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What's behind the tell phenomenon? An archaeozoological approach of eneolithic sites in Romania

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1 What's behind the tell phenomenon? An archaeozoological approach of Eneolithic sites in
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Abstract

1 This article is concerned with the Eneolithic period in southeastern Europe, which
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3 corresponds to a phase of increasing social complexity. We demonstrate that the development
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5 of a new type of settlement, the tell site, which in southeastern Romania fully began with the
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7 Gumelnița culture, was accompanied by changes in the meat component of the diet. The 39
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9 available faunal spectra are processed by correspondence analyses; this shows that the
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11 homogeneity that characterized the previous cultures (Hamangia and Boian) was followed by
12
13 a greater diversity in animal exploitation systems in the Gumelnița culture. The main change
14
15 is the important role that large game played for some Gumelnița communities (the favored
16
17 species varied). However, variability existed within the domestic species as well. This may
18
19 result from the interaction between several possible factors (e.g. new husbandry techniques,
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21 complex socio-economic relations between the sites, a great social value given to wild
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23 mammals). This diversity contrasts with the homogeneity of the pastoral practices developed
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25 for sheep (and, to a lesser extent, for cattle) at the Gumelnița tell sites (reliable kill-off
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27 patterns were established for five sites). We also show that sheep exploitation was specialized.
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29 Given that this kind of specialized exploitation became the norm from the Gumelnița period,
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31 we propose that the appearance of homogeneous and specialized practices for sheep is linked
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33 to the development of tell sites. More generally, certain standardization in pastoral practices
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35 during the Gumelnița period is possible. For three tell sites, it is likely that the youngest sheep
36
37 and goats died mainly elsewhere; we suggest that these settlements were parts of larger
38
39 pastoral systems, on a local or regional scale, and that places or sites with complementary
40
41 functions existed.
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Key-words

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44 Eneolithic; Hunting; Diversity; Pastoral practices; Sheep/goats; Specialization.
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1. Introduction

1 The fifth and fourth millennia BC are fundamental for European societies because they
2 correspond, depending on location, to the end of the Neolithization process (northern Europe)
3 and to a new stage of development, described as a phase of increasing social complexity. In
4 southeastern Europe, the fifth millennium BC is characterized by the development of copper
5 metallurgy and it is during these two millennia that an accentuation of social differentiation
6 occurred (Chapman et al., 2006; Guilaine, 2007; Marinescu-Bîlcu, 2001; Renfrew, 1978;
7 Slavchev, 2008; Todorova, 1978). Some authors advance the hypothesis that it was
8 specialization in Neolithic society that led to the development of social organization
9 (Guilaine, 1998, 2007; Lichardus et al., 1985). In southeastern Romania, the fifth millennium
10 BC is also characterized by the appearance of tell sites.

11 In southeastern Europe, specialized workshops have indeed been identified for these two
12 millennia (Chapman, 2010; Ellis, 1984; Manolakakis, 2007), roughly corresponding to the
13 Late Neolithic and Eneolithic period. In Romania, ceramic- and flint-processing areas are the
14 most common (Marinescu-Bîlcu, 2002; Popovici, 2010). At Dragușeni (Cucuteni culture), it
15 has even been demonstrated that a family specialized in an activity over many generations
16 (Marinescu-Bîlcu and Bolomey, 2000). The hypothesis that some populations used communal
17 granaries has also been advanced (Cârciumaru, 1996; Monah et al., 2003).

18 Although the number of archaeozoological studies published for this period in Romania is
19 high (Bălășescu et al., 2003a, 2005a, 2005b; Bălășescu and Radu, 2002, 2004; Cavaleriu and
20 Bejenaru, 2009; El Susi, 1996), research dealing with the identification of specialization (of
21 activities or places) is rare. The archaeozoological approach can be an effective tool for
22 dealing with these questions. Much work has shown that the analysis of pastoral practices, for
23 example, is an excellent way to reveal possible cases of specialization and thus to reveal the
24 existence of exchanges between the sites of a given geographical zone (Arnold and
25 Greenfield, 2006; Bréhard et al., 2010; Halstead, 1996; Helmer et al., 2005; Rowley-Conwy,
26 1991; Stein, 1987).

27 Our objective is to characterize the pastoral practices of some Eneolithic tell sites in Romania
28 in order to identify possible cases of specialization and to define the relations that may have
29 existed between the sites on a local or regional scale. To investigate the pastoral practices,
30 reliable kill-off patterns were established for domestic ruminants. The intention of this paper
31 is also to examine whether the appearance of a new type of settlement led to changes in
32 overall animal exploitation systems. The tell sites, whose proper development begins in the
33 middle of the fifth millennium BC in southeastern Romania, were both long-term occupations

1 and organized settlements. Should the communities inhabiting this kind of settlement be
2 characterized by their food supply strategies? In order to explore possible changes in the meat
3 component of the diet, the faunal spectra available for the period from 5000 to 3500 cal BC
4 were analyzed and processed by correspondence analysis.
5

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7 This paper focuses on the Gumelnița culture in Romania (Late Eneolithic), as it corresponds
8 to the period of full development of the tell sites (Marinescu-Bîlcu, 2001; Petrescu-Dâmbovița
9 and Vulpe, 2001; Ursulescu, 1998). It also provides the highest number of published
10 archaeozoological studies (Bălășescu et al., 2003a, 2005b), and the tell sites yield large faunal
11 assemblages that enable the establishment of reliable kill-off patterns. Since archaeological
12 levels assigned to the Boian culture are frequent at the base of Gumelnița tell sites, we
13 included archaeozoological data published for the preceding cultures, Boian and Hamangia
14 (which is partly contemporary with the Boian culture).
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25 **2. Archaeological contexts**

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27 The Hamangia culture covered a small geographical area on the western coast of the Black
28 Sea, both in Romania and Bulgaria (Fig. 1). During the Early Hamangia, the settlements were
29 generally short-term occupations, mostly small in size (Hașotti, 1997). These features partly
30 changed during the Late Hamangia (phase III), which corresponds to the beginning of the fifth
31 millennium BC (Voinea and Neagu, 2008).
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35 The Boian culture is divided into three phases (Giulești, Vidra and Spanțov) that roughly
36 cover the first half of the fifth millennium BC (Neagu, 2003; Pandrea, 2000; Table 1). The
37 first occupations are located in the Muntenia region. Then the geographical area covered by
38 the Boian culture changed over time. The late phase has been identified in the Muntenia and
39 Dobrogea regions, also in the Marița culture in Bulgaria (Pandrea, 2000; Fig. 1). The Boian
40 culture is characterized by more organized settlements. And the Vidra phase is marked by the
41 appearance of successive occupations at the same place that resulted in tell sites in the
42 Gumelnița period. According to the chronology proposed by Petrescu-Dâmbovița (2001), the
43 Late Hamangia and the Boian culture belong to the Early Eneolithic.
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53 The Gumelnița culture spread across southern and southeastern Romania, the neighboring
54 regions of the Republic of Moldova and Ukraine and the eastern part of Bulgaria (as
55 Kodjadermen and Karanovo VI cultures; Fig. 1). Within this area, regional variants can be
56 found (Marinescu-Bîlcu, 2001; Voinea, 2005). In Romania, the Gumelnița culture dates from
57 4600/4500 to 3500 cal BC according to the chronology proposed by several authors (Bem
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2001; Carozza et al., in press; Dumitrescu et al., 1983) and to recent radiocarbon dates (Cucchi et al., 2011; Ludwig et al., 2009; Tresset, personal communication 2011; Table 1).

Two main phases can be distinguished in the evolution of the Gumelnița culture: phase A and phase B, each with two stages. The second phase (Gumelnița B) does not exist in the Dobrogea region (and its second stage, B2, is attested only in the hills of Muntenia and is known as the Brătești phase). About ten radiocarbon dates assigned to phase A are regarded as reliable (Table 1). They indicate occupations between 4600/4500 and 4000 cal BC. Three radiocarbon dates with very similar intervals are available for Gumelnița B1 (at Căscioarele, Bucșani and Vitănești): from 3670 to 3500 cal BC and probably describe the end of the stage B1. The radiocarbon dates used in this paper have been calibrated (2σ) using Calib Rev 6.0.1 (Stuiver and Reimer, 1993). The Gumelnița culture belongs to the Late Eneolithic (Dumitrescu and Vulpe, 1988; Petrescu-Dâmbovița, 2001).

[Figure 1]

[Table 1]

In southeastern Romania, the period of full development of the tell sites corresponds to the Gumelnița culture. In southeastern Europe, the appearance and abandonment of the tell sites varies by areas. The fifth millennium BC is characterized by the appearance of the tell sites in southeastern Romania (and in northeastern Bulgaria; Todorova, 1978), while in the Carpathian Basin, there is the abandonment of this type of settlement. In the Great Hungarian Plain, the Tiszapolgár culture (Early Copper Age; 4600-4000 cal BC), which is contemporary with the Gumelnița A, is marked by the appearance of smaller settlements, dispersed in larger, regional settlement clusters (Parkinson et al., 2010).

Table 2 shows data about the Eneolithic sites included in the study (Andreescu and Lazăr, 2008; Andreescu et al., 2003; references in Bălășescu et al., 2005a, 2005b; Bem, 2001; Boroneanț, 2000a; Comșa, 1990 ; Haită, 2002, 2005; Micu, 2005; Nica et al., 1995; Pandrea et al., 2009; Parnic et al., 2002; Popovici et al. 2000, 2001 and 2003; Șerbănescu and Trohani, 1978; Voinea, 2004-2005) while Figure 1 indicates the location of the sites. The Gumelnița tell sites present distinct features. The geological surroundings vary (islet, floodplain, hill in the floodplain, erosion remnant, river terrace), as do the shape and size of the tell sites. There are very large tells (at Hârșova tell, the base measures 200 x 150 m) as well as small tell sites (at Vitănești, the diameter at the base is 45 m) and the preserved Gumelnița levels vary from 0.6 -7 m in height (Table 2). But in most cases, the height of the preserved Gumelnița levels

1 varies from 1- 3 m. Besides the main occupation of these tell sites dated to the Gumelnița
2 culture, archaeological levels assigned to the Boian culture are frequent at the base of the tells
3 (Table 2).
4

5 All the Gumelnița tell sites included in the study provided dwellings (often gutted by fire),
6 which are characterized by floors made of silts or sandy silts. At the oldest excavations, these
7 structures, if not gutted by fire, were sometimes not recognized as dwellings; these silty levels
8 were interpreted as natural deposits. Pedologic, sedimentological and micromorphological
9 analyses conducted during the last ten years threw new light on both the interpretation of the
10 archaeological structures and the tell formation (Haită, 2000, 2001, 2002, 2003, 2005). Areas
11 of household refuse have also been identified on the tell sites. These are the result, among
12 other things, of mammals, fishes, mollusks and cereals processing (e.g., Haită and Radu,
13 2003; Moise, 2000; Monah, 2000). Burials have also been excavated at several tell sites
14 (Hârșova tell, Căscioarele, Bordușani-Popină, Năvodari, Chitila; Bucșani); the skeletons are
15 often under the floor of a dwelling (Boroneanț, 2000a; Dumitrescu et al., 1983; Marinescu-
16 Bîlcu, 2001; Popovici et al., 2001, 2003).
17

18 The fact that dwellings were often rebuilt at the same place, according to the same plan,
19 suggests that the Gumelnița tell sites were organized settlements (Marinescu-Bîlcu, 2001;
20 Popovici et al., 2001); for most of the tell sites included in the study, the function of
21 permanent settlement is proposed (Haită and Radu, 2003; Marinescu-Bîlcu, 2001; Popovici et
22 al., 2000, 2001). At Căscioarele, the existence, in the Gumelnița B1 levels, of an annex where
23 statuettes, bone figurines, anthropomorphic and zoomorphic pottery vessels and miniature
24 chairs have been excavated (Marinescu-Bîlcu, 2001) suggests that unusual practices
25 (independent of the everyday activities) also took place at some of these settlements (painted
26 pillars have also been excavated in the Boian levels, and were interpreted as a sanctuary). On
27 the basis of published information, no other Gumelnița site included in the study provided
28 such finds (but isolated statuette or portable altar, for example, has been identified in some
29 dwellings). The function of the Gumelnița tell sites is still unclear, as no overall study has
30 been published yet; only preliminary results or studies regarding a small part of the excavated
31 structures exist.
32

33 The duration of the Gumelnița occupations is difficult to estimate. First, there are not enough
34 radiocarbon dates per tell site and per stage (see Table 1) to propose even rough estimations.
35 Moreover, very few Gumelnița A, or Gumelnița B, occupations have been entirely excavated
36 in height (it has been done for the stage B1 at Căscioarele and Bucșani). For the moment, only
37 small scale studies exist. At Hârșova tell, the micromorphological and ichthyological analyses
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1 carried out on an area of household refuse showed that the 50 cm accumulation corresponds to
2 at least one year of occupation (Gumelnița A2; Haită and Radu, 2003). These results can not
3 be applied to other archaeological contexts. The fact that dwellings have been identified at
4 most tell sites and that these settlements provided a large amount of ceramic and faunal
5 remains suggest however that, for the most part, they were not short-term occupations. But the
6 duration of the occupation varied according to the sites. Given the height of the preserved
7 Gumelnița levels, it is more than likely that the Gumelnița A occupation at Hârșova tell,
8 Însurăței Popină I or Bordușani-Popină lasted longer than at Carcaliu or Năvodari (Table 2).
9 Finally, occupations were not always continuous: periods of abandonment (between two
10 stages of the Gumelnița culture) have been identified at some tell sites (for example at
11 Vitănești and Bucșani; Table 2).
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21 [Table 2]
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25 **3. Material and methods**

26 To compare the animal exploitation systems, we first present the possible archaeological
27 biases, such as sample size, inclusion of antler remains in the count and differential collection
28 and preservation (see Greenfield, 2008). These will be used in the interpretation of the results.
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33 3.1. Material

