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This is the final peer-reviewed author’s accepted manuscript (postprint) of the following publication:

Published Version:
Riel-Salvatore J., Negrino F., Pothier Bouchard G., Vallerand A., Costa S., Benazzi S. (2022). The ‘Semi-Sterile Mousterian’ of Riparo Bombrini: evidence of a late-lasting Neanderthal refugium in Liguria. JOURNAL OF QUATERNARY SCIENCE, 37(2), 268-282 [10.1002/jqs.3411].

Availability:
This version is available at: https://hdl.handle.net/11585/879603 since: 2024-02-01

Published:
DOI: http://doi.org/10.1002/jqs.3411

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(Article begins on next page)

12 October 2024

This is the final peer-reviewed accepted manuscript of:

Riel-Salvatore J, Negrino F, Pothier Bouchard G, Vallerand A, Benazzi S. 2022. The 'semi-sterile mousterian' of riparo Bombrini: evidence of a late-lasting neanderthal refugium in Liguria? J Quat Sci. 7(2), 268–282

The final published version is available online at:

https://onlinelibrary.wiley.com/doi/full/10.1002/jqs.3411

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THE 'SEMI-STERILE MOUSTERIAN' OF RIPARO BOMBRINI: EVIDENCE OF A LATE-LASTING NEANDERTHAL REFUGIUM IN LIGURIA?

Julien Riel-Salvatore[1*], Fabio Negrino[2], Geneviève Pothier Bouchard[1], Amélie Vallerand[1], Stefano Costa[3] and Stefano Benazzi[4,5]

[1] Département d'anthropologie, Université de Montréal, Montréal, Canada

[2] Dipartimento di Antichità, Filosofia, Storia (DAFIST), Università di Genova, Genova, Italy

[3] Soprintendenza Archeologia, Belle arti e Paesaggio per la Città Metropolitana di Genova e le province di Imperia, La Spezia e Savona

[4] Dipartimento di Beni Culturali, Università di Bologna, Ravenna, Italy

[5] Department of Human Evolution, MPI for Evolutionary Anthropology, Leipzig, Germany

* Corresponding author : julien.riel-salvatore@umontreal.ca

Abstract:

Constrained by the Maritime Alps and a steep coastal shelf, Liguria served as a biogeographical corridor linking mainland Western Europe to peninsular Italy throughout the Late Pleistocene. It may also have served as a biogeographic refugium for Neanderthals, since sites in the region have yielded some of the latest Mousterian dates in Western Europe and, paradoxically, some of the earliest dates for Protoaurignacian occupations. This paper presents an overview of the Neanderthal presence in Liguria between MIS5-3, with a particular focus on the record from the Balzi Rossi site complex. This permits a critical evaluation of diachronic shifts in the Neanderthal occupation of Liguria. This is followed by an analysis of new data from 'semi-sterile Mousterian' Level MS at Riparo Bombrini that show it was occupied very ephemerally by the end of the Mousterian, highlighting major late Neanderthal behavioral shifts. We conclude by proposing that this behavioral pattern is best explained by the last Neanderthals of the Balzi Rossi having occupied the region as an ecologically stable, taxon-specific *in situ* micro-refugium. This has implications for our understanding of Paleolithic refugia more broadly and of the social and ecological conditions in place during the terminal Mousterian period in western Liguria.

Key words : Late Mousterian, Liguria, Neanderthals, refugium, Riparo Bombrini, Balzi Rossi, Italy

This paper presents new data obtained from ongoing excavations at Riparo Bombrini (Balzi Rossi, Liguria, Italy), which permit the first thorough assessment of the so-called 'semi-sterile Mousterian' or MS – *Musteriano sterile*, in Italian – levels that cap the site's Mousterian sequence. This critical evaluation, in turn, permits an evaluation of whether the 'semi-sterile Mousterian' at the Balzi Rossi is an expression of Neanderthal adaptations under refugium conditions. These new data open up a discussion of the state of human demography in the region just prior to the arrival of modern humans. The preliminary results reported here thus contribute to a more refined understanding of the conditions under which one of the most recent manifestations of the Middle-Upper Paleolithic transition in Italy took place, with implications for this process as a whole.

The study is divided in six distinct sections. First, after a general introduction about Riparo Bombrini and its place in Italian Paleolithic research, we build on a prior study (Riel-Salvatore and Negrino 2018, Negrino et al., in press) to sketch out the defining characteristics of the Mousterian over different phases of the Late Pleistocene in Liguria MIS5-3, or ca. 130-42ky cal BP. This overview is necessary to situate the distinctiveness of the 'semi-sterile Mousterian' against the overall backdrop of Mousterian adaptations in the region. What is known about the 'semi-sterile Mousterian' at Riparo Bombrini, and more generally at the Balzi Rossi, is then summarized in a separate section in order to set up working hypotheses about its nature. These working hypotheses are then confronted to new faunal, technological, spatial and paleoecological data obtained or published since new excavations at Riparo Bombrini began in 2015, under the direction of two of the authors. The last section of the paper brings together all this information to address the

question of whether the ‘semi-sterile Mousterian’ may be the results of changes in Neanderthal behavior brought about by being forced to live in a geographically constrained refugium in western Liguria. The paper concludes with a discussion of potential avenues for future research raised by the patterns we highlight in this study.

The situation of Level MS at Riparo Bombrini is somewhat paradoxical. Indeed, it has long been described as ‘semi-sterile’ and of scant interest, due to its apparently low density of artifacts and in reference to the coeval deposits at nearby Riparo Mochi (Vicino 1984, Riel-Salvatore et al. 2013, Negrino and Riel-Salvatore 2018, Holt 2019; cf. Bietti and Negrino 2007). This has suggested a rather ephemeral nature for some of the very last Neanderthal occupations in Italy (Higham et al. 2014). Yet, the Mousterian record of Liguria clearly suggests that it was a desirable, if not downright preferred, environment possibly as far back as 350,000 years ago (see Vicino 1982, Arobba and Vicino 2013), with particularly conspicuous amounts of Paleolithic sites dating to MIS 5-3 (del Lucchese et al. 1985, Palma di Cesnola 1996, Negrino et al., in press). This is in contrast to other parts of Italy where topography, paleoenvironmental conditions and volcanic activity combined to occasionally severely alter habitability (see e.g., Giaccio et al. 2017, Badino et al. 2020). Liguria, in contrast, remained largely topographically stable and served as a biogeographic corridor linking peninsular Italy to mainland Western Europe, in part due to the presence of a steep coastal shelf that limited territorial expansion to a few kilometers at the most during cold episodes, when sea levels were lower.

Another element that makes Liguria a particularly interesting setting in which to study the persistence of late-lasting Neanderthals in select environment is the chronology of cultural turnover in the region. Indeed, at 42ky cal BP, the first occurrence of the Protoaurignacian technocomplex provides a *terminus ante quem* for the end of the Mousterian in the region (Douka et al. 2012, Higham et al. 2014), with assemblages in SW France suggesting a potential western origin of that EUP industry (Barshay-Szmidt et al. 2018; cf. Onoratini and Simon 2004, Porraz et al. 2010). Furthermore, in other parts of the peninsula, the Mousterian appears to be supplanted even earlier (by 46-45ky cal BP) by the Uluzzian (Marciani et al. 2020), which would gradually spread northwards, being documented at Grotta della Fabbrica to the SE of Liguria around 40ky cal BP, where it overlies Mousterian levels dated to ca. 44ky cal BP (Villa et al. 2018). This implies that the latest Mousterian in Liguria would have been caught in a cultural vise grip of sorts by the Protoaurignacian to the west and the Uluzzian to the east, which may have had some influence on its expression.

