The Social and Economic Context for Domestic Horse Origins in Southeastern Europe: A View from Ljuljaci in the Central Balkans

Haskel J. Greenfield

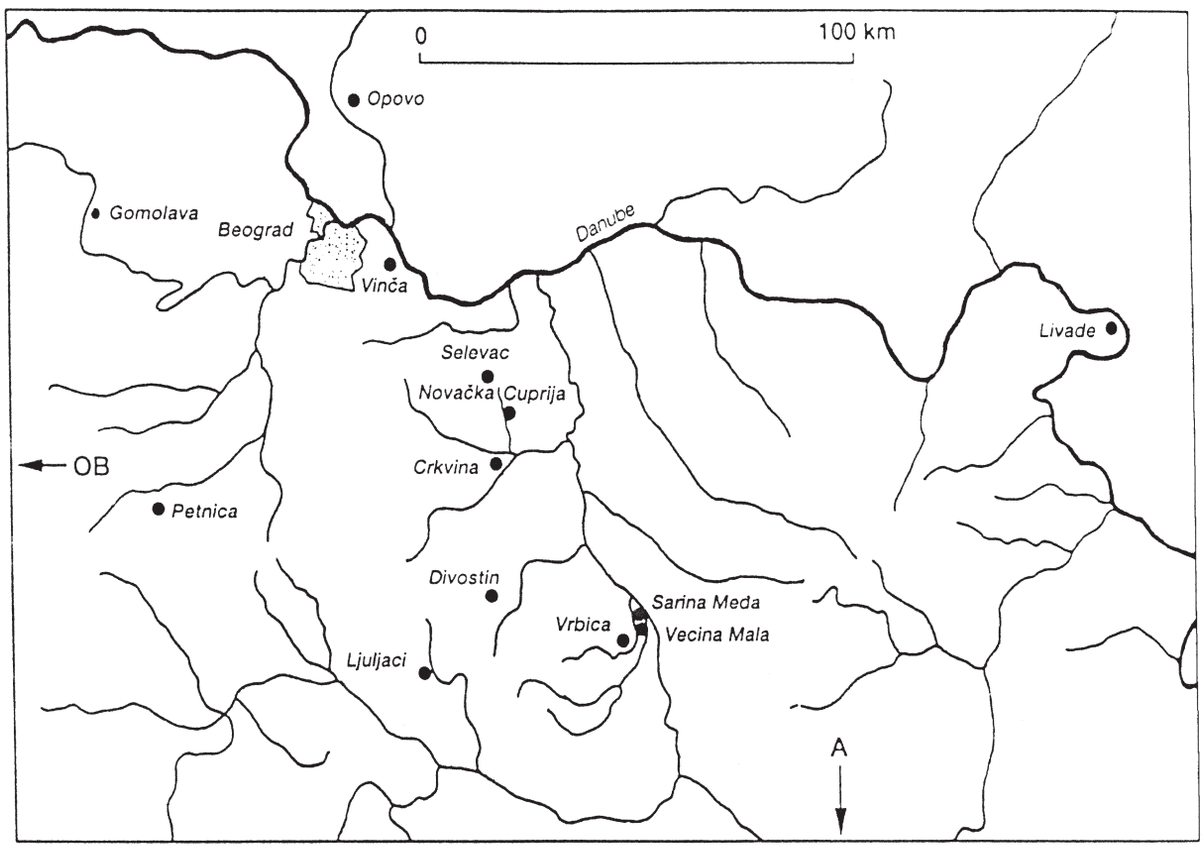

Figure 1. Map of central Balkans showing location of sites mentioned in the text.

Introduction

Most recent research on the origins and exploitation of early domestic horses has focused on the steppes of southern Russian and the Ukraine. It has become widely accepted that the horse was initially domesticated on the Eurasian steppes of Ukraine, southern Russia or Kazakhstan during the Eneolithic and subsequently diffused elsewhere (e.g. Anthony and Brown 1991; Anthony *et al.* 1991; Bibikova 1975; Bökönyi 1974a; Levine 1990; Olsen 2000).

Central Europe is one of the first regions to where domestic horses subsequently diffuse. Fifty years of research in the eastern end of the region, the Carpathian Basin and surrounding uplands, has demonstrated a total lack of evidence for indigenous horse domestication west of the Carpathians. In the Carpathian Basin, the remains of equids are found in very small numbers on a few Neolithic sites. After lengthy discourse as to their state of domestication, there emerged a general agreement that these equids were from remnant populations of wild "tarpans" (*Equus ferus)* and were not examples of early domestic horses (Bökönyi 1974a; 1978; Vörös 1981).