34 3.1.1. Faunal assemblages

35 Faunal assemblages from funerary contexts are not included. We exclude very small samples
36 (NISP < 67; and only two assemblages out of 39 have less than 100 NISP). Almost half the
37 assemblages selected are characterized by large samples (NISP > 1000, 18 cases out of 39;
38 Table 3). Eleven sites out of the 29 selected in the study are still excavated (Table 2). As
39 excavations began at least ten years ago, the available faunal assemblages are large enough to
40 provide reliable information (the sample exceeds 1000 NISP in 10 cases out of 13). We
41 exclude antler remains from the analyses except when studies do not go into any detail on this
42 point (only six cases out of 39; Table 3).
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52 It is not always specified in the archaeozoological studies from which archaeological
53 structures the faunal remains come from (“cultural level”; 10 sites out of 29; Table 2).
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55 In the Gumelnița culture (and, to a lesser extent, some Boian occupations), the animal remains
56 are mostly well preserved (Bălășescu, 2003; Bălășescu and Radu, 2004) thanks to the type of
57 site: the tell sites are stratified settlements whose survival results from very specific
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1 conditions (in particular a dry climate) that reduce the process of erosion and preserve
2 evidence of human activities. Hârșova tell and Bordușani-Popină have produced several
3 wooden platforms (Popovici et al., 2000, 2003), which are evidence of low level degradation
4 that characterizes most of the tell sites.
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7 Sieving is carried out at some Eneolithic sites since the nineties only; therefore it concerns 10
8 sites out of the 29 included in the study (Table 2). At the others, the bone remains were
9 collected by hand, so differential collection must be taken into consideration. For some of the
10 oldest excavations (at Căscioarele, Vlădiceasca and Tangâru), this recovery bias is likely to be
11 more obvious, due to the excavating methods. The identification of the assemblages highly
12 biased by excavating and recovery methods is based on the presence of small taxa, such as
13 Mustelidae, hare, birds, tortoise and fish. At Vărăști, Vlădiceasca, Șeinoiu, Tangâru and
14 Drăgănești-Olt (eight assemblages), no remains of birds, tortoise or fish and very few remains
15 of hare and Mustelidae have been identified (Bălășescu et al. 2005a; Bălășescu and Radu,
16 2004). Therefore, the importance of small mammals in the economic systems is likely to be
17 underestimated at these five sites. At Căscioarele, the same tendencies are observed for birds,
18 tortoise, hare and Mustelidae; fish represent 10% of the faunal remains that have been
19 collected (Dumitrescu, 1965). These two assemblages are biased by excavating and recovery
20 methods but probably less than the others.
21

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23 The 39 Eneolithic assemblages are different, both from the qualitative and quantitative point
24 of view. This will be taken into consideration to interpret the results. To facilitate this, the
25 names of the ten most reliable assemblages are in bold type in Table 3 and in the plots shown
26 in Figs. 3, 4 and 5. This selection is based on several criteria (Tables 2 and 3): sample size
27 (NISP > 800), excavating methods and recovery techniques (sieving).
28

29
30 Figure 1 indicates the locations of the 29 sites selected for the study. They provide 39 faunal
31 assemblages belonging to the Hamangia, Boian and Gumelnița cultures (Tables 2 and 3).
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34 Thirteen Boian assemblages characterizing the three phases of this culture are included in the
35 study (Table 2). In three cases, Boian and Gumelnița archaeozoological studies are available
36 for the same site. Six archaeozoological studies are published for the Hamangia culture in
37 Romania but only three provide raw data (Bălășescu and Radu, 2004). They are assigned to
38 the late phase (phase III). Twenty-three faunal assemblages assigned to the Gumelnița culture
39 are available (Table 2). In four cases, the same tell site provides archaeozoological studies
40 illustrating two or three different stages of the culture (Table 2). Fifteen taxonomic spectra
41 represent phase A (stage A2 is the best known: 14 assemblages out of 15) and seven phase B
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1 (stage B1 as there is no archaeozoological data published for stage B2). For one tell site,
2 Tangâru, the phase is not known.
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5 [Table 3]
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9 For the Gumelnița tell sites, all the published archaeozoological studies characterize only a
10 part of the occupation: either the Gumelnița levels have not been entirely excavated or, for the
11 two sites where the whole Gumelnița B occupation has been excavated, the study included
12 only a part of the faunal remains (stage B1 at Bucșani and at Căscioarele). The faunal remains
13 always come from several archaeological structures, often of different kinds (Table 2).
14 The data used in this study are, for each cultural stage, global data. It is not possible to
15 provide several faunal spectra per site, each of them characterizing a distinct archaeological
16 structure. For the oldest archaeozoological studies, only the global faunal spectra are
17 published. For the eight tell sites of which one of us (AB) is in charge of the study of the
18 faunal remains (see Table 3), the stratigraphic profiles are not completed. It will be possible to
19 work on a smaller scale and compare the different structures that have been excavated for one
20 occupation, when the final stratigraphic data is available. A few studies regarding one
21 archaeological structure are however available for five tell sites (Table 3): Hârșova tell (areas
22 of household refuse C521 and C720, the outer level of a dwelling C1017), Bordușani-Popină
23 (dwelling SL33, foundation trench C201), Luncavița (dwelling C4 and area of household
24 refuse C2), Însurăței (dwellings L4, L7, L8) and Bucșani (dwelling L2). We will compare
25 these 11 structures with the global data.
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42 3.1.2. Dental assemblages

43 To discuss the pastoral practices, we selected five tell sites with distinct features. Bordușani-
44 Popină, Hârșova tell and Măriuța are characterized by an animal economy based mainly on
45 husbandry while hunting played a major role at Luncavița and was predominant at Vitănești.
46 Cattle dominate the faunal spectrum at Măriuța, Vitănești (A2) and Luncavița, while
47 sheep/goats are predominant at Hârșova tell. There is a more balanced representation of cattle
48 and sheep/goats at Bordușani-Popină. These examples both date to Gumelnița A2 and B1.
49 Large faunal assemblages are available; the size of the sample exceeds 100 teeth in five cases
50 out of nine (see Tables 5 and 6). Sieving was carried out at four sites out of five (Table 2). At
51 Bordușani-Popină, Hârșova tell and Luncavița, all the archaeological structures with a high
52 archaeozoological potential have been sieved. For each site, the dental remains come from
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1 different archaeological structures. Only global kill-off patterns are given since stratigraphic
2 profiles are not completed (see above) or the subdivision would result in very small samples
3 (Hârșova tell, structure C521, sheep/goats: N=18).
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7 3.2. Methods

8 3.2.1. Taxonomic identification

9
10 In the archaeozoological studies included (see Table 3), identification to species level for
11 Bovinae (cattle, *Bos taurus*, and aurochs, *Bos primigenius*) and Suinae (pig, *Sus domesticus*,
12 and wild boar, *Sus scrofa*) is based on the osteometric and morphological criteria proposed by
13 Bökönyi (1972), Bökönyi and Bartosiewicz (1997), Degerbøl and Fredskild (1970), El Susi
14 (1996) and Manhart (1998). For sheep and goats, discrimination is based on the criteria
15 proposed by Boessneck et al. (1964), Clutton-Brock et al. (1990) and Prummel and Frisch
16 (1986). For the taxonomic determination that we conducted on teeth (see Table 3), we singled
17 out the criteria developed for the premolars (Halstead et al., 2002; Helmer, 2000; Payne,
18 1985; Zeder and Pilaar, 2010). When isolated, the dP4 were not used to make taxonomic
19 identifications.
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31 3.2.2. Analysis of the faunal spectra

32 Our objective is to investigate whether the animal exploitation systems were homogeneous
33 within each culture or whether diversity in the economic strategies occurred in the Gumelnița
34 period (and if so, which species is related to which site(s)). Since we had to analyze together
35 39 assemblages and more than ten variables (taxa; Table 3), correspondence analysis (CA)
36 was employed as the most suitable tool to achieve this purpose. The simultaneous
37 consideration of multiple categorical variables can reveal relationships that would not be
38 detected in a series of pair comparisons of variables (Bølviken et al., 1982; Clouse, 1999;
39 Smith and Munro, 2009). CA allows the introduction of small assemblages, as the process
40 characterizes each row (assemblages) and each column (taxa) by its profile (relative
41 frequencies). This partly solves the problem of differences in sample size. The rules for
42 interpreting the graphic display of row and column points in biplots are outlined by Bølviken
43 et al. (1982; see also the summary in Smith and Munro, 2009). Data analyses were conducted
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56 We selected 11 taxa as variables (Table 3). We exclude beaver, as it is present in only half the
57 assemblages. As the frequencies for each of the ten species of wild carnivore (details are
58 given in Table 3) are too low to justify their use independently, the species are treated as one
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1 large group. One purpose for hunting wild carnivores (and beaver) was for their pelts, but they
2 were also eaten (identification of fragmented bones and of cutmarks from different kinds;
3 Bălăşescu and Radu, 2002; Bălăşescu et al., 2003b, 2005a, 2005b). Dogs were also part of the
4 diet (identification of dismembering and filleting marks; Bălăşescu et al., 2003b; Bălăşescu
5 and Radu, 2003, 2004; Moise, 1997, 2001b). The fact that in most cases the (numerous)
6 remains of Suinae could not be identified to species level led us to add the group “*Sus* sp.” as
7 a variable. However, since archaeozoological studies do not usually propose this taxonomic
8 class, it is introduced as a supplementary variable (it does not contribute to the factor axes).
9 Conversely, the taxonomic categories *Bos* sp. and *Equus* sp., are eliminated because they exist
10 in only a few cases (less than ten assemblages out of 39).
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20 3.2.3. Kill-off patterns

21 A way of examining the pastoral practices is the establishment of reliable kill-off patterns,
22 constructed from the estimates of age at death of the animals (Arnold and Greenfield, 2006;
23 Bréhard et al., 2010; Helmer et al., 2005; Rowley-Conwy, 1991; Stein, 1987). The kill-off
24 patterns should be organized using relatively narrow age classes with a correspondence in
25 absolute age to permit interpretations in terms of practices.
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31 For cattle, we estimated the age at death from the stages of tooth eruption and replacement
32 given by Higham (1967) and from the abrasion indexes proposed by Ducos (1968) for the
33 molars. Precedence was always given to eruption development over wear. For sheep/goats, we
34 used the method perfected by Helmer (1995; see Vigne and Helmer, 2007). When the molars
35 were not measurable, Payne’s wear stages were used.
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40 The age classes retained for sheep/goats are those proposed by Helmer (1995; modified after
41 Payne, 1973). For cattle, we adopted those advanced by Ducos (1968) for the adults, while the
42 first three age classes are based on the stages given by Higham (1967).
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45 The kill-off patterns were constructed based on the number of teeth (N; Vigne, 1988). We
46 excluded the second premolars as we observed high variability in their wear stages, even at
47 the very beginning of usage. When the estimate covered several age classes, the number of
48 teeth was divided according to the size of the time bracket of each age class. We included
49 only the lower teeth. Estimates based on upper teeth are less precise because upper jaws are
50 more fragile, and teeth are often isolated.
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56 We do not provide species-level kill-off patterns for sheep/goats, but do provide profiles
57 including all the teeth whose age can be determined, as a precaution, following Helmer (2000)
58 and Zeder and Pilaar (2010). The *Ovis/Capra* ratio is given (see Table 4).
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1 To investigate the pastoral practices of the tell sites selected, we first examined the possible
2 biases, such as differential preservation or collection. The interpretations are based on works
3 dealing with traditional farming, modern free-range management systems and feral
4 populations.
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10 **4. Animal exploitation systems**

11 4.1. The transition from Boian (and Hamangia III) to Gumelnița culture

12 Figure 2 clearly shows that changes in the meat component of the diet occurred between the
13 Boian (and Hamangia III) and the Gumelnița cultures in southeastern Romania. Cattle
14 obviously played a less important role during the Gumelnița period, while hunting increased.
15 A Chi-square test, carried out for the Boian and the Gumelnița cultures based on the remains
16 (NISP) accumulated for each of the five taxa selected in Figure 2, confirms that the economic
17 strategies varied according to the cultural group ($\chi^2 = 7134.4$; $df = 4$; $p < 0.0001$). The
18 Hamangia culture is also different because of the very low percentages of Suinae and dog (on
19 average 2% and 1.8% of the faunal spectrum, respectively; Table 3). Suinae, for example, are
20 not so rare on the Boian sites (from 0% to 24.8% of the faunal spectrum; average: 11.4%); the
21 difference is even statistically significant ($Z = 23.48$; $p < 0.001$). However, only three reliable
22 faunal assemblages are available for this culture.
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36 [Figure 2]

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39 The next step was to examine whether these main tendencies are true for all the Gumelnița
40 sites or whether diversity in the economic strategies occurred in this period, and, if so, which
41 species is related to which site(s). An initial correspondence analysis led to treating the dog as
42 a supplementary variable: its contribution to the second factor axis was too high (32%) in
43 comparison to the low number of points that expressed this variable (2 out of 39: Bordușani-
44 Popină and Hârșova tell).
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51 Figure 3 is a plot of both assemblages and taxa for the first two factor axes. The contribution
52 of these two factor axes to the total variance (0.588) is 74.6%. The first factor axis
53 (horizontal; 56.1% of the total variance) contrasts red deer (26.9%), aurochs (12%), wild boar
54 (11.9%) and wild horse (10.2%), on the left, with cattle (25.6%) and sheep/goats (10.7%), on
55 the right. This is interpreted as an opposition between hunting and husbandry. The second
56 axis (vertical; 18.6% of the total variance) contrasts in particular cattle (27.8%), at the top of
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1 the plot with pig (23.5%), and sheep/goats (19.3%) at the bottom. We interpret this as the
2 existence of different husbandry strategies.

3 Most objects (29 out of 39) are located on the right side of the plot, with cattle and
4 sheep/goats. The domestic ruminants did play a major role in the economic systems of the
5 Boian (and Late Hamangia) and Gumelnița cultures. All the sixteen objects representing the
6 Hamangia and Boian cultures (in grey) are plotted on the right side, with cattle and
7 sheep/goats, and twelve are located in the same quadrant (with cattle). This indicates that food
8 supply strategies of the Hamangia (phase III) and Boian cultures were quite homogeneous and
9 that they were based on domestic ruminant husbandry. It is likely that the importance of
10 sheep/goats is underestimated for these cultures, as sieving was carried out at only four sites
11 out of 14. However, sheep/goats are predominant at two sites where remains were collected
12 by hand (Siliștea-Conac and Lăceni-Măgura; Boian Giulești).