In previous work, we have proposed that the Middle-Upper Paleolithic transition in Italy likely unfolded at least partly as a result of Neanderthals retreating to refugium areas within the peninsula during periods of climatic downturn, and that Liguria was one such area (e.g. Riel-Salvatore 2007, 2010; Negrino and Riel-Salvatore 2018). Indeed, Liguria's function as a refugium which constrained population size and contacts – with concomitant social and genetic implications – has also recently been proposed for the Final Epigravettian (Riel-Salvatore and Gravel-Miguel 2013, Sparacello et al. 2021). However, as detailed by Jones (this volume), the concept of a refugium in archaeology

has often been poorly defined, making it a problematic heuristic unless researchers specifically define what they mean by it beyond an area that provides a buffer against changing ecological conditions (see also Carvalho and Bicho, this volume). This haziness has prompted some scholars to argue that the concept has outlived its usefulness in archaeology (e.g., Canessa 2021). However, Jones (this volume) persuasively demonstrates that defining four key dimensions of what is meant by a refugium can make it a powerful tool for archaeological research as well as facilitate cross-disciplinary exchanges with ecologists. In this study, we therefore take the opportunity to discuss new data from the terminal Mousterian occupations from Riparo Bombrini to see whether they lend credence to a critical application of the notion of refugium and whether this helps shed new light on the process of Neanderthal disappearance in Liguria. To assess whether this is the case, it is important to review the nature of the Mousterian occupation of the region as a whole in order to underscore in what specific ways the 'semi-sterile Mousterian' from Riparo Bombrini deviates from or agrees with those general patterns.

The Mousterian in Liguria from MIS 5 to MIS 3

From MIS 5 onward, the Ligurian Mousterian record is fairly rich, particularly in western Liguria (Figure 1). It bears emphasizing, however, that much of what is known about the Mousterian of the Late Pleistocene of Liguria comes predominantly from old, poorly-dated excavations conducted using different methods, none of which provide the degree of resolution considered acceptable for Paleolithic research today (see Palma di Cesnola 1996). This explains why some ambiguities persist in the interpretation of this material,

particularly as concerns cultural dynamics and chronology. Nonetheless, there are sufficient data to draw an overall picture of the situation (Rossoni-Notter 2011, Negrino et al., in press).

As elsewhere in Western Europe, Mousterian assemblages in Liguria have solely been associated with Neanderthals. Remains attributed to these hominins are known from six sites to date: Riparo Bombrini, Grotte du Prince (Barral and Simone 1967, 1987; de Lumley 1972), Madonna dell'Arma (Cauche 2002; Ricci 2010), Grotta di Santa Lucia Superiore (de Lumley and de Lumley 2011), Arma delle Manie (Holt et al. 2012) and Caverna delle Fate (Giacobini and de Lumley 1985; de Lumley and de Lumley 2011; de Lumley and Giacobini 2013a, 2013b). Likewise, a few recurrent traits seem to characterize the Middle Paleolithic in Western Liguria between 130-42ky cal BP, namely, the constant but fluctuating presence of the Levallois method, an extension of exploited raw material sources (particularly fine-grained stone procured up to 200km away, such as radiolarite (also colloquially referred to as jasper) from Eastern Liguria or Emilia and rhyolites from the Estérel region of southern France (Negrino and Starnini 2003, 2006, 2010; Porraz 2005, 2010; Porraz and Negrino 2008; Riel-Salvatore and Negrino 2009; Rossoni-Notter and Simon 2016), and the dominance of cervids as prey animals (Valensi and Psathi 2004, Moussous 2014). Overall, the Mousterian in Liguria can be divided in broad phases that correspond to Marine Isotope Stages (Negrino et al., in press) and while we have recently described the defining features of the Mousterian of Liguria in MIS 3 (Riel-Salvatore and Negrino 2018), we summarize here this information

along with what is known of the Mousterian during MIS 5 and 4 to flesh out the picture of Mousterian adaptations during the entire Late Pleistocene.

Phase 1 (MIS 5): MIS 5 was a period of overall warm/temperate conditions, and most assemblages recovered in Liguria attributed to this period have been found immediately above Tyrrhenian fossil beaches. At the Balzi Rossi, a handful of sites document this phase (Figure 2). The most recently excavated of these are the ex-Casinò and ex-Birreria sites, which were first excavated in the 1960s and 1990s, respectively, near the base of the sedimentary talus that slopes downward from the cliff towards the sea (Vicino 1972, 1974; Cremaschi et al. 1991; Negrino 2002; Porraz 2005; Porraz and Negrino 2008; Negrino and Tozzi 2008; Tozzi and Negrino 2008). The deposits attributed to MIS 5 at both sites are part of contiguous stratigraphic units that likely represent coeval depositional environments. The base of their sequences is represented by fossil beach or rolled Tyrrhenian beach pebble deposits, which are also documented in other sites (see below). The artifact assemblages are composed mainly of rolled lithic implements and some fragmented *Callista chione* shells interpreted by some as intentionally retouched, though this interpretation remains open to debate (Oxilia 1974; Douka and Spinapolice 2012).

At the ex-Birreria site, the fossil beach levels are overlain by Level A1-2, a decarbonated *terra rossa* deposit devoid of faunal remains deposited under interglacial conditions. This level's lithic industry is fairly homogeneous, with blanks being produced mainly according to a recurrent centripetal and unipolar Levallois reduction strategy, and

exploited raw materials being almost exclusively local, mainly flints and quartzitic sandstones from the I Ciotti conglomerates (Del Lucchese et al. 2001-2002). Typologically, the assemblages are abundant sidescrapers, with rarer endscrapers and *becs*, and a complete absence of bifaces. While Vicino (1976) described a small biface from coeval deposits at the ex-Casinò site, a recent reanalysis has established that this piece is best understood as a core (Negrino et al., in press). Retouched tools were likely used for a range of tasks but were mostly small, likely due to the constraints imposed by the dimensions and quality of nodules of local lithotypes.

Barma Grande Level 13 represents the remnants of Tyrrhenian fossil beaches and has yielded only a few essentially undiagnostic stone tools, while overlying levels 2-11 from inside the cave also date to MIS 5 and have yielded more larger, more informative lithic assemblage (Bulgarelli 1974). As concerns lithic technology, these assemblages are dominated by large flakes produced using the Levallois method that were frequently transformed into lightly retouched sidescrapers. The large size of the flakes was made possible by the use of distinct raw materials, namely quartzitic sandstones, including some acquired near modern-day San Remo, some 20km away, indicating that circumlocal raw material sources were also exploited at this time. These levels are also associated with faunal assemblages indicative of warm/temperate conditions that include rhinoceros (*Stephanorhinus sp.*), the straight-tusked elephant (*Palaeoloxodon antiquus*) and even hippopotamus (*Hippopotamus amphibius*) in the lowest levels. The recent suggestion that elephant remains excavated in the late 1800s at this site date to MIS 4 or 3 (Onoratini et al. 2012) appears to us to be premature. This is because it is based on its association with

fauna also present in Levels attributed to MIS 5, there are issues of stratigraphic uncertainty due to when it was recovered, and its attribution to the Quina Mousterian is based a single sidescraper. It is therefore more parsimoniously attributed to MIS 5, like the other elephant remains from Barma Grande (Negrino et al., in press).