Subsequent to their domestication, horses spread from eastern to central and southeastern Europe during the Eneolithic and beginning of the Bronze Age (Table 1, Figure 1).[1] The reports of possibly domestic horse bones from Eneolithic sites indicate that they are present in very limited numbers, and are usually represented by only a

[1] One must be careful when using general terms, such as Eneolithic or Bronze Age. The periods begin and end at slightly different times in each part of Europe. As a result, the Eneolithic and Bronze Age begin and end slightly earlier in southeastern to northeastern Europe (Greenfield 2001).

few fragments, at best. In contrast, the evidence for horse keeping on a larger scale makes its first appearance in Central Europe (the Carpathian Basin, in general, and the central Balkans, in particular) during the Early Bronze Age (EBA) (Bökönyi 1974a, 1978).

Table 1. Calibrated radiocarbon dating of major periods in the southeastern corner of the Carpathian Basin (and central Balkans) (Bankoff *et al.* 1979; Coles and Harding 1979; Ehrich and Bankoff 1991; Greenfield 2001).

Period	Radiocarbon Dates (cal.)
Eneolithic	3300-2700
Early Bronze Age	2700-2200
Middle Bronze Age	2200-1600

In order to understand the importance of early domestic horses to societies that adopt them from the outside, the context in which horse remains are found must be understood. On the steppes of the former Soviet Union, horse burials quickly become associated with the emergence of a local elite during the Bronze and Iron Ages. This is most obvious through the numerous tumulus burials with horse remains (Piggott 1981; references in this volume). In contrast, few mortuary contexts have been found in the Carpathian Basin with horse remains, even though, tumuli became a facet of the archaeological record in the area during the Bronze Age (Bökönyi 1974a, 1978:54; Ecsedy 1979). As a result, it has been difficult to evaluate the impact of early domestic horses upon the evolution of social hierarchies within the larger society.

In the absence of burials, settlement data can be used to monitor the relationship between a social hierarchy and domestic horses. During the Bronze Age of the Carpathian Basin, the frequency of sites with horse remains dramatically increased. Most of the evidence for early domestic horses derives from settlement sites. Almost all settlements have at least a few horse remains that constitute a very small percentage of the fauna (Table 2), however, some sites have dramatically higher frequencies of horses. There are suggestions in the data that the variation in horse remains may be significant between low and high status settlements, perhaps because horses were more accessible to the emerging elite in the region. In order to identify if there is an association between high and low status settlements in a region, both types of sites have to be excavated. Yet, in most areas few if any "elite" settlements have been excavated.

Table 2. Frequency of horse bones in central Balkan zooarchaeological assemblages (based on NISP).

Site	Period	Culture	Frequency of Horse Bones		Level in Settlement Hierarchy	Sorted by Period	Sequence No.
			No.	% Food Taxa			
Vinca-Belo Brdo	Eneolithic	Baden	0	0.00	High	1	1
Novačka Ćuprija	Eneolithic	Baden	0	0.00	Low	1	2
Petnica	Eneolithic	Baden	0	0.00	Low	1	3
Novačka Ćuprija	Early Bronze Age		10	1.40	Low	2	4
Crkvina	Early Bronze Age		2	2.10	Low	2	5
Vinca-Belo Brdo	Middle Bronze Age	Vatin	7	0.64	High	3	6
Ljuljaci	Early-Middle Bronze Age	Vatin	115	6.97	High	3	7
Mala Vrbica-Livade	Late Bronze Age	Dubovac-Zuto Brdo	33	2.54	Low	4	8
Sarina Medja	Late Bronze Age	Hallstatt A	3	1.00	Low	4	9
Vecina Mala	Late Bronze Age	Hallstatt A	1	3.40	Low	4	10
Vrbica	Late Bronze Age	Hallstatt A	0	0.00	Low	4	11
Novačka Ćuprija	Late Bronze Age	Bronze D-Hallstatt A	0	0.00	Low	4	12
Petnica	Late Bronze Age	Hallstatt A	2	1.00	Low	4	13
Kadica Brdo	Early Iron Age	Hallstatt C/D	14	0.21	High	5	14
Foeni-Salas	Early Iron Age	Hallstatt C/D	0	0.00	Low	5	15

In the southeast corner of the Carpathian Basin, known as the central Balkans, one such "elite" site, Ljuljaci, has been excavated (Bogdanović 1986), and its faunal assemblage has been analyzed (Greenfield 1986a, b). In addition, a large sample of settlement sites spanning the Eneolithic and Bronze Age has been excavated and their faunal remains have been analyzed. These data provide both a temporal and spatial context for analysis. Traditional archaeological analysis of the settlement data indicates the existence of a regional settlement hierarchy, with a single, often fortified settlement dominating each valley or region at a time (e.g. Bogdanović 1986; Govedarica 1982; Greenfield 2001). As well as Ljuljaci, a number of "low-level" sites have had their faunal assemblages analyzed (Greenfield 1986a, b, c:1995, n.d.).