13 Conversely, the 23 Gumelnița assemblages (in black) are plotted in the four quadrants, which
14 means that various taxa played a role in the economic systems. This scattering is accurate as
15 the most reliable assemblages for the Gumelnița culture (7) are also plotted in the four
16 quadrants (Fig. 3 and Table 3). This difference between the Boian (and Late Hamangia)
17 culture and the Gumelnița also exists at a small scale level. At Căscioarele and Hârșova tell,
18 where faunal assemblages are available for both the Boian Spanțov and the Gumelnița
19 cultures (Table 3), changes in the meat component of the diet are obvious. At the former, red
20 deer replaced cattle (Fig. 3). At Hârșova tell, pig and dog took the place of cattle.

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38 [Figure 3]
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42 4.2. Hunting

43 Ten Gumelnița assemblages out of the 23 are located on the left side, with the wild mammals.
44 Four of them belong to the category of the most reliable assemblages (Fig. 3; Table 3). At
45 Căscioarele, Vitănești (Gumelnița A2 and B1), Însurăței, Luncavița, Carcaliu, Drăgănești-Olt
46 (Gumelnița A2 and B1), Seciu and Bucșani, hunting occupied an essential place in the
47 economy: from 29% to 84% of the faunal spectrum (average: 50%; Table 3). The highest
48 percentage, observed at Căscioarele, is probably wrong. Given the excavating and recovery
49 methods used at this tell site (see 3.1.1. above), all the possible remains from small domestic
50 mammals (e.g., sheep/goats and young pigs) have not been collected. Therefore, it is highly
51 likely that the proportion of large mammals (of large game) is overestimated. However, the
52 average hunting rate calculated for these ten assemblages (50%) is correct as it is the same
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than the one based on the four most reliable assemblages (51%; Table 3). For the 13 Gumelnița points located on the right side of the plot, with cattle and sheep/goats, wild mammals represent on average 16% of the faunal spectrum (the average for the three most reliable assemblages is 20%; Table 3). If we exclude the remains of aurochs and wild boar, for which species-level identifications are debatable, wild mammals retain an essential place for the first group (from 23% to 78% of the faunal spectrum; average: 40%) in comparison to the 13 others sites (average: 9%). Moreover, this does not result from differences in sample size or from differential collection as the ten assemblages present various characteristics (half of them are quite small assemblages, from 309 NISP to 822, and sieving was conducted at some sites). The higher hunting rates observed are thus indisputable.

Some differences can be observed among these eight tell sites. To show this, the second factor axis is replaced by the third one (10.9% of the total variance) in the correspondence plot (Fig. 4). It contrasts red deer (28.4%) and wild boar (4.3%), at the top, with aurochs (21.6%), wild horse (3.8%) and wild carnivores (3.7%), at the bottom. We interpret this as indicative of the existence of two distinct strategies: red deer (and wild boar) were mainly hunted at Căscioarele, Carcaliu, Luncavița and Drăgănești-Olt (in the upper half) while at Vitănești and Însurăței (in the lower half) aurochs (and wild horse) are predominant. These differences are accurate as there are reliable assemblages in both groups (Fig. 4; Table 3). Red deer represent 50.2% to 73.4% of the wild taxa in the first group while the percentages are between 17.4% and 30.7% in the second group. The aurochs frequencies range from 23.2% to 31% at Vitănești and Însurăței, and only 0.5% to 10.1% in the first group. This difference is shown in Figure 5. Bucșani presents a more balanced profile. At Seciu, the sample of wild species is too small to be reliable (NISP < 100). These two strategies are neither a reflection of differential discrimination since the same archaeozoologist worked on half of the studies (Table 3), nor the difference is due to differential collection as only large mammals are concerned. It is possible that these distinct strategies are related to different landscapes, since red deer and wild boar are indicative of forested areas, while wild horses of grasslands. But the archaeobotanical data dealing with landscape reconstructions are too few to be applied.

[Figure 4]

[Figure 5]

4.3. Husbandry

1 For the domestic species, the first correspondence plot (Fig. 3) distinguishes the Gumelnița
2 sites where cattle were predominant (14 faunal assemblages in the upper half) from those with
3 sheep/goats and pigs (7 points in the lower half). The last two faunal assemblages (Luncavița
4 and Măriuța; with coordinates very close to zero on the second factor axis) present a more
5 balanced profile. Cattle thus appear to have been the most common domestic species,
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7 whatever the overall animal exploitation system. However, given the absence of sieving at 11
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9 tell sites (out of 18; see Table 2), it is likely that the proportions of the smaller taxa, such as
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11 sheep/goats, are underestimated in some cases. It is noticeable that at the three sites where
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13 cattle provide at least 50% of the faunal spectra (six assemblages: Gumelnița A2 and B1,
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15 Vlădiceasca A1, A2 and B1 and Șeinoiu), remains have been collected by hand (Vlădiceasca
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17 and Șeinoiu have been characterized as assemblages highly biased by excavating and
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19 recovery methods; see 3.1. above). Conversely, sieving was carried out at the three tell sites
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21 where sheep/goats dominate (Hârșova, Năvodari and Sultana). Pigs are predominant only at
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23 Bordușani-Popină, but have the same importance as cattle at Seciu and Vitănești (A2 and B1).
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25 Sheep/goats are more often in second place than pigs.

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27 The ratio *Ovis/Capra* can be calculated reliably only for eight faunal spectra (Bălășescu, 2003
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29 and unpublished; Bălășescu et al., 2005a; Moise, 1997, 2000, 2001a, 2001b). Sheep are
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31 clearly predominant (3 sheep for 1 goat) at Bordușani-Popină, Hârșova tell, Măriuța and
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33 Vitănești (A2 and B1). At Luncavița, Vlădiceasca (A2) and Năvodari, there is a more
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35 balanced representation of sheep and goats. For five sites, we can compare these results to
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37 those based exclusively on teeth (Table 4). They confirm the predominance of sheep at
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39 Bordușani-Popină, Hârșova tell and Măriuța. The percentages of sheep are even higher (four
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41 sheep for one goat). This could be the consequence of a more systematic and advanced
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43 taxonomic discrimination, as all the dental remains were displayed and analyzed at the same
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45 time. At Vitănești and Luncavița, the number of mandibles identified to species level is too
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47 small (N=9) to be reliable. Variability likewise exists within the Caprinae, and there is no link
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49 between the predominance of sheep or goats and the overall animal exploitation systems
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51 (preponderance of husbandry or hunting).

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53 [Table 4]

54 55 56 4.4. Chronological variation

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58 The faunal assemblages dated to the Early (phase A) and to the Late (phase B) Gumelnița
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60 appear both on the right side and on the left side of the first correspondence plot (Fig. 3; there
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1 are reliable assemblages in both groups). The cultural phase and the rate of hunting thus
2 appear to be independent. On the other hand, the seven faunal spectra dated to Late Gumelnița
3 (phase B1) are located at the top of the plot. We interpret this as a decrease in the importance
4 of sheep/goats during the second phase of the Gumelnița period (sieving was conducted at
5 some sites). A Chi-square test, based on the remains (NISP) accumulated for each of the nine
6 taxa selected as variables, confirms that the economic strategies varied according to the time
7 period ($\chi^2 = 1563.1$; $df = 8$; $p < 0.0001$). However, the number of available faunal spectra for
8 Late Gumelnița is low and this hypothesis needs to be confirmed.
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16 This study leads to the conclusion that the homogeneity of the animal exploitation systems
17 during the Hamangia (phase III) and Boian period was followed by a greater diversity in the
18 economic strategies. The main change is obviously the important role that hunting played for
19 some Gumelnița communities (the favored species varied). Variability existed however within
20 the domestic species as well.
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27 4.5. Intra-site comparisons

28 To get an estimate of the variability in economic strategies on the settlement scale, we
29 compared, at five tell sites, the global data with data coming from distinct archaeological
30 structures (Table 3). We added the 11 faunal spectra as supplementary objects in the first
31 correspondence plot. Figure 6 shows that, except in one case (Însurăței L4), the global faunal
32 spectrum and the archaeological structures are in the same quadrant. Intra-site variability
33 existed, but, according to the available data, it seems to have been limited. The three tell sites
34 with high hunting rates (Însurăței, Luncavița, Bucșani) did not provide archaeological
35 structures characterized by a predominance of domestic mammals. The reverse is true as well
36 (Bordușani-Popină and Hârșova tell). At Însurăței, the variability is due to differences in wild
37 horse proportion. At Hârșova tell, it is caused by differences in sheep/goats (and cattle)
38 percentage.
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51 [Figure 6]
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54 4.6. Greater diversity in the animal exploitation systems during the Gumelnița period: 55 possible explanations

56 For Bovinae and Suinae, the taxonomic identifications distinguishing domestic and wild
57 animals are debatable. Recent research based on DNA analysis has shown that some large
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1 Bovinae from Romania, probably aurochs according to osteometric criteria, have domestic-
2 like haplotypes (haplotype T; Tresset, personal communication 2011). Hunting rates may be
3 less for the Gumelnița culture. On the other hand, it is an undeniable fact that very few bone
4 remains are assigned to large Bovinae (categories *Bos* sp. and *Bos primigenius*) and to large
5 Suinae (categories *Sus* sp. and *Sus scrofa*) in the Boian and Hamangia cultures, whereas these
6 taxonomic categories present high frequencies for Gumelnița. Species-level identifications
7 were in both cases based on the same criteria (see 3.2.1. above) and were conducted in some
8 cases by the same archaeozoologist. Large animals did appear with the Gumelnița culture.
9 Besides the aurochs hypothesis, the appearance of large oxen must be considered. However,
10 evidence of osteological trauma related to work is rare on cattle remains for this period
11 (Bălășescu et al., 2006). Only occasional use appears possible (Bartosiewicz et al., 1997;
12 Johannsen, 2006). Castration, reflecting a desire to increase meat yield, is perhaps more
13 likely. For Suinae, post-domestication introgression between wild and domestic populations is
14 possible, as well as the introduction of pigs from other geographical areas.

15 Hunting rates may be less for the Gumelnița culture; nevertheless we demonstrated that wild
16 mammals (especially red deer and wild horse; see 4.2. above) did play an important role for
17 some Gumelnița communities. The eight Gumelnița tell sites with high hunting rates have no
18 obvious common characteristic, in terms of the type of tell (hill in the floodplain, islet and
19 river terrace), cultural phase (they are assigned to phases A2 and B1) or geographical area
20 (they are located in Dobrogea and Muntenia). Hunting rates are not linked to the duration of
21 the Gumelnița occupation. Însurăței Popină I, Hârșova tell and Bordușani-Popină, which are
22 the largest tell sites included in the study and where the preserved Gumelnița levels reach
23 about 7 m in height (Table 2), are characterized both by high (Însurăței) and low proportions
24 of wild mammals. Both cases also exist at the tell sites where the preserved Gumelnița levels
25 are less than 1.5 m in height (Carcaliu and Bucșani-B1, on the one hand, and Măriuța and
26 Năvodari on the other; Table 2). Therefore, it is likely that this phenomenon resulted from
27 distinct factors.

28 The high hunting rates that appeared with the Gumelnița culture could have been a reaction to
29 unstable periods related to environmental changes. This mechanism is well known, based on
30 Neolithic lake shore settlements in Central Europe, where high levels of hunting occurred
31 during short periods of climatic deterioration (Arbogast et al., 2006; Schibler and Jacomet,
32 2010). For Gumelnița, this would imply that several unstable periods occurred, as the
33 settlements with high hunting rates were occupied during different periods of time. Indeed,
34 phase A2 at Vitănești and Luncavița is roughly dated to between 4350 and 4200 cal BC while
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1 phase B1 at Vitănești and Căscioarele is roughly dated to between 3670 and 3500 cal BC
2 (Table 1). A period of climatic deterioration, which resulted in more humid climatic
3 conditions according to Tomescu (2000), has indeed been identified for the second half of the
4 fifth millennium BC. In the examples discussed by Schibler and Jacomet (2010), hunting
5 focused on large mammals that provided high meat yield, for example red deer, and species
6 diversity among prey animals is much reduced during periods of climatic deterioration. For
7 the Gumelnița settlements, no such decrease in species diversity is observed among sites with
8 high numbers of wild mammal remains (Fig. 7). According to these criteria, the hypothesis of
9 a response to occasional instability seems unlikely. However, the available Gumelnița faunal
10 assemblages do not reflect short-term occupation, unlike those published for the lake shore
11 settlements. Current archaeological research, with the objective of distinguishing occupation
12 phases of the tell sites, will provide more precise information on economic changes through
13 time on the settlement scale.
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25 [Figure 7]
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29 An increase in the exploitation of large game (aurochs, wild boar and red deer) also occurred
30 in the Late Neolithic of the Carpathian Basin (Bartosiewicz, 2005). And, like the sites of the
31 Gumelnița period, these sites are multi-layer settlements. This change is interpreted as the
32 development of close relations between the Late Neolithic communities and the environment,
33 whereas the first Neolithic herders attempted to continue their pastoral tradition, sheep/goat
34 husbandry, in spite of an environment that was ill-suited. Large game had both economic and
35 social importance. As hunting may have had great social value for the Gumelnița
36 communities, it is possible that the high hunting rates observed sometimes reflect collective
37 practices. At Căscioarele, where large game played an important role, the existence of unusual
38 practices is likely, given the exceptional character of the archaeological finds (see 2. above).
39 This hypothesis seems unlikely at Luncavița and Vitănești, where no exceptional structure or
40 unusual butchery practice has been identified.
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51 It is also possible that complex socio-economic relations existed between some of the
52 Gumelnița tell sites and other settlements. Some of the animal exploitation systems described
53 may have been parts of larger economic systems. At Polgár-Csőszhalom for instance, a Late
54 Neolithic site in Hungary, over half the animal remains from the tell are assigned to wild
55 species, while the adjacent horizontal settlement mostly provides domestic animal remains
56 (Schwartz in Raczky et al., 2002). Raczky et al. (2002) proposed that ritual practices took
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1 place on the tell and that everyday living was on the horizontal site. 'Flat' sites existed in the
2 Gumelnița period, but they are poorly known, and no archaeozoological studies are available
3 (Andreescu et al., 2001, 2003; Boroneanț, 2000b). Archaeological research focused on the
4 Gumelnița 'flat' sites and their possible relationship with the tell sites is essential in order to
5 examine this hypothesis.
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9 The greater diversity observed during the Gumelnița period could also be due to different
10 choices regarding overall food supply strategies. Some communities could have developed an
11 economy based on agriculture, with hunting as a way to provide meat and raw material, while
12 others may have preferred animal husbandry. Unfortunately, botanical remains have not been
13 as widely studied as faunal remains (Cârciumaru, 1996; Comșa, 1996). However, large
14 amount of pulses (*Vicia ervilia*), regarded as having been cultivated for human consumption,
15 has been identified at Căscioarele (Cârciumaru, 1996; Monah, 2000), a site which is
16 characterized by an animal exploitation system based mainly on hunting. This contrasts with
17 the system at Hârșova tell, where domestic animals represent 76% of the faunal spectrum and
18 most of the plant species identified are cultivated (Monah, 2000). Pulses, domestic cereals
19 (cultivated in areas close to the tell site) and weeds have been identified.
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31 The high hunting rates and the greater diversity that occurred with the Gumelnița culture may
32 have resulted from the interaction between several possible factors: the appearance of new
33 husbandry techniques (Bovinae and Suinae), the development of complex socio-economic
34 relations between the sites, a greatest social value given to wild mammals and a more
35 intensive exploitation of natural resources. Environmental factors may have increased some of
36 these changes.
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42 43 44 45 **5. Pastoral practices, specialization and complementary functions of the Gumelnița sites**