At the Balzi Rossi, similar associations of lithic and faunal assemblages have also been identified in the "lower formation" from Grotta dei Fanciulli (Bachechi and Revedin 1996) as well as in Units C-D-E of Grotte du Prince, although at the latter also includes a fair number of retouched points, a few limaces and occasional scrapers bearing Quina retouch (Iaworsky 1961, 1962; Barral and Simone 1967, 1987; Simone et al. 2010, Rossoni-Notter 2011, Rossoni-Notter et al. 2016a,b, c). de Lumley (1969) and Palma di Cesnola (1996) have attributed these assemblages as belonging to a "Typical Mousterian rich in scrapers." However, this label, devised in an earlier phase of the history of Paleolithic research in the region, minimizes their internal techno-economic variability just highlighted in this review. This indicates that thinking of them as a homogeneous cultural phenomenon glosses over important dimensions the behavioral and technological strategies that structured their production, as emphasized in several recent publications (e.g., Rossoni-Notter 2011, Rossoni-Notter et al. 2016b).

The 'I Ciotti' Eocenic conglomerates, located about 650m inland from the Balzi Rossi, have also yielded implements that could date to MIS 5 based on pedogenic evidence. While the area was exploited as a raw material source at least throughout the Middle and Upper Paleolithic of the region, the lowest unit of a test pits, yielded several flakes that

could be refitted to a core and a large hammerstone likely used as a mattock to break loose the conglomerate to access nodules (Del Lucchese et al. 2001-2002, Negrino et al. 2006).

At Madonna dell'Arma, located some 30km east of the Balzi Rossi, the basal Tyrrehnian deposits from 'strato V' are dated by U/Th to 95ky +/- 5ky BP are thus dated to this period, though they have only yielded a scant lithic assemblage (Isetti et al. 1962, Stearns and Thurber 1965). Excavations at the site in the 1980s and 1990s revealed a 17m-thick stratigraphic sequence, which includes an artifact-rich level dated by Blanchin (1999) to between 97-69ky BP by ESR and U/Th (Isetti et al. 1962, Ricci 2010). The assemblage from this level, located in Strato I ca. 4m above hearth A, is mostly made on local quartzitic sandstone that allowed the generalized use of the Levallois reduction strategy to produce flakes of various dimensions, along with a few laminar flakes, all of which were often retouched into sidescrapers (Cauche 2002, 2004, 2007).

Further still to the east, near Finale Ligure, two other sites complete the picture for the Mousterian during MIS 5 in Liguria. Grotta delle Fate has also yielded deposits dating to MIS 5 that contain Mousterian assemblages rich in sidescrapers and retouched points that recall that from the basal levels from Grotte du Prince described above (Arobba et al. 1987; Echassoux et al. 1989). These levels have also yielded some *cuvette*-type hearths. Dated flowstone from an internal corridor indicates that these levels are older than 70ky BP while the remnants of overlying levels destroyed in prior uncontrolled excavations date to MIS 4 (Falguères et al. 1990). At nearby Grotta di Bergeggi, bone-bearing

breccias have also yielded some flaked stone tool. U/Th dates on the alabastrine flowstone that overlies them indicates they are older than 78ky ±7ky BP (Vicino 1981, Firpo 2008).

Phase 2 (MIS 4): Mousterian assemblages dating to MIS 4, a cold period, arewell-documented at the Balzi Rossi: they have been recovered in several units of Grotte du Prince (Rossoni-Notter et al. 2016a, Moussous 2006, 2014), in Hearths II-III of Grotta del Caviglione (Moussous et al. 2016a, Rossoni-Notter et al. 2016b), the external deposits of Barma Grande (Palma di Cesnola 1996), Grotta del Conte Costantini (Bachechi 2001, 2008), Units Br5-7 from the ex-Birreria site (Cremaschi et al. 1991, Negrino 2002) and cuts 45-55 of Level I at Riparo Mochi (Kuhn and Stiner 1992, Grimaldi and Santaniello 2014). These deposits have yielded lithic assemblages characterized by an abundance of flat, lightly retouched sidescrapers and by the production of large and occasionally laminar blanks made on quartzitic sandstone (Kuhn 2006). The Levallois method was used to exploit these large nodules, but also to reduce small cores. Typologically, these assemblages have generally been lumped together as belonging to a “Typical Mousterian rich in scrapers,” again belying the internal dynamism of the Mousterian during this phase (Negrino et al., in press; Clark and Riel-Salvatore 2006).

During this phase, the Mousterian is somewhat less well-documented in the rest of the region. Near Toirano, Grotta del Colombo and Grotta di Santa Lucia have yielded Mousterian assemblages showing similar techno-typological characteristics and dated to this period (Tozzi 1962; Arobba et al. 2008; Lumley et al. 2008). Further east, near Finale

Ligure, the assemblages from upper units from Caverna delle Fate date to MIS 4 (Falguères et al. 1990). Various dating assays also attribute Levels III-VIII from Arma delle Manie to MIS 4 (Abbassi and Desclaux 1996; Abbassi et al. 1998; Karatsori 2003; Mehidi 2005). However, in these levels, the Discoid reduction strategy characterizes a part of the lithic assemblages, mainly that made on a local limestone with limited conchoidal properties. It seems likely that the situation at Arma della Manie reflects the ability of Neanderthals to adapt their behavior and technology to make the best of local circumstances and resources, the optimal exploitation of which required flexibility.

Phase 3 (MIS 3): Since the record of this period has been presented in a recent publication, we only summarize its most salient features here (see Riel-Salvatore and Negrino 2018). This phase, too, is best known from the Balzi Rossi, where it is documented in the upper cuts (Level I, cuts 25-45) and maybe Level H of Riparo Mochi (Bietti and Negrino 2007, Grimaldi and Santaniello 2014), in Levels MS1-2 at Riparo Bombrini (Vicino 1984, Holt et al. 2019), in Units Br 3-4 of the ex-Birreria site (Cremaschi et al. 1991, Negrino 2002), as well as probably in Unit A from Grotte du Prince and the "upper formation" of Grotta dei Fanciulli (Rossoni-Notter 2011, Moussous 2014, Rosssoni-Notter et al. 2016b, Negrino et al., in press). Further afield, it is also documented at Arma delle Manie and Arma Veirana (Cauche 2002, 2004, 2007; Negrino et al. 2017, Valensi and Psathi 2004). At the latter site, Mousterian levels likely dating to over 50ky cal BP show a sharp decrease in the intensity of occupation from the bottom to the top of the sequence.