In the central Balkans, therefore, there is the opportunity to examine the relationship between the distribution of horse remains and settlement hierarchy. In this paper, two major questions will be investigated:

1. The reason why there is prevalence for regular, but small quantities of horse remains in domestic contexts is rarely raised. Most scholars simply assume that the horses were part of the diet. Is this assumption warranted? This will be investigated through a comparison of the remains from traditional food animals with those of horses; and
2. Why do some sites have higher quantities of horse remains than most other sites? Is there any possible linkage between status and the presence of horses? Data from the settlement site of Ljuljaci, located in the mountains of central Serbia near the city of Kragujevac, will be presented to support the association of domestic horses with emerging regional elites.

In order to investigate these questions, the paper will begin with a summary of the archaeological record for the Early Bronze Age of the central Balkans. Second, the site of Ljuljaci will be presented as an example of an elite settlement in the region. Third, the results of the analysis of the faunal remains from Ljuljaci will be discussed in order to set the context for the ensuing discussion on early horses. Fourth, the evidence for early domestic horses from the Carpathian Basin and the southeastern corner of the central Balkans will be reviewed as a prelude to discussing the horse remains from Ljuljaci. Fifth, the evidence for "elite" settlement sites in the central Balkans and how the site of Ljuljaci is an example of an early "elite" settlement from the region will be discussed. Ljuljaci is one of the earliest archaeological sites in the central Balkans where domestic horses appear in any significant frequencies.

The Early and Middle Bronze Ages of the Central Balkans: A Short Review of Culture History

In order to understand the unique nature of the site of Ljuljaci and its data, it is necessary to describe the temporal and spatial context in which it is embedded. The following discussion derives from recent syntheses of the region (e.g. Coles and Harding 1979; Garašanin 1972, 1973, 1983; Greenfield 2001; Tasi 1984).

By the EBA, the settlement system of the region displayed qualities that every student of historic European cultures would find familiar; small farming villages were inhabited by families pursuing a diversified subsistence strategy that included, small-scale craft production, plow agriculture, and diversified pastoralism. Each village is integrated into a larger regional social and economic system, within which it derives access to non-local minerals and other goods and which it owes political allegiances and obligations. Settlement hierarchies emerge with two clearly distinguishable levels:

1. The upper level sites or regional centers are often located in a commanding position (naturally defensible hilltop or spur), fortified (ditch, palisade, stone walls), and permanently occupied. Each river valley area is dominated by one or two such sites. They are frequently associated with a richer metal inventory and are occasionally accompanied by relatively richly equipped individual burials. There are indications that craft activities and items obtained through long-distance exchange occur more frequently at such sites. By implication of their position and differential access to resources, these sites and their inhabitants probably had additional functions of an economic, social or religious nature, such as regional center of metal production and political organization. Most are extremely small and could not have contained large populations. They probably were occupied by no more than the household of the local chief and retainers.
2. The lower level sites are ubiquitous, very small scale and undifferentiated. Several sites may occur per small stream valley. These represent the local villages or hamlets.

Two types of houses are known: surface and semi subterranean (pit houses). The surface houses are typically small and rectilinear (e.g. 3x4 m, 10x8 m, and 7x5 m), although larger houses are known (e.g. 22x16 m and 17x6 m). Size varies tremendously. They are made of insubstantial wattle and daub architecture with floors made of earth or wooden beams or planks. Pit houses are typically small and were probably occupied for a short period of time. Hearths and clay ovens are commonly found within structures. There is little evidence of functional differences between houses within settlements, since the nature and distribution of artifacts does not vary dramatically. Little is known about the pit houses, which are commonly reported in the literature but poorly described.

Wild animals and plants represent a minor, but still significant component of the food species at most sites. The most common animals include red and roe deer, aurochs, and wild pigs. In the lowlands, fish are an important

component of the wild fauna. The decrease in wild fauna is probably attributable to continued forest clearance by humans, increased human population, and more extensive reliance upon domestic animals.