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47 This paper focuses on domestic ruminants, since cattle are the predominant domestic species
48 during the Gumelnița period; we have observed that sheep/goats are more often in second
49 place than pigs.
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52 53 54 **5.1. Sheep and goats**

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56 The kill-off patterns established for sheep and goats at Bordușani-Popină, Hârșova tell,
57 Măriuța and Vitănești show very similar tendencies (Fig. 8; Table 5). The main characteristic
58 is a high proportion of animals slaughtered between six and 12 months (class C: from 37.4%
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1 to 58.3% of the dead animals). More generally, the age classes C and D (six months to two
2 years) represent 59.2% to 71.4% of the animals slaughtered at these tell sites. These age
3 classes represent animals that had attained their optimum or maximum weight, and we
4 interpret this as animals intended for human consumption (meat type; Halstead, 1996; Helmer
5 et al., 2007; Payne, 1973; Vigne and Helmer, 2007). These are specialized kill-off patterns.
6 They are due to the fact that practices and strategies were the same during the whole
7 occupation. This kind of profile is uncommon both in Europe (e.g., Greenfield, 2005; Vigne
8 and Helmer, 2007) and in the Near East (e.g., Helmer et al., 2007) during the Neolithic and
9 Chalcolithic periods; mixed kill-off patterns are the norm. These four sites have another
10 common characteristic: sheep are clearly predominant over goats (see 4.3. above, Table 4).
11 These kill-off patterns clearly show that the main product that the inhabitants of these tell sites
12 sought for was sheep tender meat. Luncavița is different because of the lower proportion of
13 sheep/goats slaughtered between six and 12 months (11.6% of the dead animals; Table 5); the
14 majority of the dead animals are adults (Fig. 8). This is a mixed kill-off pattern. Luncavița is
15 the only site characterized by a more balanced representation of sheep and goats.
16 Hârșova tell, Bordușani-Popină, Măriuța and Vitănești were favored places for the
17 consumption of sheep meat but we cannot propose that these animals were always raised at
18 these settlements. Indeed, the first age classes (A and B), that is, animals aged less than six
19 months, consist of only 0.5% to 3.1% of the dead animals at Hârșova tell, Bordușani-Popină,
20 Măriuța and Luncavița (Table 5). Newborn lambs and kids are very fragile (Clutton-Brock
21 and Pemberton, 2004; Dahl and Hjort, 1976; Lécirvain and Janeau, 1988), thus the very low
22 proportions of the youngest animals observed (age class A: from 0% to 0.6% of the dead
23 animals) are questionable. At a free-range sheep farm located in the lower French Alps (meat
24 production), for example, the natural mortality rate for very young lambs (age class A)
25 represents 11% of the animals that died over a period of one year (Blaise, 2006: Annex 1).
26 Open-air sites characterized by quite high proportions of young sheep/goats are known for the
27 Neolithic period (for example at Blagotin, Cuiry-les-Chaudardes and Halula 5; age classes A
28 and B: from 10% to 24% of the dead animals; Greenfield, 2005; Hachem, 1995; Helmer et al.,
29 2007).
30 Young sheep and goats are not absent due to differential preservation. These tell sites are well
31 preserved, in particular Hârșova tell and Bordușani-Popină, which have produced several
32 wooden platforms (see 3.1. above). Moreover, sieving was carried out (Table 2), so we can
33 reject the hypothesis of differential collection. At Hârșova tell for example, although the
34 remains from 4 mm sieves are included, age class A represents only 0.6% of the dead animals.
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Finally, this absence is not due to the fact that only parts of these tell sites have been excavated. Indeed, several settlements show the same tendencies in spite of variations in surface area. This shows that the available kill-off patterns are representative of the overall pastoral practices of the settlements.

On the other hand, the existence of bone gnawing is obvious at these five tell sites (from 8% to 18% of mammal remains concerned, both dog and pig gnawed bones; Bălăşescu, unpublished) and carnivore activity affects the preservation of young animals. However, contrary to what we observed for sheep/goats, very young Suinae (0-4 months) are present at Borduşani-Popină and Hârşova tell (10% and 6% of the dead animals respectively; N = 173 and N = 111; Bălăşescu, unpublished). It would be surprising that dogs had eaten all the young sheep/goats but not the young Suinae. Moreover, the analysis of the survival of humerus proximal and distal ends (Brain, 1981), for the five sites, shows that sheep/goat assemblages have not been highly modified by dogs, except at Măriuţa (proximal ends survived at all sites, unlike the example of the Hottentot villages studied by Brain, 1981). Mandibles and teeth are the most resistant part of the skeleton. This suggests that dogs are not the only ones responsible for the absence of the youngest sheep and goats and that the very low proportions of the first age classes (A and B) observed at Hârşova tell, Borduşani-Popină and Luncaviţa are due to the fact that, for the most part, the youngest animals died elsewhere. At Vităneşti, a larger sample and sieving are essential for further analysis.

[Figure 8]

[Table 5]

5.2. Cattle

As there are more aurochs than cattle at Vităneşti (stage A2), and as no reliable criteria exist to discriminate these two species based on teeth, we do not provide cattle kill-off pattern for this tell site.

The four kill-off patterns established for cattle (Table 6; Fig. 9) show tendencies that are distinct from those that have been described for sheep/goats. Borduşani-Popină, Hârşova tell, Luncaviţa and Măriuţa are characterized by mixed kill-off patterns and the youngest calves (first age class, 0-6 months) are present (from 3% to 7% of the dead animals). No obvious truncated profile or specialized pattern (as existed in Western Europe at the beginning of the fourth millennium BC; Bréhard et al., 2010) is observed for the four Gumelniţa settlements studied.

1 [Figure 9]

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3 [Table 6]

4 5 6 7 5.3. Discussion

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9 Homogeneity of the pastoral practices developed for sheep has been observed at Hârșova tell,
10 Bordușani-Popină, Măriuța and Vitănești. We have shown that sheep exploitation was
11 specialized. The main product that the inhabitants sought for was sheep tender meat. At
12 Luncavița, the mixed profile may result from the cumulative effect of two distinct strategies
13 for sheep and for goat exploitation. A specialization of sheep exploitation is possible but
14 dental remains assigned to sheep are too few to confirm or refute this hypothesis. For goats,
15 available samples are too small at each site to address this question. At least four out of the
16 five sites studied show the same practices for sheep. These tell sites have no obvious common
17 characteristic. Their overall animal exploitation systems clearly differ (see 3.1.2. above, Fig.
18 3). Moreover, they are located in different geographical areas (Fig. 1), are of different size
19 (Table 2) and date to both Gumelnița A2 and B1. Specialized kill-off patterns are uncommon
20 during the Neolithic and Chalcolithic periods (see 5.1. above). Given these points, we propose
21 that the homogeneity of the practices observed for sheep is specific to a type of settlement, the
22 tell site.
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Sheep/goat kill-off patterns published for earlier Eneolithic and Neolithic cultures are rare in Romania. Only three are available for eastern Romania; they belong to the two cultures (Hamangia and Boian) preceding the Gumelnița period. These are open-air settlements. As a species clearly dominate in each case (sheep at Techirghiol and Cheia, goats at Vlădiceasca), these three kill-off patterns do not result from the possible cumulative effect of two distinct strategies and can thus be compared to the four specialized Gumelnița kill-off patterns. Vlădiceasca and Techirghiol kill-off patterns are different from the Gumelnița profiles. At Vlădiceasca (Boian Vidra; N = 109; Bălășescu, unpublished), it is a mixed kill-off pattern (like Luncavița, adults represent 60% of the dead animals). At Techirghiol (Hamangia; N = 102; Haimovici and Bălășescu, 2006), animals were slaughtered between one and two years (age class D; 32% of the dead animals) rather than between 6-12 months (age class C; 24% of the dead animals). Contrary to these two examples, the kill-off pattern established for Cheia (Hamangia; N = 240; Bălășescu, 2008) shows tendencies similar to those observed at the four Gumelnița sites, but the remains studied come from only one stratigraphic unit. Thus the kill-off pattern established is unlikely to be representative of the overall pastoral practices of the

1 settlement. The study of a more heterogeneous assemblage is essential for viable results.
2 These three examples dated to the Early Eneolithic are characterized by distinct tendencies.
3 Specialized exploitations similar to those observed for the Gumelnița period may have existed
4 during the Neolithic and the Early Eneolithic, but the available examples show that these
5 practices became the norm from the Gumelnița period only. An increase in the number of kill-
6 off patterns established from large samples (for the Neolithic and the Eneolithic) is essential
7 to confirm this. It is difficult for the moment to propose explanations for this phenomenon
8 given the limited information available for the Gumelnița tell sites and their unclear function.
9 The high homogeneity of sheep exploitation suggests however a certain standardization in
10 pastoral practices during the Gumelnița period. Even if it is less noticeable, kill-off patterns
11 established for cattle show similar tendencies too (Fig. 9); the practices developed for pigs are
12 identical at least at two of these sites (Hârșova tell and Bordușani-Popină; Bălășescu,
13 unpublished). Finally, as such a specialization in exploitation strategies is risky, it suggests
14 stable and highly structured economic systems during the Gumelnița period.
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27 It is very likely that a part of the youngest sheep/goats are lacking at Hârșova tell, Bordușani-
28 Popină and Luncavița. It implies that the first stages of sheep/goat husbandry (in particular
29 lambing) took place mainly elsewhere and that sheep/goats were brought to these tell sites for
30 the most part when they had reached their optimum weight (age class C) to be eaten. The
31 available kill-off patterns would then reflect only a portion of the dead animals (truncated
32 patterns; Bréhard et al., 2010; Halstead, 1996; Helmer et al., 2005; Stein, 1987).
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38 As the hypothesis that sheepfolds were not on the tell itself is plausible, we propose that each
39 of these three tell sites was part of a larger pastoral system and that places or sites with
40 complementary functions existed. Of course, pastoral functions were not as sharply contrasted
41 as those proposed by Stein (1987) for later periods (consumer versus producer sites). Hârșova
42 tell and Bordușani-Popină show a high consumption of animals at their optimum (and
43 maximum) weight; the culling of adults (old breeding females, for example) also took place at
44 these sites (adults aged more than 4 years represent 23% and 22% of the dead animals; Table
45 5), contrary to the “consumers site” proposed by Stein (1987).
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53 The identification of kill-off patterns complementary to those of the tell sites (characterized
54 by higher percentages of young animals and very low proportions of sheep/goats at their
55 optimum weight) are evidence for the existence of complementary functions during the
56 Gumelnița period, but the kill-off patterns described are the only ones available for the
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1 Gumelnița culture. Even so, we can presume that pastoral systems functioned on a local or
2 regional scale.

3 First, there could have been designated places close to the tell sites. Lambing would have
4 taken place mainly there and the dead newborn lambs and kids would have been discarded
5 close to the sheepfolds. For example, at Podgoritsa (a contemporary Bulgarian tell site), the
6 identification of activity areas and built structures immediately surrounding the tell led to the
7 conclusion that the geographic limits of a tell did not always coincide with the topographic
8 limits of the tell's mound (Bailey, 1999; Bailey et al., 1998). Archaeological occupations have
9 been discovered close to the Romanian tell sites but they are poorly known (data are mostly
10 provided by surveys), their contemporaneity with the tell is not confirmed, and no
11 archaeozoological data are available (Andreescu et al., 2001, 2003; Bem, 2007; Micu et al.,
12 2009).

13 It is also possible that large pastoral systems existed on a regional scale (Bréhard et al., 2010;
14 Halstead, 1996; Helmer et al., 2005; Stein, 1987). This second hypothesis is supported by the
15 fact that such examples existed elsewhere in Europe in the same period. At the beginning of
16 the fourth millennium BC in the Rhone valley (France), for example, lambing took place
17 almost exclusively in caves, and sheep/goats were brought to large open-air settlements once
18 they had reached their optimum weight (Bréhard et al., 2010; Helmer et al., 2005). The kill-
19 off patterns established for the three Rhone valley caves (Helmer et al., 2005) are
20 characterized by a very high proportion of young sheep/goats (age classes A and B): from
21 20% to 46% of the dead animals. These caves at that time were used only for animal penning
22 (“sheepfold-caves”) and their occupation could have been seasonal (at least during lambing
23 season). However, the situation is different, because unlike the Gumelnița tell sites, the
24 Chassean open-air settlements were probably gathering places rather than permanent
25 settlements. In southeastern Romania, the complementary sites could have been ‘flat’ sites or
26 cave and rock shelter occupations. These kinds of settlements existed in the Gumelnița period
27 but they are poorly known (Boroneanț, 2000b). Fieldwork focusing on cave occupations is
28 being carried out in the Dobrogea region (Szmoniewski and Petcu, 2008; Voinea, 2010) but
29 the faunal remains from the Gumelnița levels are still too few (Popa et al., 2010). These
30 complementary sites could have been occupied only seasonally. A part of the Gumelnița
31 community could have moved with the flocks from the tell sites to other sites, at least during
32 the lambing season.