These assemblages have often generically been attributed to the 'Denticulate Mousterian' by de Lumley (1969; see also Palma di Cesnola 1996) based on the putative prevalence of this kind of retouched tool, but this typological label has rarely been critically assessed in functional, cultural or behavioral terms (cf. Clark and Riel-Salvatore 2006, Riede et al. 2020). The fact that de Lumley originally included within this facies the laminar assemblage from Via San Francesco now known to well predate MIS 5 speaks to the problematic nature of this approach to describing the salient traits of the assemblages of this phase corresponding to the terminal expressions of the Mousterian in Liguria. In fact, a recent technological and behavioral synthesis by Negrino and colleagues (in press) highlights that while the Levallois method continues to be used to produce blanks, Discoid reduction is also well documented, often as the tail-end of the *chaînes opératoires* used at these sites. Overall, the lithic technology of this phase is characterized by decreased laminarity and by the co-occurrence of small Discoid cores alongside larger Levallois products (Riel-Salvatore and Negrino 2018). These diminutive cores could have been used expediently to produce polyvalent blanks useful in the context of changing subsistence and land-use strategies (Negrino et al., in press).

Here, we highlight one noteworthy trend within MIS 3, as documented clearly in Level I (cuts 25-56) at Riparo Mochi. Indeed, several researchers over the past 30 years have documented a gradual decrease in the presence of laminar elements from the bottom to the top of this sequence (Kuhn and Stiner 1992, Kuhn 2004, 2006; Grimaldi and Santaniello 2014). Throughout, the exploitation of local lithotypes dominates (especially from the I Ciotti conglomerates), except in cuts 44-46 which appear to correspond to a

cold climatic oscillation and when non-local lithotypes are better represented (up to 5% of the assemblage). Finally, lithic technology in the upper cuts (31-25) appears to have been geared towards the production of small, occasionally elongated, flakes knapped from heavily reduced cores. Similarly to what can be seen in Levels MS1-2 at Riparo Bombrini (Holt et al. 2019), the top of the MIS 3 Mousterian sequence at Mochi coincides with a more ephemeral human presence and a contraction of the range of exploited raw material sources. The scant artifactual assemblages from these levels has in fact led researchers to refer to them as 'semi-sterile' (Bietti and Negrino 2007, Riel-Salvatore et al. 2013, Holt et al. 2019). The last Neanderthals in the region thus appear to have contracted demographically and well as geographically, employing more flexible lithic implements to exploit increasingly local resources (see below).

The dates from these levels suggest the 'last gasp' of the Mousterian in Liguria during MIS 3 occurred around 43-42ky cal BP, during the cold interval between the GI-11 and GI-10 interstadials, being separated from overlying Protoaurignacian deposits by a depositional hiatus, likely erosional in nature (Douka et al. 2012, Higham et al. 2014, Holt et al. 2019). These dates indicate the latest Middle Paleolithic of the Balzi Rossi was deposited while the Uluzzian was expanding to the south and east and while the Protoaurignacian and Early Aurignacian were already thriving to the north and west of the Alps (Villa et al. 2018, Barshay-Szmidt et al. 2018, 2020). It thus seems as though the latest Mousterian in Liguria may represent a residual Neanderthal enclave within a region otherwise occupied by modern humans making Early Upper Paleolithic industries.

The question of the 'Semi-Sterile Mousterian' at Riparo Bombrini

This overview thus sets the stage for a more detailed review of what is known about the "semi-sterile Mousterian" of Levels MS1-2 at Riparo Bombrini. By way of context, the site has been excavated on several occasions. In 1976, the first systematic excavations took place at the site immediately outside the collapsed dripline and identified the presence of Late Mousterian and Protoaurignacian deposits, the latter of which yielded a deciduous *Homo sapiens* incisor (Vicino 1984, Formicola 1989). From 2002-2005, a second excavation project excavated the area immediately east of Vicino's excavation in order to get a better sense of the timing and nature of the transition at the site (, Riel-Salvatore et al. 2013, Higham et al. 2014, Holt et al. 2019). Beginning in 2015, a new excavation project that is still ongoing has focused on documenting the transition over a more extensive area and using new analytical methods (Negrino and Riel-Salvatore 2018, Riel-Salvatore and Negrino 2018a, b). These methods have included the large-scale implementation of a ZooMS program to identify faunal strategies at the site (Pothier Bouchard et al. 2019, 2020), the use of photogrammetry and total station to document the site and the evolution of the excavation (Martin-Moya et al. 2020), and the use of cryptotephrochronology to resolve some outstanding chronological issues at the site (Hirniak et al. 2020).

Critically, the ongoing phase of the Bombrini project has involved integrating the collections and documentation collected over the three phases of excavation at the site in

order to develop a fine-grained understanding of occupation dynamics across time based on as extensive a dataset as possible. This has allowed the contextualization of the Protoaurignacian human tooth (Benazzi et al. 2015) as well as detailed analyses of some aspects of Protoaurignacian chronology, lithic technology and faunal exploitation at the site (Negrino et al. 2016, Riel-Salvatore and Negrino 2018a, b, Pothier Bouchard et al. 2020). As well, this has permitted us to aggregate all the material recovered since 1976 along with its spatial coordinated in an effort to get a holistic view of the transitions at the site, for instance by documenting shifting spatial organization and intensity in human occupation that can bear on our understanding of the nature of the Middle-Upper Paleolithic transition at the site (e.g., Vallerand 2021, Riel-Salvatore et al., in review). It has also permitted to integrate data from Bombrini in recent syntheses about the lithic, faunal and symbolic dimensions of the transition in Italy (Arrighi et al. 2020, Marciani et al. 2020, Romandini et al. 2020).

While much of the focus so far has been on the Protoaurignacian assemblages at the site, a fair amount is known about the most recent Mousterian deposits from Riparo Bombirni. Known as Level MS and comprising two subunits (MS1 and MS2), this 30-40cm thick level caps the Mousterian sequence and is separated from the overlying Protoaurignacian deposits by an erosional disconformity (Vicino 1984, Holt et al. 2019). This phenomenon parallels the situation seen at Riparo Mochi, where the ‘semi-sterile’ Mousterian Level H is likewise separated from the base of the Protoaurignacian in Level G by an erosional surface (Douka et al. 2012). Level MS as a whole is marked by the presence of large blocks of limestone vault and cliff collapse embedded in a colluvial sedimentary matrix

of orangish clayey loam, suggestive of an accumulation under comparatively cold conditions (Holt et al. 2019). This is borne out by palynological and microfaunal data that indicate that MS was characterized by more rigorous conditions than in the underlying Mousterian Levels M1-7 (Arobba and Caramiello 2009, Holt et al. 2019).

This fits with what is understood about the general chronology of Level MS. While there are no dates for this level, the Protoaurignacian appears by ca. 42ky cal. BP at the Balzi Rossi, serving as a *terminus ante quem* (Douka et al. 2012). Two AMS dates on charcoal indicate an age of ca. 43.5ky cal BP for level M4, which sits some 40cm below Level MS (Riel-Salvatore 2007, Holt et al. 2019), while dates on shell for levels M3 and M2 yielded ages younger than 42ky cal. BP, suggesting they underestimate the true age of these deposits (cf. Higham et al. 2014). This age is also consistent with the age range of recently identified cryptotephra from the same level (Hirniak et al. 2020). Assuming for argument's sake a constant accumulation rate at the site, it seems reasonable to assume that Level MS accumulated between roughly 42,750 and 42,000 cal. BP, which coincides with a period of decreasing temperature in the NGRIP ice core (Andersen et al. 2006).