The major domestic animals include sheep, goat, cattle, pigs, dogs, and horses. With the exception of dog, they were exploited for both primary (meat, hide, bone) and secondary products (traction, milk and wool). Traction is suggested by the presence of carts and double ox burials in central Europe. An emphasis upon milk and wool production is attested to by changes in the ages at which cattle, sheep and goats were slaughtered and the emphasis on new artifact forms, such as ceramic spindle whorls, and new cup, jug and sieve forms. New breeds and species of domestic animals appear (wooly sheep, horses) in the region. The shift toward greater diversification in subsistence is also reflected by changes in land use. There is a shift from reliance upon the rich alluvial soils along the edges of rivers, streams and lakes (during the Neolithic) to a wider range of locations, including most major environmental zones – from highlands to lowlands, from dry loess terraces to swamps. During the Eneolithic and the EBA, the high altitude mountain (sub- and alpine) zones are colonized to control pastures and other resources. The implication is that there was more of an emphasis on pastoralism and transhumance, with potentially greater numbers of domestic animals being herded in order to produce primary and secondary products. Hence, the origins of the historic European mixed farming system lie in this period.

Horse bones constitute a regular but small percentage of the domestic fauna for the first time. Also appearing at this time are bone artifacts, often elaborately decorated, that are believed to be cheek pieces for horse bridles. These suggest that horses were either ridden or used for draft by the EBA. Horses and their tackle were probably associated with high status members of the community.

The same types of crops are exploited as during the Neolithic. Wheat (einkorn and emmer) and barley (two- and six-row) are the most common. Barley cultivation may have increased during the Bronze Age in most of Eastern and Central Europe, although this is somewhat in dispute. There is a greater variety of crop types than in previous periods, although many species are of minor importance (e.g. bread wheat, rye, field pea, and lentils). Wild plants do not seem to have been very important in the diet. The appearance of a plethora of drinking vessel forms has been associated with the emergence of mead as a social beverage.

These subsistence innovations led to radical changes in agricultural strategy – more intensive cereal agriculture and increased stock raising. The integration of plant agriculture with the use of the plow and wheeled transport led to greater productivity in cultivation, and the ability of small-scale farmers to clear and cultivate a larger area. More extensive clearances made the landscape more suitable for sheep rearing and associated wool production. A larger cleared area would have been necessary for the pasturing of larger numbers of animals maintained for traction and milking. Larger numbers of domestic animals would have discouraged forest regeneration. The result was an expanding agricultural and settlement system.

Several new technologies revolutionized society. Metal tools became common during this period. Stone tools almost completely disappeared during this period. The most common stone tools were small blades. Evidence from cut marks on animal bones indicates that stone remained an important part of the butchering technology in the commoner small sites, while metal cutting implements increased in frequency in elite sites. Wood, reed and other raw materials were used for tools and containers, as evident from their remains in Swiss lakeside dwellings. Wheeled-vehicles appear in the region during the Eneolithic. By the EBA, they were employed extensively and changed the nature of food production and trade (more can be moved over larger distance by fewer people). The plow also appeared in the Eneolithic and was extensively incorporated into subsistence during this period.

Local communities (as represented by sites) were small (<100 people), but there was a strong emphasis on symbolic expression of status. It is likely that local communities were exogamous, given their small size. Prior to this period, there is very little evidence for social hierarchies. During the EBA, some burials contained much more elaborate grave goods than others, both within communal cemeteries and in separate, isolated locations. Many of these burials have very sophisticated grave goods made of bronze, copper and gold and non-local goods obtained through long-distance exchange. This suggests a substantial indigenous demand for luxury artifacts. In contrast, most burials have only a few (or no) goods made from only local materials. The existence of a two-level settlement hierarchy and differentiation among burials suggests the appearance of low-level hierarchical societies, known as chiefdoms.

Regions and local communities were controlled by means of violence, allegiance to lineages or other social groupings, and other features characteristic of low-level hierarchical societies. Fortified sites became common throughout the region. The prevalence of such sites is suggestive of endemic local raiding. In times of danger, they might have been places of refuge for the surrounding population in times of conflict, but would have been permanently occupied and defended by local leaders. Competition, in the form of endemic raiding, likely existed between local hierarchical groups.

Ljuljaci: An Elite Settlement in the Central Balkans

Ljuljaci is considered to be an example of a site from the upper level of the regional settlement hierarchy – in other

words, an elite settlement. In order to substantiate this statement, the data from the various excavations at Ljuljaci are summarized next. The conclusions are based on the analysis of the site by Milenko Bogdanović (1986).