6. Conclusion

1 This research has shown that the development of a new type of settlement, the tell site, which
2 fully began with the Gumelnița culture, was accompanied by changes in the meat component
3 of the diet. The homogeneity that characterized the Hamangia (phase III) and Boian cultures
4 was followed by a greater diversity in the animal exploitation systems during the Gumelnița
5 period. The main change is that hunting played an important role for some Gumelnița
6 communities (the preferred species varied). However, variability existed among the domestic
7 species as well. This may result from the interaction between several possible factors: the
8 appearance of new husbandry techniques (Bovinae and Suinae), the development of complex
9 socio-economic relations between the sites, a great social value given to wild mammals and a
10 more intensive exploitation of natural resources. Environmental factors may have increased
11 some of these changes. To understand the relations that may have existed between the sites of
12 a given geographical zone, the characterization of the animal exploitation systems of
13 Gumelnița sites other than tell sites is essential.

14 This diversity contrasts with the homogeneity of the pastoral practices developed for sheep
15 (and, to a lesser extent, for cattle) at the Gumelnița tell sites (five sites have been studied). We
16 have also shown that sheep exploitation was specialized (the main product that the inhabitants
17 sought for was tender meat). Given that this kind of specialized exploitation became the norm
18 from the Gumelnița period, we propose that the appearance of homogeneous and specialized
19 practices for sheep is linked to the development of a new type of settlement, the tell site. More
20 generally, certain standardization in pastoral practices during the Gumelnița period is
21 possible. An increase in the number of kill-off patterns established from large samples is
22 essential to confirm this, and the publication of global archaeological studies on the
23 Gumelnița tell sites will help to understand the homogeneity in pastoral practices.

24 It is also very likely that a part of the youngest sheep and goats are lacking at three tell sites.
25 This implies that the first stages of animal husbandry (lambing in particular) took place
26 mainly elsewhere and that sheep/goats were brought to these tell sites for the most part when
27 they had reached their optimum weight to be eaten. We suggest that these tell sites were parts
28 of larger pastoral systems, on a local or regional scale, and that places or sites having
29 complementary functions existed. These pastoral systems could have included places
30 immediately surrounding the tell or the 'flat' sites and the cave and rock-shelter occupations
31 present at that time. But these Gumelnița occupations are poorly known. Archaeological
32 research focusing on these kinds of sites is needed to prove the existence of complementary
33 functions (identification of kill-off patterns complementary to those of the tell sites).

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32 **Figure caption list**

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37 Fig. 1. Geographical distribution (in light grey) of the main Eneolithic cultures in southeastern
38 Romania (Hamangia, Boian and Gumelnița), and location of the 29 Romanian sites included
39 in the study. 1: Drăgănești-Olt; 2: Lăceni-Măgura; 3: Vitănești; 4: Izvoarele; 5: Bucșani; 6:
40 Chitila; 7: Seciu; 8: Măriuța; 9: Șeinoiu; 10: Tangâru; 11: Căscioarele; 12: Radovanu; 13:
41 Vlădiceasca; 14: Sultana; 15: Vărăști; 16: Gumelnița; 17: Bogata; 18: Ciulnița; 19: Bordușani-
42 Popină; 20: Însurăței; 21: Siliștea-Conac; 22: Carcaliu; 23: Luncavița; 24: Isaccea; 25:
43 Hârșova tell; 26: Hamangia; 27: Cheia; 28: Năvodari; 29: Techirghiol. See table 1 and 2 for
44 details. Map after Bălășescu et al. 2005a.
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Fig. 2. Comparison of the faunal spectra between Hamangia (phase III), Boian and Gumelnița cultures. The number of identified specimens (NISP) is given in parentheses.

Fig. 3. Plot of the correspondence analysis including Boian, Hamangia and Gumelnița faunal assemblages, factor axes 1 and 2 (see table 3 for details and text, 3.2.2., for explanation of the methodology). The names of the most reliable assemblages are in bold type (see the text, 3.1.1., for explanation). The Boian and Hamangia assemblages are in grey; the latter are underlined. The size of the symbols for the eight variables is proportional to their contribution to factors 1 and 2.

Fig. 4. Plot of the correspondence analysis including Boian, Hamangia and Gumelnița faunal assemblages, factor axes 1 and 3 (see table 3 for details and text, 3.2.2., for explanation of the methodology). The names of the most reliable assemblages are in bold type (see the text, 3.1.1., for explanation). The Boian and Hamangia assemblages are in grey; the latter are underlined. The size of the symbols for the eight variables is proportional to their contribution to factors 1 and 2.

Fig. 5. Comparison of the faunal spectra between the nine Gumelnița assemblages with high hunting rates. Only the main wild mammals are included. See table 3 for the complete names of the tell sites. The number of identified specimens (NISP) is given in parentheses. The names of the most reliable assemblages are in bold type (see the text, 3.1.1., for explanation).

Fig. 6. Same plot than in figure 3, but data coming from eleven distinct archaeological structures (table 3) have been added as supplementary objects (the names are in italic type).

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2 And only the names of the five Gumelnița sites that provided these detailed faunal spectra are
3 given. See the text (3.1.1.) to have details on the archaeological structures.
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7 Fig. 7. Relationship between assemblage size (number of identified wild mammal specimens,
8 NISP) and number of species of wild mammals based on the Hamangia, Boian and Gumelnița
9 faunal assemblages in Romania (see table 3 for details). Logarithm is used to overcome the
10 high variability in sample sizes (from 13 NISP to 5989). A trend line is added ($y = 0.2212x +$
11 0.4541 ; $R^2 = 0.772$).
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21 Fig. 8. Sheep/goat kill-off patterns for the five Gumelnița tell sites selected for the study (see
22 table 5 for details). See the text (3.2.3.) for explanation of the methodology. Sheep are
23 predominant, except at Luncavița (in grey), where there is a more balanced representation of
24 sheep and goats. As the age classes used are not the same length, the histograms of relative
25 frequencies are corrected according to the size of the time bracket of each age class. The
26 minimum number of individuals (MNI) is given in parentheses.
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38 Fig. 9. Cattle kill-off patterns for the four Gumelnița tell sites selected for the study (see table
39 6 for details). See the text (3.2.3.) for explanation of the methodology. As the age classes used
40 are not the same length, the histograms of relative frequencies are corrected according to the
41 size of the time bracket of each age class. The minimum number of individuals (MNI) is
42 given in parentheses.
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Tables with captions

Table 1

Eneolithic cultures from southeastern Romania, and chronological data. The radiocarbon dates have been calibrated (2σ) using Calib Rev 6.0.1 (Stuiver and Reimer, 1993).

<i>Culture</i>	<i>Stage</i>	<i>Chronological limits</i>	<i>Region</i>	<i>Lab dating (BP) ; 2σ calibrated age (cal BC)</i>
HAMANGIA	III	(Beginning 5th mill. BC)	Dobrogea	6020 \pm 43; 5020-4797 (Cheia) a
BOIAN	Giulești	/	Muntenia and Dobrogea	5797 \pm 43 (UBA-7793); 4730-4540 (Ciulnița)
5000-4450 cal BC	Vidra	/	Muntenia	/
	Spanțov	(4800-4450 cal BC)	Muntenia and Dobrogea	5774 \pm 28 (UBA-9631); 4702-4547 (Hârșova)
				5850 \pm 70; 4852-4537 (Radovanu) b
				5750 \pm 80; 4790-4447 (Căscioarele) b
				5705 \pm 80; 4715-4368 (Căscioarele) b
				5780 \pm 65; 4785-4489 (Căscioarele) b
GUMELNIȚA	A1	/	Muntenia and Dobrogea	5620 \pm 50; 4543-4354 (Isaccea) b
4600/4500-3500 cal BC	A2	(4350-4000 cal BC)	Muntenia and Dobrogea	5575 \pm 65; 4544-4328 (Hârșova) b
				5425 \pm 40; 4353-4229 (Luncavița) c
				5380 \pm 45; 4336-4055 (Hârșova tell) b
				5304 \pm 51; 4261-4034 (Hârșova tell) b
				5382 \pm 43 (UBA-7791); 4336-4057 (Hârșova)
				5461 \pm 42 (UBA-7792); 4369-4235 (Hârșova)
				5379 \pm 27 (UBA-9632); 4331-4164 (Vitănești)
				5430 \pm 40; 4354-4231 (Vitănești) d
				5400 \pm 40; 4343-4162 (Vitănești) d
	B1	(3670-3500 cal BC)	Muntenia	4785 \pm 43; 3651-3511 (Bucșani) e
				4758 \pm 26 (UBA-9633); 3637-3516 (Vitănești)
				4820 \pm 40; 3667-3520 (Căscioarele) d

a: Voinea and Neagu, 2008; b: Bem, 2001; c: Micu, 2005; d: Ludwig et al., 2009; e: Cucchi et al., 2011; others radiocarbon dates are from the Chronobos project (Tresset, personal communication 2011).

Table 2

Romanian archaeological sites included in the study. na: data not available; Gum: Gumelnița; BV: Boian Vidra.

<i>Site</i>	<i>Region</i>	<i>Eneolithic culture(s)</i>	<i>Tell size</i>	<i>Tell stratigraphic data</i>	<i>Culture (and stage) with an archaeozoological study</i>	<i>Sieving</i>	<i>Faunal remains come from</i>
Cheia *	Dobrogea	Hamangia			Hamangia III	x (partial)	Dwellings and pits
Hamangia	Dobrogea	Hamangia			Hamangia III		na ("cultural level")
Techirghiol	Dobrogea	Hamangia			Hamangia III		Pits
Isaccea *	Dobrogea	Boian			Boian Giulești	x (partial)	Dwellings and pits
Bogata	Muntenia	Boian			Boian Giulești		Pits
Ciulnița	Muntenia	Boian			Boian Giulești		Dwellings and pits
Siliștea-Conac	Muntenia	Boian			Boian Giulești		Pits
Lăceni-Măgura	Muntenia	Boian			Boian Giulești, Spanțov	x (extensive)	na ("cultural level")
Vărăști	Muntenia	Boian			Boian Vidra		Pits
Izvoarele	Muntenia	Boian			Boian Spanțov		na ("cultural level")
Vlădiceasca	Muntenia	Boian; Gumelnița	40x80 m	3.8-4.2 m in height (2 m BV; 1.8-2.2 m Gum)	Boian Vidra; Gumelnița A1, A2, B1		na ("cultural level")
Radovanu	Muntenia	Boian; Gumelnița	50x70 m; 3500 m2	1.6 m in height (Boian+Gum)	Boian Spanțov		na ("cultural level")
Căscioarele	Muntenia	Boian; Gumelnița	57x103 m	5 m in height (1.4/1.8 m Boian; ~ 3 m Gum)	Boian Spanțov; Gumelnița B1		na ("cultural level")
Hârșova tell *	Dobrogea	Boian; Gumelnița	150x200 m	10 m in height (3 m Boian; 7 m GumA)	Boian Spanțov; Gumelnița A2	x (extensive)	Areas of household refuse, foundation trenches, dwellings
Luncavița *	Dobrogea	Gumelnița	75x102 m	3.5 m in height (GumA)	Gumelnița A2	x (extensive)	Areas of household refuse, pits and dwellings
Carcaliu	Dobrogea	Gumelnița	1 ha	0.6 m in height (GumA2)	Gumelnița A2		Dwellings and pits
Năvodari *	Dobrogea	Gumelnița	120x250 m	1.5 m in height (GumA)	Gumelnița A2	x (extensive)	Dwellings
Bordușani-Popină *	Muntenia	Boian; Gumelnița	70x180 m	8.7 m in height (Boian+GumA)	Gumelnița A2	x (extensive)	Areas of household refuse, foundation trenches, dwellings
Însurăței Popină I *	Muntenia	Gumelnița	85x275 m	7 m in height (GumA1+A2)	Gumelnița A2		Areas of household refuse and dwellings
Chitila	Muntenia	Boian; Gumelnița	60x80 m (but partly destroyed)	na	Gumelnița A2		na ("cultural level")
Șeinoiu	Muntenia	Gumelnița	45x54 m	2.1-2.2 m in height (GumA2+B1)	Gumelnița A2		na
Sultana *	Muntenia	Gumelnița	30x35 m (but ~ half destroyed)	2.6 m in height (west)- 4 m (east) (Gum)	Gumelnița A2	x (partial)	Areas of household refuse and dwellings
Seciu	Muntenia	Gumelnița	60 m in diameter	0.5-1.1 m in height (GumA)	Gumelnița A2		Areas of household refuse
Vitânești *	Muntenia	Gumelnița	40-45 m in diameter	1 m in height (GumA1); 1.7 m (natural deposits); 4 m (GumA2+B1)	Gumelnița A2, B1		Areas of household refuse and dwellings
Drăgănești-Olt	Muntenia	Gumelnița; Salcuța	75x123 m	2-2.85 m in height (Gum+Salcuța)	Gumelnița A2, B1		na ("cultural level")
Gumelnița	Muntenia	Boian; Gumelnița	2 ha	2.3-2.4 m in height (Gum)	Gumelnița A2, B1		Dwellings
Măriuța *	Muntenia	Gumelnița	52x85 m (but partly destroyed)	1.15-1.3 m in height (Gum)	Gumelnița B1	x (partial)	Areas of household refuse and dwellings
Bucșani *	Muntenia	Gumelnița	55x64 m	2.86 m in height (GumA+natural deposits+ GumB1)	Gumelnița B1	x (partial)	Areas of household refuse and dwellings
Tangâru	Muntenia	Boian; Gumelnița	50x90 m	4 m in height (Boian+Gum)	Gumelnița		na ("cultural level")

*: sites that are still excavated.

Table 3

Taxonomic spectra for the 39 Romanian assemblages included in the study. The wild carnivores category includes *Canis lupus*, *Vulpes vulpes*, *Lynx lynx*, *Felis silvestris*, *Meles meles*, *Martes martes*, *Mustela putorius*, *Mustela nivalis*, *Mustela* sp., *Lutra lutra*, *Mustelidae*, *Ursus arctos*. Sheep/goats: *Ovis aries* and *Capra hircus*. NISP: number of identified specimens. Antler remains have been subtracted from NISP for red and roe deer, except when studies did not go into any detail on this point (*). H: Hamangia; BG: Boian Giulești; BV: Boian Vidra; BS: Boian Spanțov; G: Gumelnița. The names of the most reliable assemblages are in bold type (see the text, 3.1.1., for explanation). See the text (3.1.1.) for details about the Gumelnița archaeological structures that are at the bottom of the table.