Archaeologically, Level MS has historically been described as 'semi-sterile' due to its scant artifactual content and in reference to the similar situation seen in Level H at nearby Riparo Mochi (Bietti and Negrino 2007). Indeed, prior analyses have shown that it has yielded the least dense assemblage of the entire Mousterian sequence at Riparo Bombrini (Riel-Salvatore 2007, 2010; Riel-Salvatore et al. 2013), with only 22 identifiable faunal remains dominated by cervids (40.9%), *Bos/Bison* (13.6%), *Sus scrofa* (13%) and single

individuals of *Rupicapra rupicapra* and *Stephanorhinus kirchbergensis* and one unidentified carnivore (Holt et al. 2019). While the exploitation of shellfish for dietary purposes is documented at the site (Negrino and Riel-Salvatore 2018), evidence for this in Level MS has been very poor, with a single shell piece plotted for the entire level (Riel-Salvatore et al. 2013). The presence of carnivore coprolites in this level also indicates that human presence may have been less sustained in MS than in any other level at the site, although no taphonomic data have been presented to date to support this (Holt et al. 2019). A preliminary spatial analysis of the piece-plotted finds from Level MS also revealed that Level MS has yielded the most abundant evidence of ochre use of all the Mousterian sequence at the site, along with a concentration of faunal remains inside the shelter (Riel-Salvatore et al. 2013).

Technologically, the lithic artifacts recovered in Level MS are Mousterian, attributable prevalently to a Discoid reduction strategy although a very few Levallois elements have also been found; again this pattern agrees with that seen at Mochi (Negrino 2002, Riel-Salvatore 2007, Negrino and Riel-Salvatore 2018). A very few Protoaurignacian elements, mostly bladelet fragments, were reworked downward into the top of Level MS, probably as a result of trampling or site maintenance, but these can easily be recognized and eliminated. The assemblage was made almost exclusively on poor-quality flint procured from the I Ciotti conglomerates located less than 1km away (Del Lucchese et al. 2001-2002, Negrino 2002, Rossoni-Notter and Simon 2016), along with a small fraction of pieces made on circumlocal materials such as silicified limestone and quartzite from sources located near San Remo, some 20 km away (Riel-Salvatore and Negrino 2009).

Typologically, the 2002-05 assemblage from Level MS is dominated by denticulates (5) and pseudo-Levallois points (6, including one retouched), but it also includes convex sidescrapers (2), atypical bladelets (2, read small elongated flakes), retouched flakes (2) and a Levallois flake (Riel-Salvatore 2007: Table 6.8). Three Discoid cores complete the assemblage.

New Data on Level MS

The excavation project begun in 2015 has so far expanded the area excavated into Protoaurignacian Levels A1-A3 as well as into Mousterian Levels MS and M1. Here we will present preliminary observations focusing on Level MS to address issue related to the behavior of the last Neanderthals at the Balzi Rossi. The combination of new excavation and analytical protocols combined to the integration of data sets from prior projects has yielded a wealth of new data that allow us to test the view of Level MS as 'semi-sterile' based on the data recovered from 1976 to 2005.

Spatial organization: Figure 3 shows the distribution of piece-plotted archaeological finds and features in Level MS (Vallerand 2021). It provides a straightforward point of comparison to the preliminary data drawn from the 2002-05 excavations presented in Riel-Salvatore et al. (2013). As can readily be seen, our recent excavations in the southern part of the site and the incorporation of the data from Vicino's excavations give a much more complete perspective on how the shelter was occupied in Level MS. First, in contrast to what was presented in Riel-Salvatore et al. (2013), there is now clearly an

occupation outside of the shelter itself. Additionally, our ongoing excavations have revealed that the 2002-2005 project had barely scratched the surface of Level MS and have yielded an assemblage eight times larger than that recovered in 1976 (Table 1). This may be in part due do slightly different field documentation protocols, but it is also likely linked to the identification in 2017 of an ovaloid combustion area centered on squares DD2 and EE2. While this is not a formal hearth like the 'cuvette'-type hearths recovered in the overlying Protoaurignacian deposits, it appears delimited and is located in the same area of the shelter, close to the backwall (Holt 2019, cf. Riel-Salvatore et al. 2013). This hearth appears to be associated with much of the new archaeological material recovered from Level MS in 2016-2018.

Strikingly, the recent excavations have more than tripled the evidence for ochre use in Level MS (Table 1), and they confirm that it is tightly associated with the back wall of the shelter, with more than half of the ochre being found within a meter of the backwall. An important difference revealed by the recent work in contrast to the 2013 patterns, is that shellfish is actually well represented in Level MS and found concentrated inside the shelter (Table 1). Our sample now includes shell fragments of limpets, *Phorcus turbinatus* and other gastropods, indicating that these species were exploited for food as in the rest of the Mousterian levels at Riparo Bombrini, indicating an expansion of the Neanderthal diet breadth prior to the Upper Paleolithic. Additionally, the expansion of the excavated area confirm that lithic and faunal remains are concentrated within the shelter, with more marginal evidence of human activities outside the shelter and, in particular, at the mouth of the shelter; this patterning is non-random and most parsimoniously

understood as the result of Neanderthal site occupation patterns structured around distinct activity areas in Level MS (Vallerand 2021). Given the prevalence of roof and cliff spalling during the formation of Level MS summarized above, it is unsurprising that the area near along the dripline would not have been the setting for much activity. Some processing of carcasses may have taken place immediately in front of the shelter, however, as indicated by the co-occurrence of faunal remains and lithics in that area.

Fauna: In addition to the newly collected evidence for shellfish exploitation in Level MS, other data provide a refined understanding of faunal representation at the site. Using an approach combining zooarchaeology, taphonomy and large-scale ZooMS sampling that has been implemented for the analysis of the Protoaurignacian faunal assemblage from Riparo Bombrini (Pothier Bouchard et al. 2019, 2020), it has been possible to more than quintuple the NISP for Level MS (Table 2; Pothier Bouchard 2021). Taxonomic identifications were based on the morphological identification of the rare partially complete teeth and skeletal elements (cf. Holt et al. 2019), complemented by ZooMS identifications when collagen was preserved. The samples analyzed for this study come from squares A1 and C1 (1976 excavation), AA1, BB1, CC1, and DD1 (2002-05 excavation), and DD2, and EE3 (2015-19 excavations). It shows an overall dominance of large cervids (23%) mostly comprising red deer skeletal remains. In contrast to what had been highlighted in Holt et al. (2019), however, there is also a significant presence of caprines (5%), in particular of ibex (Figure 4). All caprine remains, however, show traces of carnivore alteration. Beyond these, the faunal assemblage confirms the sporadic

presence of *Bos/Bison* and boar, and provide new evidence of the presence of both equids and bears in Level MS.

Various taphonomic observations from the 2016-2018 excavations indicate that Level MS saw only sporadic human occupations. These include the fact that the only documented anthropic modification is represented by the low frequency of burnt bones and that there is a relatively high proportion of bone alterations by carnivore, including digested bones displaying gastric etching and tooth and gnaw marks. The abundance of carnivore coprolites in this level, while not a taphonomic indicator per se, also indicates that the site was occupied by carnivores as well as humans to a much greater extent than in any other Mousterian or Protoaurignacian level at Riparo Bombrini. While seasonality data would help better pinpoint when the site was occupied by Neanderthals and perhaps help situate this in alternance to the carnivore occupations, the available data at this stage are not sufficient to shed light on this issue.