Site Location

Ljuljaci is a hilltop settlement located on Milica Brdo in the village of Ljuljaci, about 20 km west of the city of Kragujevac, Serbia.

History of Research at the Site

Ljuljaci has been the focus of excavations for the better part of this century. It was first tested in 1930 by the joint Yugoslav-American archaeological expedition directed by V. Fewkes (Robert Ehrich 1982, personal communication). Various parts of the site were excavated around the hilltop and down in the nearby valley. During early 1952, other portions of the site were excavated by the *Narodni Muzej* (National Museum) of Belgrade (Bogdanović 1986). In 1965, Dragoslav Srejović, under the auspices of the *Narodni Muzej* of Kragujevac and the Archaeological Institute of Belgrade, conducted a series of excavations on the hilltop. During 1976 and 1977, and Milkenko Bogdanović, of the University of Belgrade and *Narodni Muzej* of Kragujevac, respectively, conducted large-scale intensive excavations of the Bronze Age section of the locality. Trenches were placed over various section of the site in order to investigate the fortifications, foundations of the settlement, thickness of the cultural deposits, and stratigraphic relations within the site.

Between 1965 and 1977, 386 m^2 of the surface of the site were investigated (82 m^2 in 1965 and 304 m^2 in 1976-1977). While most of the excavations focused on the central and western parts, virtually every section of the site was sampled (Figure 2).

Since 1965, Ljuljaci has been recognized as one of the most important localities for the development of the Middle Bronze Age Vatin culture and its West Serbian variant (Bogdanović 1986; Garašanin 1973; 1983). It is a highly unrepresentative locality for this time period because of the good conditions of preservations existing at the site. Most contemporaneous settlements, like Novacka Cuprija, Vinca and Crkvina, are greatly disturbed by a variety of processes and, at best, may yield a few discrete rubbish pits. To find a Bronze Age locality with preserved house floors is an exceptional situation in this region.

Surrounding Environment

Topographically, the region is one of broad and very dissected limestone platforms. Throughout the area,