Site		Cattle		Pig	Aurochs		Red deer	Roe deer			Wild	Beaver	Suinae	TOTAL	References
		Bos taurus	Sheep/ goats	Sus domesticus	Dog Canis familiaris	Bos primigenius	Cervus elaphus	Wild horse Equus ferus	Wild boar Sus scrofa	Capreolus capreolus	Wild carnivores	Castor fiber	Sus sp.		
Cheia	Cheia_H	1674	1396	0	6	52	77	0	56	19	61	1	28	3370	Bălăşescu & Radu 2002-03; Bălăşescu 2008
Hamangia	Ham_H	23	25	1	3	2	8	0	3	0	1	0	1	67	Haimovici 1987
Techirghiol	Tec_H	543	449	22	7	4	3	13	3	9	14	0	0	1067	Haimovici & Bălăşescu, 2006
Bogata	Bog_BG	144	14	0	4	0	0	0	0	0	0	0	0	162	Necrasov & Haimovici 1959
Ciulnița	Ciu_BG	1785	583	23	14	15	6	2	4	3	3	0	1	2439	Bălăşescu 2003-2004
Isaccea	Isac_BG	301	73	58	106	5	113	6	36	15	26	15	42	796	Bălăşescu 2000; Bălăşescu & Radu 2004
Lăceni-Măgura	Lac_BG	66	83	15	9	1	6	1	3	3	9	1	13	210	Bălăşescu 2002; Bălăşescu & Radu 2004
Siliştea-Conac	Sil_BG	36	38	14	8	1	6	2	21	0	10	2	13	151	Bălăşescu & Radu 1999
Vărăşti	Var_BV	143	64	26	7	8	0	2	9	1	0	0	0	260	Bolomey 1966
Vlădiceasca	Vla_BV	1876	307	74	46	156	86	42	19	26	10	1	40	2683	Bălăşescu & Udrescu 2005
Lăceni-Măgura	Lac_BS	175	37	11	10	6	7	0	1	0	1	0	9	257	Bălăşescu 2002; Bălăşescu & Radu 2004
Căscioarele	Cas_BS	223	31	0	7	0	10	0	0	1	0	0	65	337	Bolomey 1981
Hârşova tell	Hva_BS	663	386	130	77	32	93	1	109	3	9	0	127	1630	Bălăşescu & Radu 2004
Izvoarele	Izv_BS	612	205	202	50	5	34*	0	8	5*	9	4	0	1134	Necrasov & Gheorghiu 1970
Radovanu	Rad_BS	224	67	85	12	0	22*	0	9	2*	5	0	0	426	Necrasov 1973
Radovanu	Rad_BS2	2295	424	1012	130	1	154*	2	8	18*	59	7	0	4110	Ştirbu 1980
Vlădiceasca	Vla_GA1	231	46	36	18	69	25	17	13	7	6	0	0	468	Bălăşescu et al. 2005a
Borduşani-P.	Bord_GA2	1996	1604	2320	1343	75	509	35	757	154	323	97	722	9935	Moise 1997; Bălăşescu et al. 2003b, 2005a
Carcaliu	Car_GA2	118	14	61	13	17	166	2	72	4	0	4	0	471	Haimovici 1996
Hârşova tell	Hva_GA2	618	1514	1009	896	55	78	20	890	66	92	32	560	5830	Moise 2000; Bălăşescu et al. 2005a
Însurăţei	Ins_GA2	107	113	60	20	76	47	75	41	16	12	1	5	573	Moise 1999
Luncavița	Lunc_GA2	301	129	167	32	17	373	6	207	36	40	5	87	1400	Bălăşescu 2003 and unpublished
Năvodari	Nav_GA2	81	168	53	27	19	13	13	19	7	22	1	8	427	Moise 2001a
Drăgăneşti-Olt	DO_GA2	200	170	124	14	1	156	9	34	7	2	2	1	720	El Susi 2002
Gumelnița	Gum_GA2	1180	226	176	62	19	62*	31	111	12*	6	0	23	1908	Necrasov & Haimovici 1966
Vitâneşti	Vit_GA2	1055	381	1190	252	1368	1512	773	1326	143	411	363	0	8774	Bălăşescu et al. 2005a
Vlădiceasca	Vla_GA2	1733	846	483	127	190	28	25	16	21	25	0	0	3494	Bălăşescu et al. 2005a
Chitila	Chi_GA2	217	76	24	8	8	67	1	45	26	6	0	27	505	Bălăşescu et al. 2003c
Şeinoiu	Sein_GA2	59	10	8	1	6	0	9	3	1	0	0	0	97	Bălăşescu et al. 2005a
Sultana	Sult_GA2	134	147	22	11	1	13	0	3	0	4	0	32	367	Bălăşescu unpublished
Seciu	Seciu_GA2	55	48	55	4	1	38	0	47	7	1	2	51	309	Popa et al. 2011
Bucşani	Buc_GB1	275	66	163	15	51	109	33	22	18	32	21	17	822	Bălăşescu 1998
Căscioarele	Cas_GB1	201	27	57	166	239	1193*	245	550	121*	11	16	196	3022	Bolomey unpub. in Bălăşescu et al. 2005a
Măriuța	Mar_GB1	603	332	178	49	10	49	57	54	9	12	0	48	1401	Moise 2001b; Bălăşescu unpublished
Drăgăneşti-Olt	DO_GB1	419	156	282	35	15	450	25	115	6	6	5	8	1522	El Susi 2002
Gumelnița	Gum_GB1	284	43	49	14	8	28*	6	34	4*	5	1	6	482	Necrasov & Haimovici 1966
Vitâneşti	Vit_GB1	843	161	809	90	515	510	220	209	17	75	115	53	3617	Bălăşescu & Radu 2003
Vlădiceasca	Vla_GB1	618	196	138	23	13	8	5	1	5	2	0	0	1009	Bălăşescu et al. 2005a
Tangăru	Tan_G	120	80	45	4	0	0	0	0	0	0	0	0	249	Necrasov & Haimovici 1959
<i>Structure</i>															
Hârşova tell	Hva_C521	104	264	116	124	12	3	3	187	6	10	11	219	1059	Moise, 2000
Hârşova tell	Hva_C720	178	135	133	88	3	11	1	3	0	17	2	144	715	Bălăşescu, unpublished
Hârşova tell	Hva_C1017	49	60	44	35	0	2	0	4	2	8	3	127	334	Bălăşescu, unpublished
Însurăţei	Ins_L4	37	54	34	12	17	25	11	22	3	3	0	2	220	Moise, 1999
Însurăţei	Ins_L7	19	16	0	5	17	5	16	1	2	0	1	0	82	Moise, 1999
Însurăţei	Ins_L8	33	28	12	2	29	16	35	5	4	4	0	1	169	Moise, 1999
Borduşani-P.	Bord_C201	71	37	58	44	4	8	0	13	0	16	1	40	292	Bălăşescu et al., 2003b
Borduşani-P.	Bord_SL33	23	15	16	5	0	2	0	10	0	7	0	18	96	Bălăşescu et al., 2003b
Luncavița	Lunc_C2	16	12	23	3	2	44	1	18	4	8	1	11	143	Bălăşescu, unpublished
Luncavița	Lunc_C4	26	11	24	0	2	18	0	22	2	4	1	4	114	Bălăşescu, unpublished
Bucşani	Buc_L2	58	13	29	1	12	14	6	5	8	9	5	4	164	Bălăşescu, 1998

Table 4

Species-level identification for sheep and goats remains of the five Gumelnița tell sites selected for the establishment of kill-off patterns. See the text (3.2.1.) for explanation of the methodology. O: *Ovis aries*; C: *Capra hircus*.

Site	Cultural stage	Mandibles		Post-cranial elements	
		NISP species-level	% <i>Ovis</i>	NISP species-level	% <i>Ovis</i>
Hârșova tell	Gumelnița A2	103	93.2	332	76.8
Borđușani-Popină	Gumelnița A2	58	82.8	292	75.0
Măriuța	Gumelnița B1	29	89.7	82	76.8
Vitânești	Gumelnița A2	9	5O for 4C	113	73.5
Luncavița	Gumelnița A2	9	6O for 3C	38	52.6

Table 5

Raw data for the sheep/goat kill-off patterns for the five Gumelnița tell sites selected for the study (see table 2 for details). See the text (3.2.3.) for explanation of the methodology.

Sheep & goats		Hârșova tell (Gum A2)		Borđușani-Popină (Gum A2)		Luncavița (Gum A2)		Vitânești (Gum A2)		Măriuța (Gum B1)	
Stage	Suggested age	N	%	N	%	N	%	N	%	N	%
A	0-2 months	3.3	0.6	0		0		0		0	
B	2-6 months	15.1	2.5	10	2.5	1	1.8	3	6.3	0.8	0.5
C	6-12 months	256.6	43.3	165	41.7	6.5	11.6	28	58.3	62.5	37.4
D	1-2 years	112	18.9	96.7	24.4	15	26.8	6.3	13.1	36.4	21.8
EF	2-4 years	69.5	11.7	38.3	9.7	10.7	19.1	8.7	18.1	41.8	25.0
G	4-6 years	71.8	12.1	53.3	13.5	13.2	23.6	1.3	2.7	6.5	3.9
HI	6-10 years	64.7	10.9	32.7	8.3	9.6	17.1	0.7	1.5	19	11.4
	Σ	593		396		56		48		167	

Table 6

Raw data for the cattle kill-off patterns for the four Gumelnița tell sites selected for the study (see table 2 for details). See the text (3.2.3.) for explanation of the methodology.

<i>Cattle</i>	<i>Hârșova tell</i> (<i>Gum A2</i>)		<i>Bordușani-Popină</i> (<i>Gum A2</i>)		<i>Luncavița</i> (<i>Gum A2</i>)		<i>Măriuța</i> (<i>Gum B1</i>)	
	<i>N</i>	<i>%</i>	<i>N</i>	<i>%</i>	<i>N</i>	<i>%</i>	<i>N</i>	<i>%</i>
<i>Suggested age</i>								
0-6 months	6.6	6.4	11.9	7.1	1.3	2.9	3.3	4.9
6-12 months	8.6	8.3	16.3	9.8	7.1	15.7	10.1	15.1
1-2 years	26.8	26.0	38.7	23.2	6.8	15.2	15.9	23.7
2-4 years	15.7	15.2	45.5	27.2	14.3	31.8	13.8	20.6
4-6.5 years	26.3	25.5	20.5	12.3	5.2	11.6	11	16.4
6.5-9 years	14.2	13.8	19.1	11.4	4.4	9.7	9.3	13.8
9-11.5 years	2.8	2.7	6.1	3.6	2.8	6.1	3.3	4.9
> 11.5 years	2	1.9	9	5.4	3.2	7.1	0.5	0.7
Σ	103		167		45		67	

Figure1

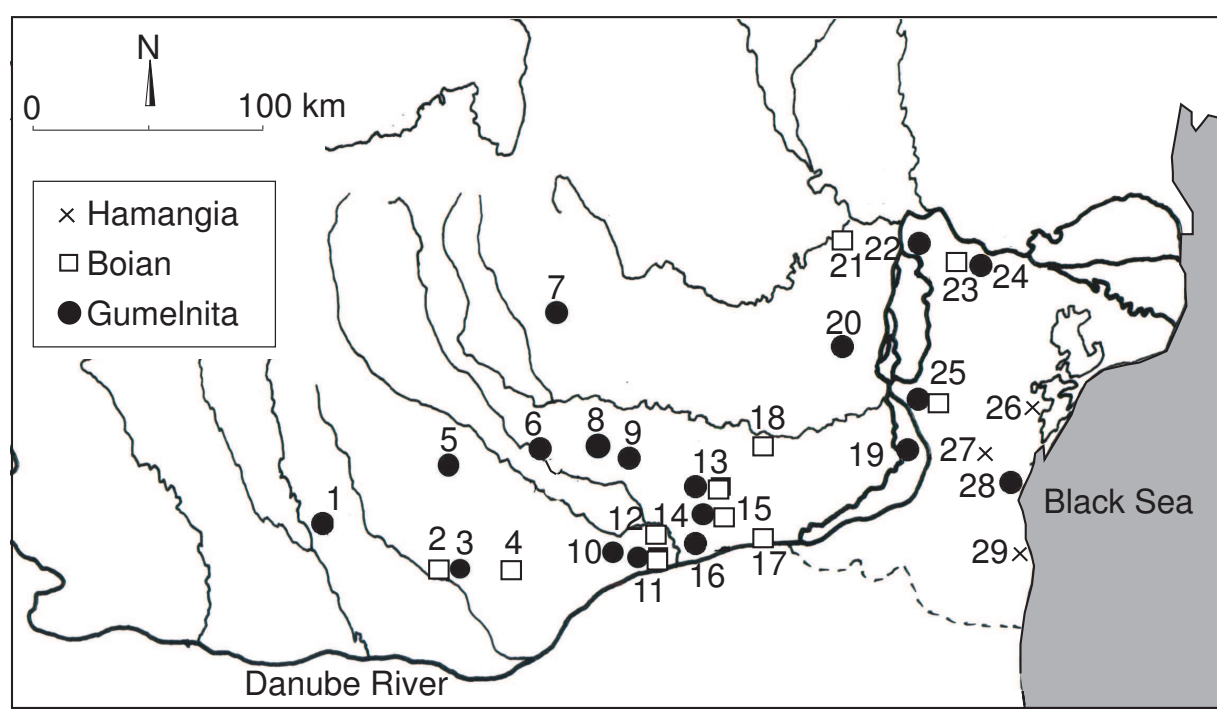
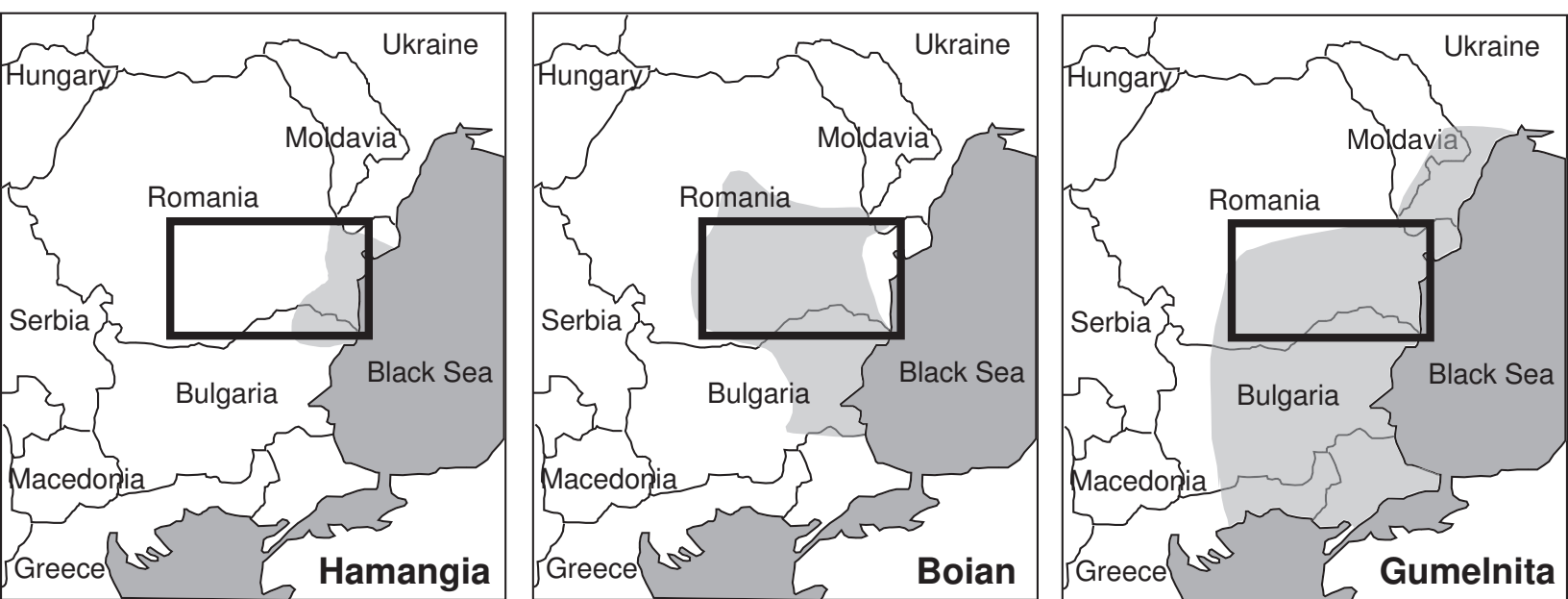