Lithic technology: The technological make-up of the MS lithic assemblage is also distinctive. Here we present some preliminary information on it drawn from the analysis of the sample from sub-level MS1 collected during the ongoing project. This partial presentation is due to our inability to complete this analysis as planned in the summers of 2020 and 2021 due to fieldwork restrictions imposed by the COVID-19 pandemic. It will be published in full once the ongoing excavations at the site are completed in the near future. Nonetheless, because it was recovered from the entire excavated area and because it characterizes the very last phases of Mousterian occupation documented at Riparo

Bombrini, this samples it provides an important window into Neanderthal techno-economy at otherwise poorly documented moment at the Balzi Rossi, and Liguria more generally.

As in other levels at Bombrini, the MS1 lithic assemblage is composed mostly of minute shatter, followed by amorphous, blocky chunks (Table 3). The overrepresentation of the latter is likely owed to the prevalence among exploited raw materials of small nodules from the I Ciotti conglomerates that include numerous internal fault planes. No cores have been recovered in this sample, but flakes are fairly well represented. Overall, these flakes are smaller and broader than those documented in the overlying Protoaurignacian, supporting the notion that there was a technological break across the transition (Figure 5; see also Marciani et al. 2020). This also agrees with prior observation about decreased laminarity in the late Mousterian levels at Riparo Mochi. The fact that cortex is almost absent on both flakes (5/57 pieces, with only one with more than 50% cover) and chunks (16/325, with only two with more than 50% cover) pieces indicates that while knapping took place at the site, the worked nodules and blocks were decorticated, likely at the site of procurement. In terms of platform preparation, the majority (34) of flakes display plain unfaceted platforms, 8 have faceted platforms (including three displaying a 'chapeau de gendarme' morphology), three have punctiform and two are cortical. The platform of the remaining flakes was either illegible or thinned away. This low level of investment in platform preparation is in accord with the generally Discoid or even opportunistic character of the lithic assemblage of Level MS1. Only four flakes bear retouch, generally showing single sidescraper morphologies attained with light retouch.

In terms of exploited lithotypes, the overwhelming majority of knapped stone appears to have come from the I Ciotti conglomerates, as alluded to above. Five flakes (8.77%) and no blocks are manufactured on fine-grained quartzarenite from the San Remo area, located about 20km away, while exotic lithotypes are extremely rare, being represented by 5 flakes and 12 chunks. These materials include French rhyolite (1 flake, 2 chunks), reddish jasper (2 chunks), a dark fine-grained flint (1 flake, 1 chunk), as well as nonlocal materials of undetermined origin (3 flakes, 7 chunks). This indicates that artifacts of non-local origins appear to have very rarely been discarded on site, suggesting brief occupations during which local stone may have been acquired to replenish highly-mobile toolkits predominantly manufactured in regions to the east, in accordance to what is seen in other Mousterian levels at the site. This indicates that in MS1, Riparo Bombrini was probably not provisioned with raw material, which agrees with previous interpretations of Level MS being occupied as a task-site by foragers already equipped with needed lithic toolkits (Riel-Salvatore 2007, 2010; Riel-Salvatore et al. 2013).

Paleoenvrionmental context: Recent paleoecological work also permits situating the Level MS patterns in their broader environmental context. In a recent review of the paleoecological data available up to 2019, Badino et al. (2020) highlight that northern Italy would have been more forested than southern Italy for much of MIS 3. Further, based on the pollen records drawn from the cores from Lake Fimon, Lagaccione, Valle di Castiglione and Monticchio, the period 45-40ky cal BP was marked by an expansion of

xerophytic steppe environments and a shift from temperate to pine forest over the overall peninsula that is consistent with the establishment of cooler and drier conditions.

While these records unfortunately do not provide data pertaining directly to the situation in Liguria at the time during Level MS was deposited at Riparo Bombrini, the recent publication of the lake core data from Pian del Lago, near modern-day Sestri Levante, provides useful fine-grained data to better situate this period (Guido et al. 2020). Local area pollen zone PdL-1b from Pian del Lago has been dated to the interval 43.4-41.94ky cal. BP, which corresponds precisely with the terminal phases of Mousterian occupation at Bombrini (Riel-Salvatore and Negrino 2018b, Holt et al. 2019). It is bracketed by an earlier (PdL-1a) and later (PdL-2) LPAZ which both immediately precede and follow it, providing a robust paleoecological control on the human occupation of the region. In agreement with Badino et al. (2020), LPAZ Pdl-1b indicates an expansion of evergreen forests, with *Abies* and *Pinus* accounting for over 50% of identified specimens, with fir dominating. This contrasts with preceding LPAZ PdL-1a which is dominated by *Quercus* and *Fagus*, indicative of more temperate woodlands, whereas PdL2 would see a marked increase in the representation of coniferous species, especially *Pinus*. In sum, these data agree with the sedimentary, palynological and faunal data from Riparo Bombrini to suggest that Level MS is associated with markedly more rigorous climatic conditions.

Another interesting insight from Pian di Lago is provided by microcharcoal counts, which can be correlated with the intensity of human burning activities on the landscape (Guido et al. 2020). In turn, it can serve as an indirect indicator of the overall intensity of

human occupation in the past (Scott 2009, 2010). At Pian di Lago, microcharcoal counts in LPAZ PdL-1a average ca. 1500 fragments per sample, indicating that fire, while documented, was not a particularly important factor in structuring the landscape. Interestingly, LPAZ Pdl1b shows a much lower incidence of fire (ca. 200 fragments per sample), with some samples devoid of microcharcoal altogether. Guido et al. (2020: 4) interpret this as "indicating little influence of fire on ecosystem dynamics;" a possible attendant implication is that the landscape was largely devoid of humans at the time. In contrast, microcharcoal counts are low (ca. 300 fragments) at the beginning succeeding LPAZ PdL-2 (ca. 41.94ky cal BP) but subsequently increase substantially (up to ca. 12,500 fragments per sample) towards the end of this period (i.e., 35.47ky cal. BP)," suggesting an important role of fire in shaping vegetation structure and composition" (idem). This could suggest that the Protoaurignacian, which spans this interval at the Balzi Rossi, is associated in its later moments with more sustained human fire engineering of Liguria. This would also imply that the early phase of the Protoaurignacian was associated with comparatively low populations that had similar impacts on fire regimes as the Neanderthals before them, in accordance with evidence from other parts of Western Europe (e.g., Daniau et al. 2010). It bears emphasizing, however that Pian di Lago is located ca. 200km away from the Balzi Rossi, implying a need for caution in extrapolating patterns from it to Riparo Bombrini. It nonetheless provides the closest long-term paleoenvironmental archive to the Balzi Rossi, and we present these interpretations as working hypotheses that can be tested and refined in future work.

Discussion

In sum, these new interdisciplinary data from Level MS gathered from our ongoing excavations at Riparo Bombrini and contextualized paleoenvironmentally using the Pian di Lago sequence both confirm and nuance some of the previous interpretations put forward to interpret Level MS at the site, and its equivalents at the Balzi Rossi. These provide important new insights into both the nature of the last Neanderthal presence at the site and in Liguria more generally and allow us to address whether these groups of Neanderthals occupied the region as a refugium.