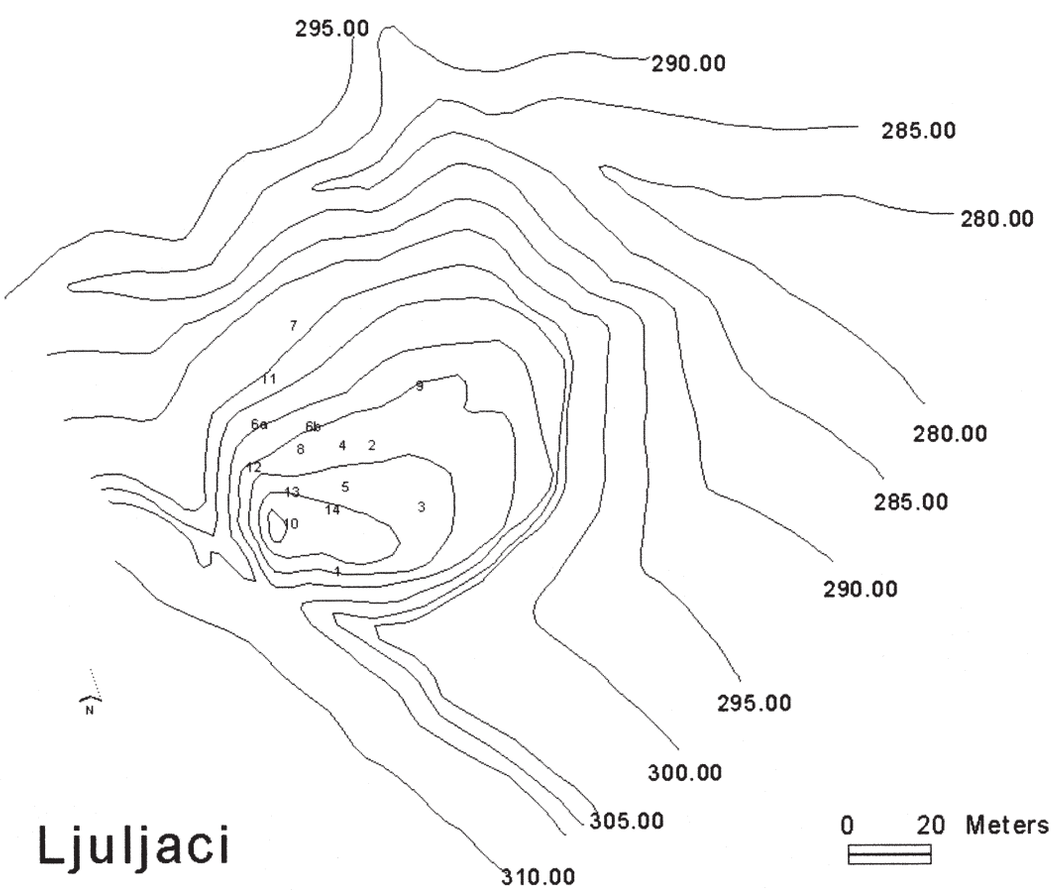

Figure 2. Topographic map of Ljuljaci, including location of excavation trenches.

groups of rocks protrude through and above the soft Tertiary mantle of limestone, sandstone and shale. These older and more resistant rocks, often containing mineral rich deposits, stand up as hills above the rest.

The region has a southern temperate climate with features similar to those of Central Europe. However, it does retain features of the more arid Mediterranean climatic zone to the south. The farther north from the Dinaric Mountain's divide that one goes, the more it resembles the Central European climatic regime. Climatic variability is largely a function of altitude and proximity to the two neighboring climatic regions. In general, winters are very cold and summers are hot. The climate is continental and precipitation is evenly distributed throughout the year, with an annual average of 600 mm. In conjunction climate resembles the Central European climatic regime. Climatic variability is largely a function of altitude and proximity to the two neighboring climatic regions. In general, winters are very cold and summers are hot. The climate is continental and precipitation with the water-retentive soil, this is sufficient for dry farming. The highest precipitation is during the summer (June) and the lowest during the winter (February). The region has an annual average temperature of 11-12°C. In the late fall and early winter (November), snow begins to fall and may last until March. The average temperature in January is 0-2.5°C and in July it is 20-25°C. Summer-highs range up to 42 °C and winter lows to about -26 °C, and the average temperature for the growing season is 18-19°C. The open plains allow snow accumulations to be easily blown away by the winds, while snow readily accumulates in the surrounding forested and hilly environments. Even fast flowing streams and rivers may freeze. Snow arrives and remains for a longer period of time in the mountains (late April/early May) than in the plains (early March).

The plant community falls within the Central European biotic region. There is usually an 8.5-month growing season (between the last and first frosts of the year), from the middle of March through November. Pollen diagrams from surrounding regions indicate that the environment was probably much the same in the Bronze Age as at present, taking into consideration modern deforestation. Central European deciduous forests (i.e. thick mixed-oak forest) and grasslands, with a rich diversity of plant and animal life, characterize the region. Beneath 1000 m, there is a thick mixed-oak forest. A beech forest zone begins at about 1000 m (a.s.l.). The leafy branches of the beech forests were favored fodder for horses, sheep and cattle. At about 2300 m, the coniferous forests begin to appear. Above them, at 5000-6200 m. (a.s.l.), lie the high mountain brushwood and grasslands (Greenfield 1986a, 2001).

Site Topography

The site is located on the western half of a natural plateau, overlooking the surrounding valleys. The southwest approach to the plateau resembles that of a steep ramp. The western and northern sides descend quite steeply to the stream below. The western side is the widest. The Glavica is a thin, winding stream that bends around the western, northern, and eastern foot of the plateau. Then, the stream flows east and northeast until the valley opens up into the larger valley of the Gruže River. The Gruže flows south and east until it merges with the Western (Zapadni) Morava in the mountains to the south. On the opposite side of the stream, the terrain quickly rises up again.

Stratigraphy

The thickness of the cultural layer varied from 130-148 cm. in the western and southwestern parts of the site to 30-40 cm. in the eastern. The stratigraphy proved to be quite simple. The strata were laid down horizontally and were parallel to the sterile substrate (Bogdanović 1986). According to the radiocarbon dates, the site was occupied from the Early Bronze Age and was abandoned at the end of the Middle Bronze Age, after approximately 300 years. Three broad cultural strata were identified (Ljuljaci I, II and III) and associated with surrounding regional prehistoric cultures:

> Ljuljaci I. Early Bronze Age (analogies with the Vinkovci and Bubanj-Hum III ceramic groups, *c.* 1950 BC, uncalibrated),
> Ljuljaci II. Late Early Bronze Age-early Middle Bronze Age (Pančevo-Omoljica variant of the Vatin ceramic group - 1730-1690 BC, uncalibrated), and
> Ljuljaci III. Middle Bronze Age (classic Vatin ceramic group, *c.* 1600-1550 BC, uncalibrated).