Figure2

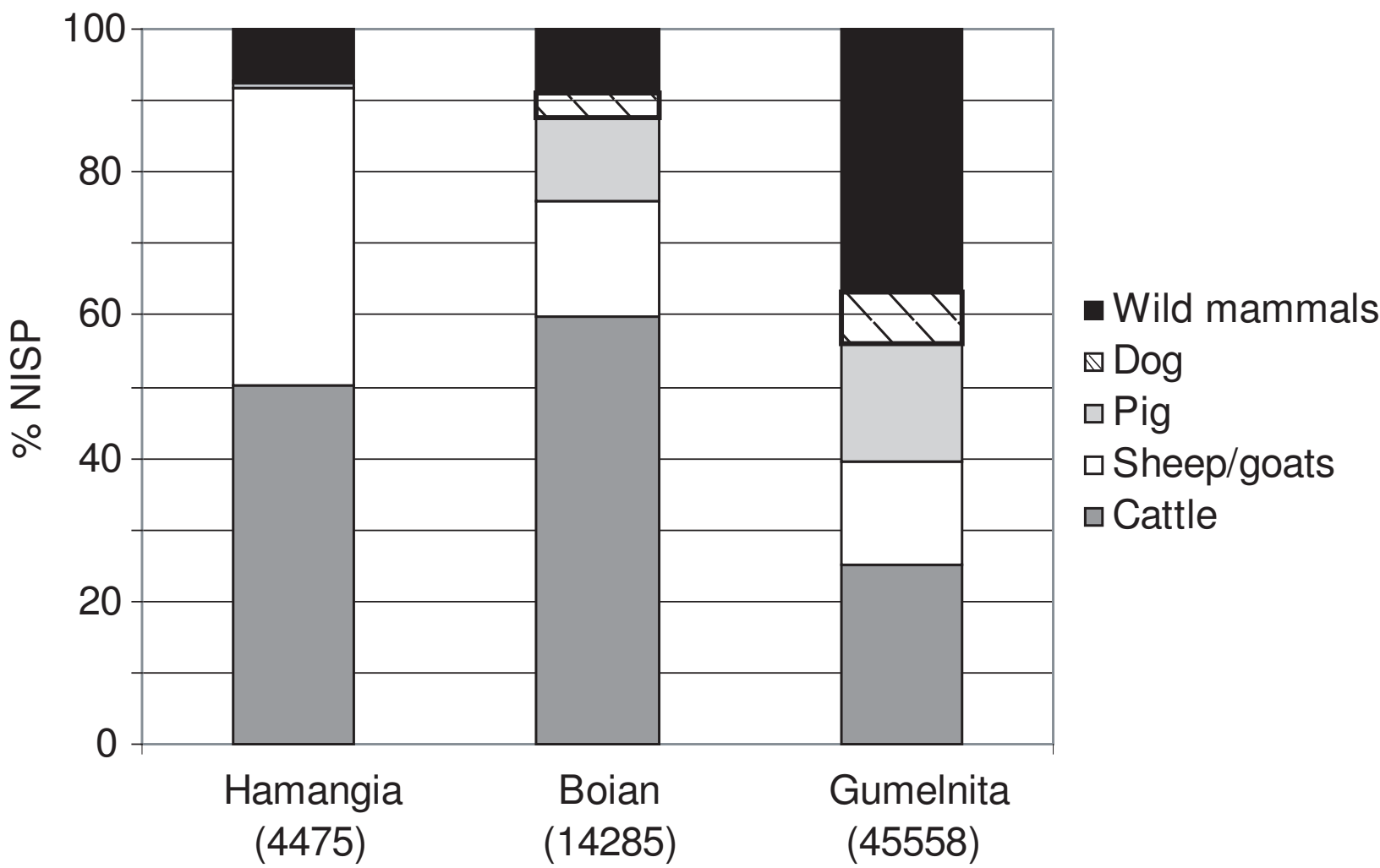


Figure3

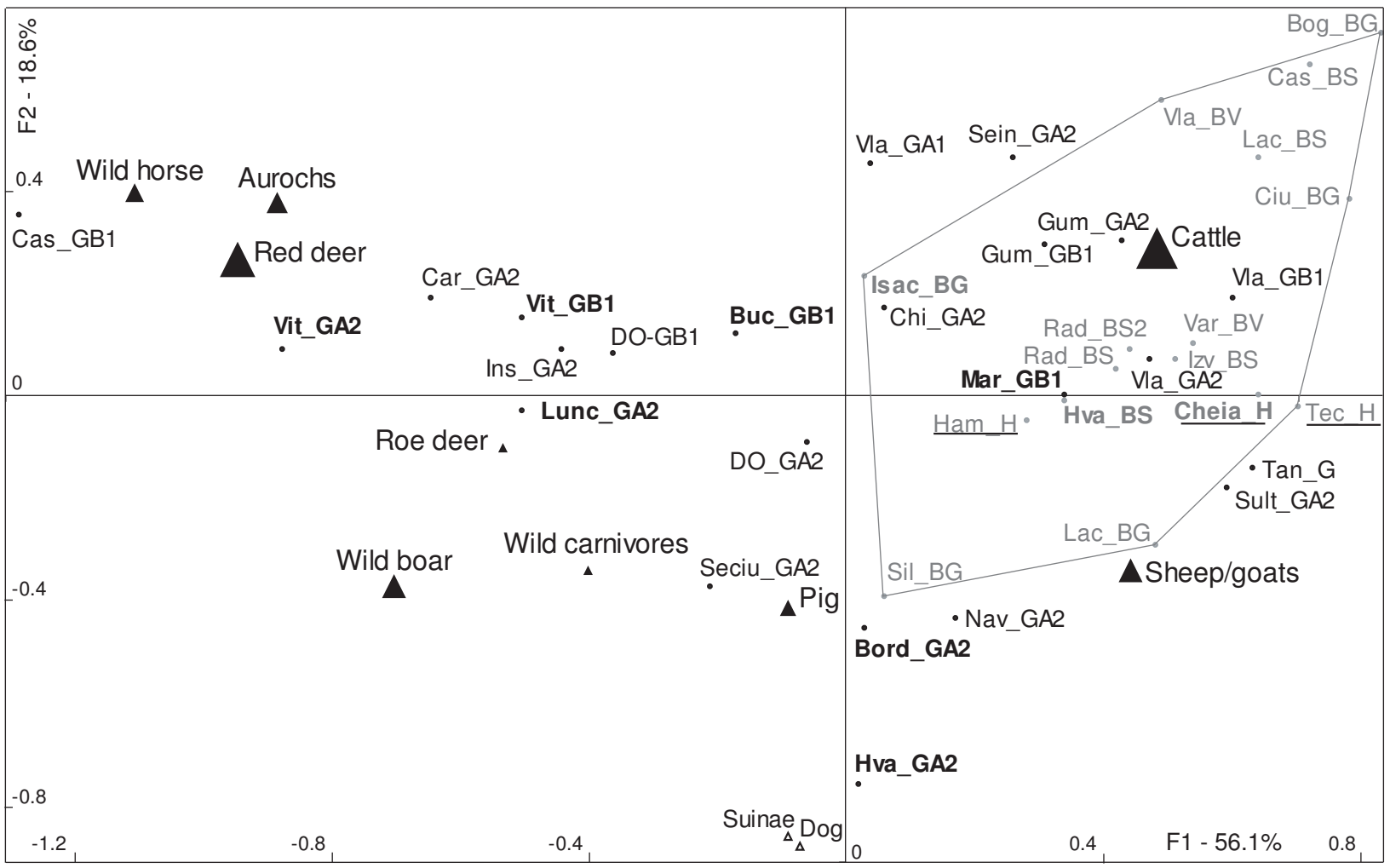


Figure4

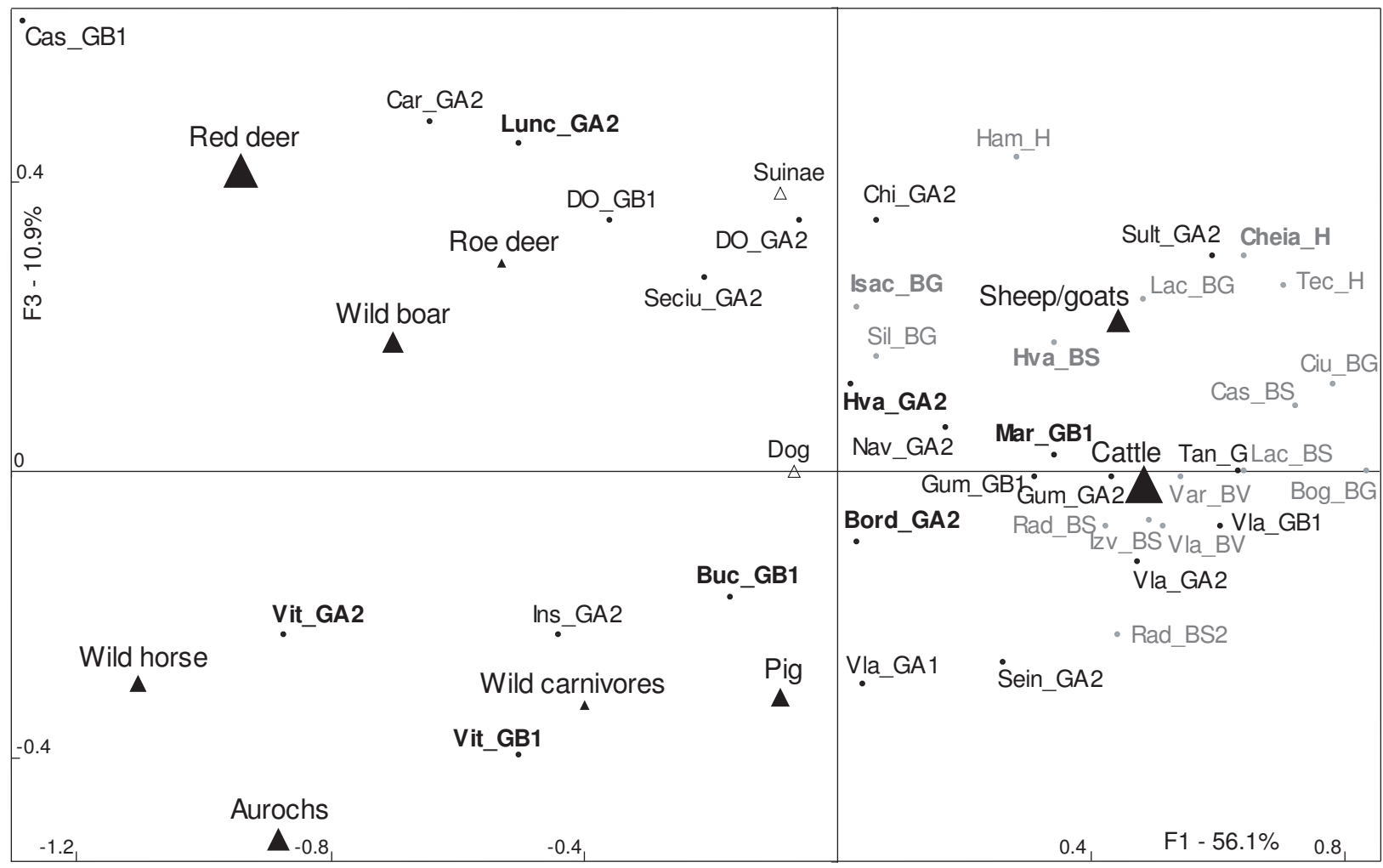


Figure5

