quaternary Science Reviews* 124: 209-223.

Santoni V., Wilkens B. (1996) – Il complesso nuragico di "Madonna del Rimedio" di Oristano, *Quaderni della Soprintendenza per i Beni Archeologici delle Province di Cagliari e Oristano* 13: 29-43.

Silver I.A. (1969) – The ageing of domestic mammals, in Brothwell D.R., Higgs E.S. eds. – *Science in Archaeology*, second edition. London: Thames and Hudson: 283-302.

Teichert M. (1969) – Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei vorund frühgeschichtlichen Schweinen, *Kühn Archiv* 83(3): 237-92.

Teichert M. (1975) – Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei Schafen, in Clason A.T. ed. – *Archaeozoological studies*. Amsterdam: North-Holland Publishing Company/Elsevier: 51-69.

Tykot, R. H. (1998) – Mediterranean Islands and Multiple Flows. The sources and Exploitation of Sardinian Obsidian, in Shackley M.S. ed. – *Archaeological Obsidian Studies*. *Method and Theory*. New York-London: Plenum Press: 67-82.

Vanzetti A., Castangia G., Depalmas A., Ialongo N., Leonelli V., Perra M., Usai A. (2013) – Complessi fortificati della Sardegna e delle isole del Mediterraneo occidentale nella protostoria, *Scienze dell'Antichità* 19 (2/3): 83-123.

Wilkens B. (2012) – *Archeozoologia. Il Mediterraneo, la storia, la Sardegna.* Sassari: Ed. Democratica Sarda.