The preliminary analyses of faunal, lithic and spatial data from Level MS presented here converge to confirm a scant, ephemeral occupation of Riparo Bombrini in the terminal Mousterian during the last centuries preceding 42ka cal BP. The lithic assemblage appears limited to Discoid and opportunistic flaking strategies, with almost no evidence for the Levallois technology that is documented across Liguria during MIS 5 and 4, and the earlier part of MIS 3. In a way, the Level MS lithic assemblage can thus be seen as technologically more constrained, perhaps as a result of a type of site occupation with no analog in the rest the Mousterian record of Liguria. Likewise, the documented absence of nonlocal raw material types suggest a contraction of their social geography, combined with the decision to prioritize technological schemes designed to maximize the utility of lithic resources. This was accompanied by a focus of hunting activities on cervids, especially red deer. The presence of caprids in Level MS appears to be in part due to carnivore activity, which are also attested by the presence of frequent coprolites in this

level. The low frequency of burned bones also argues against intensive human processing of animal remains in this level. The presence of mollusk shells, in contrast, indicates that these resources remained accessible to the site's occupants between roughly 43-42ky cal BP.

In spite of the overall dim nature of the human presence in Level MS, the current excavations have nonetheless revealed that these episodic occupations were patterned, with fires being repeatedly lit at the same spot within the shelter. Strikingly, the area in which these fires were lit corresponds to that found in both underlying Mousterian levels and overlying Protoaurignacian ones, likely to take advantage of the natural convexity of the backwall of the shelter to diffuse heat in the protected area (see discussion in Riel-Salvatore et al. 2013). Further, recent excavations at the site have also established that ochre use within the shelter sees its most intense expression of the entire Mousterian sequence at the site. While this may suggest some affinities with the Protoaurignacian levels that overlie Level MS and which have yielded conspicuous quantities of ochre, it must be emphasized at this stage that the exact function and provenance of this ochre remain to be determined.

These data thus allow us to get a better sense of the nature of the adaptations of the last Neanderthals at the site. The new data indicate that the subsistence base remained in line with what had been done previously, while the lithic technology displays a 'hyper-local' signature focused almost exclusively on locally available material from the I Ciotti conglomerates, exploited mainly using a Discoid reduction strategy. A few exotic

elements indicate possible links to areas to the west in southern France and the east in Liguria, but the data from the most recent excavations confirm that almost no circumlocal materials were exploited (Riel-Salvatore 2007, Riel-Salvatore and Negrino 2009). The fact that the excavations since 2015 have revealed the presence of a diffuse combustion area within the shelter that is also associated with substantial traces of ochre use do indicate, however, that there was a structure to the way in which Neanderthals used the site. This, in a way, then belies the 'semi-sterile' label that has been given to this level for several decades, although it is undeniable that the pattern of occupation of the site changed radically at that moment relative to prior Mousterian occupations at the site, the Balzi Rossi and western Liguria as a whole.

What could have prompted this shift, and how does this relate to the scenario of this representing a refugium for some of the last Neanderthals in that region, and indeed in Italy? As is the case in other regions of Italy (Boschin, this issue), it seems clear that climate alone is not a sufficient explanation since, even though Level MS accumulated during a phase of climatic downturn, Neanderthals were clearly able to withstand comparable climatic shifts earlier during the course of the Late Pleistocene. Yet, the 43-42ky cal BP interval is associate with a decrease in microcharcoal concentrations at Pian di Lago (Guido et al. 2020), which may signal a decrease in the overall level of human presence on the landscape in Liguria at that time. It is important to highlight that Neanderthals seem to have otherwise been present continuously in the region starting at least from MIS 5 on, and likely longer. This peculiar paleoecological signal, combined with the 'hyperlocal' behavioral signature detailed above, could be interpreted be a

reflection of a breakdown of the social geography that had previously been exploited by Neanderthals to ride out shifts in condition and allow them to repeatedly 'reboot' their occupation of the region (see Riel-Salvatore and Negrino 2018). It is not unconceivable that the contemporaneous presence of the Protoaurignacian technocomplex to the west and the Uluzzian to the southeast may be related to the peculiar manifestation of the Mousterian of Level MS. Indeed, combined with a change in ecological conditions, the arrival of new groups in neighboring regions may well have been a 'perfect storm' that would impose an ever more confining vise around the last Neanderthals in the region. We propose this as the most likely working hypothesis because, in spite of our extensive knowledge of Mousterian adaptations across Liguria between MIS 5 and MIS 3 (see discussion above; Riel-Salvatore and Negrino 2018), in no other context and at no other moment do we encounter Mousterian assemblage that display this unique suite of characteristics. This thus argues against the 'semi-sterile Mousterian' of the Balzi Rossi representing solely a peculiar functional pose of Neanderthals.

If this is the case, then it may well be warranted to speak of Level MS at Riparo Bombrini as reflecting Neanderthal adaptations in a refugium context. It is probably also warranted to include Level H and the top of Level I at Riparo Mochi into this phenomenon (Bietti and Negrino 2007, Grimaldi and Santaniello 2014), though this awaits the publication of additional data about the associated faunal assemblage, its chronology and its spatial organization. This opens the question of what kind of a refugium would Riparo Bombrini and the Balzi Rossi have represented at the dusk of Neanderthals. Referring to the criteria laid out by Jones (this volume), it seems

appropriate to take a taxon-specific perspective to the question, one focused on Neanderthals. Further, considering the overall constrained nature of Liguria, the region would have constituted a micro-refugium for Neanderthals, as opposed to the larger scales envisioned for, say, peninsular Italy (cf. Riel-Salvatore 2010). The Balzi Rossi would have also represented a classic *in situ* refugium, whereby Neanderthals occupied some of the last suitable habitat of their previously larger range. Lastly, this refugium would have been ecologically stable, as shown by continuities in both subsistence practices and exploited sites on the landscape, both living sites and lithic outcrops. In sum, by all aspects of the definition, the geographically and chronologically circumscribed presence of Neanderthals in western Liguria, and particularly around the Balzi Rossi, would appear to correspond to the biogeographical definition of a refugium for that taxon (Ashcroft 2010, Feliner 2011).

Conclusions

We have presented here new data that allows us to better characterize the oft-mentioned but poorly documented 'semi-sterile' Mousterian of the Balzi Rossi first reported by Bietti during his excavation at Riparo Mochi in the 1990s (Alhaique et al. 2000; Negrino 2002; Bietti and Negrino 2007:42-43). Identified at Riparo Bombrini during the 2002-2005 excavations (Riel-Salvatore et al. 2013; Holt et al. 2019), recent excavation over a larger area at that site have confirmed that the archaeological assemblage is rather sparse and corresponds to a moment of attenuated human presence on the landscape as a whole. This is accompanied by an inward withdrawal manifested by an intense focus on local

lithic outcrops to provision Neanderthal forager with knappable stone. A caveat here is that, in the absence of cortex, it might occasionally be difficult to ascertain whether this material was acquired in primary context (cf. Rossoni-Notter and Simon 2016). Nonetheless, the site appears to have been occupied consistently, as shown by the presence of both combustion areas and possible activity areas in different parts of the shelter. The presence of ochre also spikes in this level, showing that even in its waning phases, the Mousterian nonetheless displayed some capacity for innovation. A combination of ZooMS with more traditional zooarchaeological and taphonomic analyses fleshes out the subsistence pattern of Neanderthals at the site, confirming the long-standing focus by Neanderthals on cervids in the region and establishing a significant carnivore impact on (and possible contribution to) the faunal assemblage at the site. The identification of bear remains, along with coprolites, clarifies the possible carnivore input to this level and lends additional support to an episodic, yet structured human occupation of the site at this time.