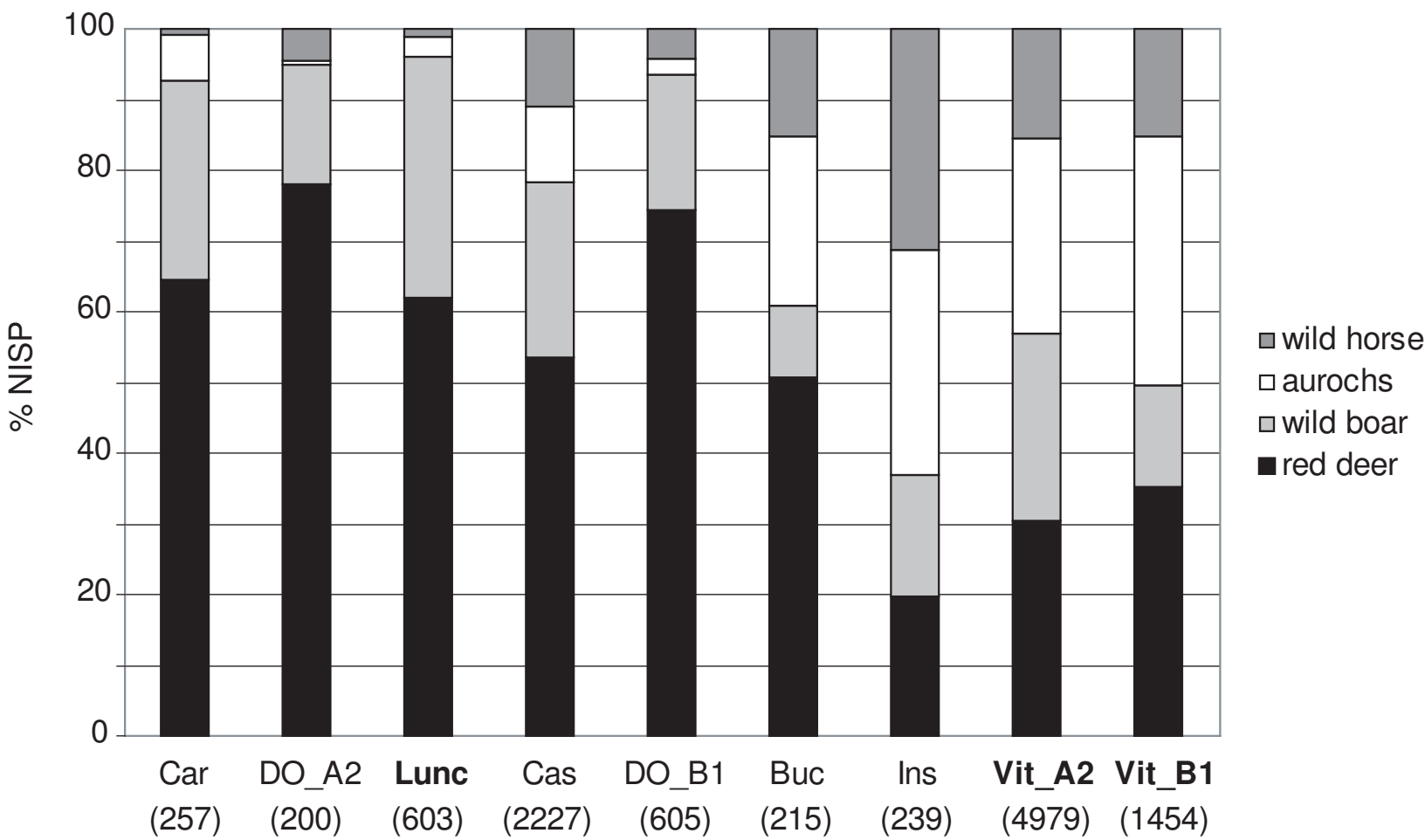


Figure6

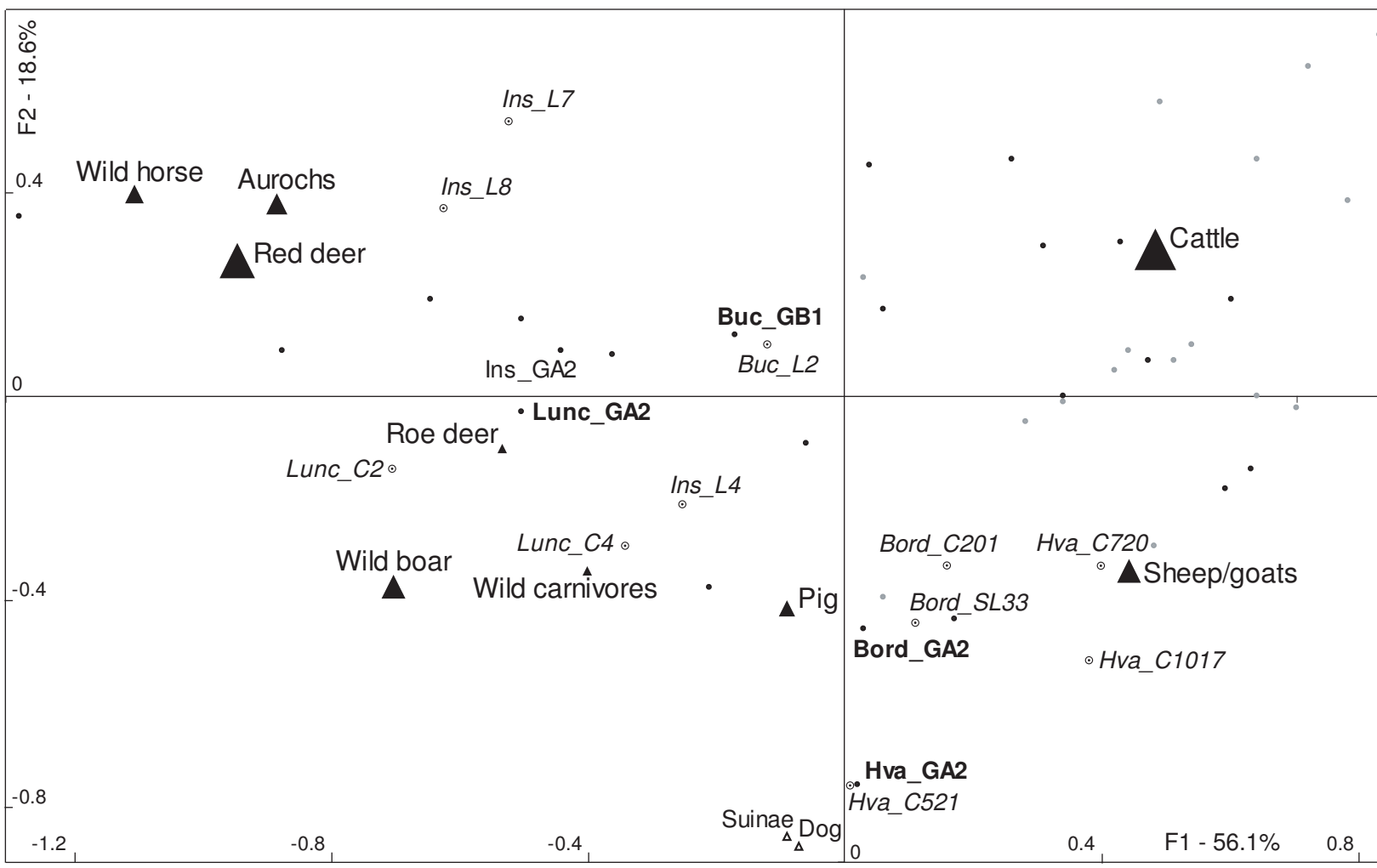
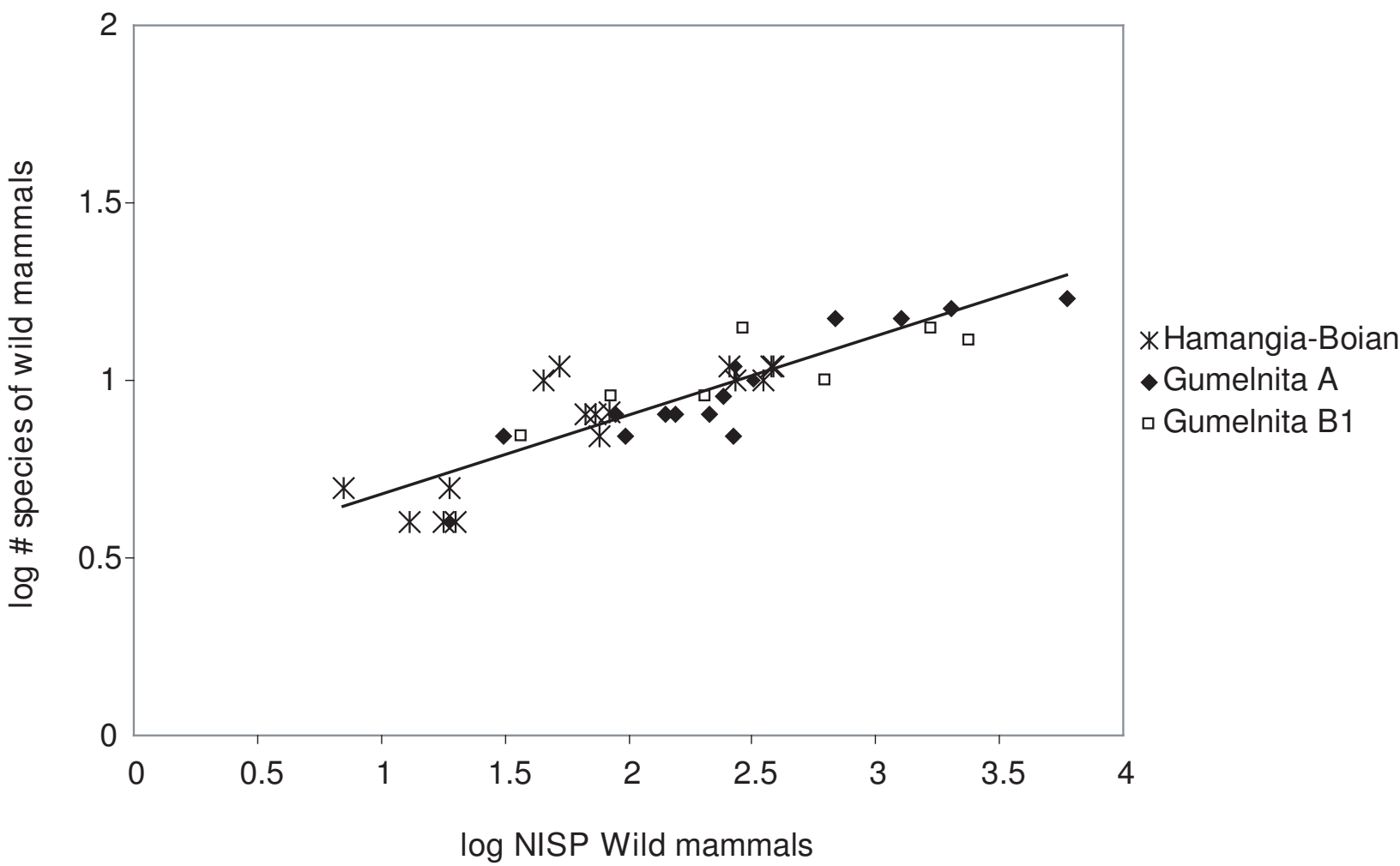


Figure7



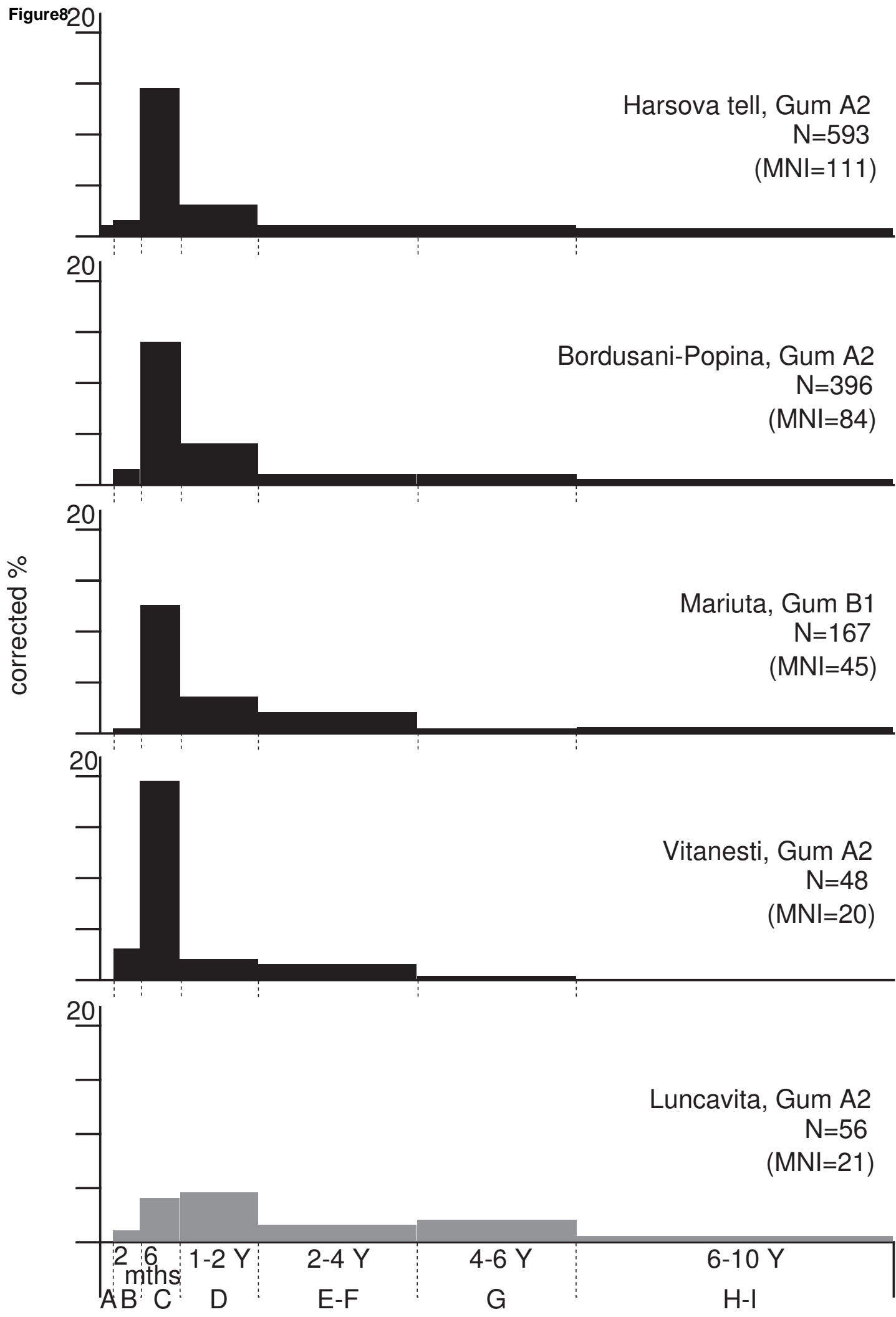


Figure9