All three phases of occupation were found superimposed along the western half of the site in trenches (or *sonda*) 1, 5, 6a, 6b, 7, 7a, 7b, 8, 8a, 8b, 8c, 12, 13 and 14. In the eastern half, only Ljuljaci III deposits were found (Trenches 2, 3, 4, 9 and 11). Between Ljuljaci I and II, the settlement siz e remained constant, but in the final period, it spread over previously unoccupied areas, as well.

Architecture

Fortification

Ljuljaci is frequently thought of as a *gradina* (Serbian for a small, fortified locality) because of its position atop a small plateau surrounded on three sides by steep slopes. The settlement was built on the western half of the hill, on the area lying between the steep slopes of the hill and the north-south axis that divides it into two equal parts. Easy access was available only from the eastern side. The settlement may have been surrounded by a wooden and ditch enclosure system, but it is poorly preserved evidence for due to erosion along the edges of the plateau. Walls constructed of earth and rubble were found on the southwestern side of the settlement (Bogdanović 1986:121).

Domestic architecture

The Bronze Age settlement was built on the western side of the plateau (Bogdanović 1986, fig. 21). During the 1976-77 excavations, 29 freestanding houses and associated features and artifacts were uncovered. Not all were contemporaneous, since several were built atop earlier houses. House design, shape, and construction were relatively uniform throughout the site. Houses were constructed of wood, daub and stone. The limestone flooring was smeared with a layer of daub. The foundations were quadrilateral and varied between 3x3 and 4x4 m in length. House frames were built using the wattle-and-daub technique – upright and deeply buried wood posts, with thinner pieces of brushwood woven between. Roof construction techniques are poorly known. The houses appear to be similarly oriented – with one placed before the second and an intervening open space ranging from 2-4 meters separating them. Paths wind between the houses. In the southwestern part of the site, there appears to have been a relatively undeveloped section. The function of this area is unknown.

House contents

There is no functional differentiation between houses. Each of the artifact categories is found in all houses. Open-air hearths, grain-mortars, ceramic vessels, and stone and bone tools are frequently found within houses. Artifacts found on the floor and around the houses were made of clay, stone and bone. In one house, almost 200 fragments of ceramic dishes were recovered. Twelve basic ceramic forms, with a variety of sub-forms are distinguished – ranging from a large *pithos* and amphora for storage to miniature cups and bowls. Many (n=74) fragments of worked stone were collected, including flint knives and awls and ground stone amulets. Bone and antler tools were also found.

The Faunal Remains

The Sample

The faunal sample considered here comes from the 1976-77 excavations of the site. A total of 3772 fragments were recovered from the site (3538 unarticulated bone fragments). The sample of faunal remains was originally divided temporally for analysis. However, the resulting samples were disproportionate in size and all were too small to adequately illustrate vertebrate exploitation at the site. In addition, certain dense concentrations of faunal remains cross cut the temporally subdivided strata (i.e. wild pigs in Sonda 12 – see below). As a result, it was decided to pool all the sub-samples and to analyze them as a single unit.

Taphonomic Considerations

Excavation and recovery strategies

Very little faunal material was kept from the pre-1965 trenches. Since the excavation objectives were different from modern ones, collection and curation of faunal remains were under-emphasized. Of the 1965 trenches (Sondas 1 – 5), only Sonda 5 had any curated bones (n=24). These bones were included in the overall analysis, since they belonged to the same temporal phase. Sondas 6-14, which were excavated in 1976-1977, yielded most of the material. The excavated area of Sondas 6-14, excluding Sonda 10, was 304 sq^2 and the cultural layer varied between 30 and 160 cm in depth. Sonda 10 yielded no bones because it was an old ditch used as a stratigraphic check for that part of the site. Within each sonda, the bones were collected by use of vertically superimposed excavation units and internal zones. All remains were hand-collected. None of the earth was sieved, resulting in under-representation of the remains of smaller animals and body parts. The low frequencies of small bones at Ljuljaci reflect the differential recovery of material by size. Larger bones were, generally speaking, more visible and recovered to a greater extent than smaller bones. In addition, the smaller the body size of a species *(i.e. Ovis/Capra, Capreolus* and *Canis),* the smaller the representation of small bones in the sample (mean = 6.99% for small animals as opposed to 36.92% for larger animals - *Bos, Sus, Cervus* and *Ursus*, see Table 3). This is interesting in light of the evidence for attrition. The smaller, denser bones, like astragali, are usually more frequent than long bones and bone fragments in sieved assemblages. In this case, an opposite relationship is in effect, reflecting the greater influence of recovery procedures.