These data, in tandem with the available geographical, paleoecological and chronological data, indicate that this shift in the nature of human occupation at Riparo Bombrini and the Balzi Rossi more broadly coincided with a phase of climatic downturn and the arrival of different cultural traditions to the east and west. All the available data thus points to western Liguria having served as a biogeographical refugium for some of the last Neanderthals in Italy. This observation raises the question of why this phenomenon has so far only been documented at the Balzi Rossi, in spite of overall richness of the Mousterian record of Liguria. Here we venture to propose that these two elements might

be important determinants of whether we encounter the ‘semi-sterile’ Mousterian: the presence of Protoaurignacian deposits that serve as a *terminus ante quem* and the presence of long archaeological stratigraphies. Because the semi-sterile Mousterian immediately precedes the Protoaurignacian, identifying this technocomplex provides a possible sign that we may find it immediately underneath it. Unfortunately, as detailed above the Protoaurignacian is so far only known in the region at the Balzi Rossi and at Grotte de l’Observatoire to the west, as well as, perhaps, at Arma degli Zerbi, in the Finalese, to the east. Second, long sequences might be key to identify the semi-sterile Mousterian as it may otherwise at first glance appear to be a level devoid of human presence. Long sequences are known elsewhere in Liguria that may eventually allow to test this, for instance at Caverna delle Arene Candide, though they have yet to be explored down to Mousterian levels (see Riel-Salvatore et al. 2018).

As the data in this paper indicate, the peculiar expression of the Mousterian in Liguria colloquially known as the ‘semi-sterile Mousterian’ thus emerges as a biogeographical, behavioral and potentially chronological marker. That it might also reflect a dramatic decline in Neanderthal populations is a related possibility, but the perduraton of Neanderthals precisely in that area would bring it back to the fact that, biogeographically, the region around the Balzi Rossi served as a taxon-specific and ecologically stable *in situ* micro-refugium for late Neanderthals (Jones, this issue; Carvalho and Bicho, this issue). Behaviorally, it is marked by a shift towards high mobility and a ‘hyperlocal turn,’ whereby locally available resources were the immediate focus of exploitation; technologically, this is marked by the almost exclusive use of the Discoid method and,

economically, by a contraction of the exploited range of raw material sources to focus almost exclusively on those available within a day's walk from the site. Finally, in chronological terms, if the association of sparse assemblages, Discoid technology, local resource exploitation, and climatic downturn conditions between 43-42ky cal BP can be shown to hold at other sites in the region, the 'semi-sterile Mousterian' offers the possibility to serve as a chronological marker horizon across Liguria, indicative of the end of the world as Neanderthals knew it.

Acknowledgments:

Thanks to Milena Carvalho and Nuno Bicho for inviting us to contribute this chapter to the special issue on Neanderthal refugia in Europe and for their editorial guidance. We wish to acknowledge the very useful comments of one anonymous and one not-so-anonymous reviewer that helped strengthen some of the arguments developed in this study. Thanks are also due to Geneviève Mailloux-Root and Antoine Laliberté for help in collecting lithic data in the field. Research at Riparo Bombrini is coordinated by the University of Genoa (F.N.) and Université de Montréal (J.R.S) and supported by FRQSC grant 2016-NP-193048 (J.R.S), the Direction des affaires internationales UdeM (JRS), SSHRC Insight Grant 435-2017-1520 (J.R.S. & F.N.) and the ERC Horizon 2020 Grant 724046 (SUCCESS, to SB). Fieldwork is conducted under authorization of the Ministero per i beni e le attività culturali with local supervision by the Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Genova e le province di Imperia, La Spezia e Savona, with logistical support from the Istituto Internazionale di Studi Liguri (Bordighera), the Museo preistorico nazionale dei Balzi Rossi and the Direzione Regionale Musei della Liguria.

Author contributions:

JRS conceived the study. FN and JRS codirect excavations and the scientific study of the Riparo Bombrini material. JRS, FN and SB secured funding for the project. JRS wrote the first draft of the manuscript with specific author input on the Mousterian of Liguria (FN), the faunal remains (GPB) and the spatial data (AV). SC provided logistical support for fieldwork. All co-authors contributed to the revision and editing of the manuscript.

Table and figure captions:

Table 1: Counts of piece plotted artifacts recovered from the three areas at Riparo Bombrini (see Fig. 3).

Table 2: NISP and species identification obtained by combining proteomic and zooarchaeological identifications for Level MS.

Table 3: Technological categories and lithotype representation for the lithic assemblage from Level MS1. Sample from the 2015-2019 excavation.

Figure 1: Map of Liguria, with the position of some of the key sites discussed in the text.

Figure. 2: Cartographic sketch of the Balzi Rossi, with the location of the main Paleolithic sites indicated. Highlighted names indicate sites where Tyrrhenian beach deposits have been found.

Figure 3: Map of Riparo Bombrini, showing the distribution of artifacts (by category) and features, including rock fall and the combustion area.

Figure 4: Proportional importance of different animal taxa and classes in the MS faunal assemblage.

Figure 5: Distribution of length and width of flakes in the Mousterian (Levels MS) and Protoaurignacian (Levels A1 and A2) at Riparo Bombrini.

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	Inside	Dripline	Outside
Fauna	293	38	41
Charcoal	89	1	0
Lithic	296	32	30
Ochre	34	3	0
Other	19	1	4
Shells	26	2	2
Total artifacts	757	77	77
Area (in m2)	9.92	6.49	3.56

Table 1: Counts of piece plotted artifacts recovered from the three areas at Riparo Bombrini (see Fig. 3).

Taxa	NISP	%NISP
Herbivores		
Bos/Bison	2	2%
Capra ibex	3	4%
Cervus elaphus	5	6%
Equus sp.	1	1%
Sus scrofa	2	2%
Bovid s.2/3	2	2%
Caprine s.2/3	1	1%
Cervid s.3/4	11	13%
Cervid s.4	3	4%
Artiodactyl s.2/3	15	18%
Artiodactyl s.3/4	12	14%
Artiodactyl s.4	2	2%
Ungulate s.3/4	16	19%
Ungulate s.4	1	1%
Carnivores		0%
Ursus sp.	1	1%
Carnivore s.2	1	1%
Carnivore s.3/4	4	5%
Carnivore s.4	1	1%
Total NISP	**83**	100%
Indeterminate	4850	
Total NSP	**4933**	

Table 2: NISP and species identification obtained by combining proteomic and zooarchaeological identifications for Level MS.

	Local	Circumlocal	Rhyolite	Black flint	Jasper	Other exotic	Total
Flakes	47	5	1	1	0	3	57
Chunks	317	0	0	1	0	7	325
Shatter	334	4	2	2	2	8	356
Undetermined	37	2	0	1	0	4	44

Table 3: Technological categories and lithotype representation for the lithic assemblage from Level MS1. Sample from the 2015-2019 excavations.