Other sources of assemblage attrition

The site is located on an exposed plateau. The plateau has been deforested, inhabited, cultivated and reforested over the course of human occupation and utilization. The soil has also been subjected to the annual processes of freeze, thaw, saturation, and evapo-transpiration. These function to break up and destroy bones, frequently leaving behind only the harder and more durable parts. This is reflected in the large numbers of weathered bones and bone ends in the assemblage (Greenfield 1986a, table 16). Exposure to the elements (wind, sun, and water action) will leave erosional traces on bones that can be used to judge the degree of weathering to which the sample has been subjected. A small percentage (8.78%) of the assemblage showed light weathering, indicating that the faunal material had been quickly covered after disposal and not re-exposed afterwards. Slightly more (11.2%) showed medium to heavy weathering, indicating longer periods of exposure before or after initial burial. The rest appeared to have been unaffected by weathering processes. A few (0.2%) were fresh, possibly representing contamination of some units by more recent animal deposits. Invariably, the deeper the stratum, the better will be the preservation of bones at the site. This is a characteristic frequently encountered on thinly stratified sites.

Burning can also contribute to bone disintegration. A very small percentage of the overall assemblage exhibited characteristic traces of burning. Three dozen (0.95%) fragments were partly or completely burnt. Most of these were unidentifiable to the species level (63.9%). Cattle

Table 3. Frequency of faunal remains by taxon recovered from Ljuljaci.

State of Domestication	Species	No. of Frags.	NISP	% of Total	% Food Taxa
Not Applicable	*Rodentia sp.*	2	2	0.06	
Unknown	Unknown	601	595	16.72	
	Bos sp.	2	2	0.06	
	Bos/Cervus	51	49	1.38	
	Bos/Cervus/Equus	128	122	3.43	
	Mammal - Large	721	713	20.03	
	Mammal - Medium	378	373	10.48	
	Mammal - Small	13	9	0.25	
	Ovis/Capra/Capreolus	23	22	0.62	
	Sus scrofa	22	22	0.62	
Total – Not Applicable, Unknown		1941	1909	53.64	
Domestic	*Bos taurus*	406	364	10.23	22.06
	Canis familiaris	42	28	0.79	1.70
	Capra hircus	1	1	0.03	0.06
	Equus caballus	120	115	3.23	6.97
	Ovis aries	13	10	0.28	0.61
	Ovis/Capra	56	44	1.24	2.67
	Sus scrofa dom.	440	417	11.72	25.27
Domestic Total		1078	979	27.51	59.33
Wild	*Bos primigenius*	31	29	0.81	1.76
	Capreolus capreolus	16	15	0.42	0.91
	Castor fiber	2	2	0.06	0.12
	Cervus elaphus	283	249	7.00	15.09
	Lepus europaeus	2	1	0.03	0.06
	Meles meles	9	9	0.25	0.55
	Sus scrofa fer.	374	344	9.67	20.85
	Unio sp.	1	1	0.03	0.06
	Ursus arctos	21	21	0.59	1.27
Wild Total		739	671	18.85	40.67
Domestic + Wild Total			1650		100.00
Grand Total		3758	3559	100.00	

(13.9%) and pigs (11.1%) were the most frequently identified taxa with burned bones.

Gnawing by carnivores and omnivores is a more serious taphonomic process. Carnivores are able to chew and break-up the hardest bones. Omnivores, such as pigs, are able to seriously deplete a faunal assemblage, as well. Many of the bones (15.3%; n = 576) in the assemblage showed chew marks. Distinguishing between canine and suid (pig) tooth marks on bones is difficult if not impossible. A distribution analysis of the species and body parts most frequently chewed provides some guide in determining the nature and extent of the depletion. Unfortunately, it may also be the case that those bones that remained in the archaeological record to be found by the excavators may simply represent those parts least digestible. The softer and least represented body parts may have been devoured to the point of disappearance and, consequently under-representation in the assemblage. This is very likely since erosion, weathering, and so forth seem not to have been major taphonomic factors and the high pH levels contribute to bone preservation.

Spatial patterning

Two areas of high bone concentration are visible: Zone A = Sondas 7, 7a and 7b and Zone B = Sondas 8, 8a, 8b, 8c, 12, 13 and 14. Between the two areas, there appears to be a decline in density and frequency (Sondas 6a and 6b). This may be attributable to differences in collection strategies

between trenches since bone densities and the stratigraphy are more or less the same on either side. To the west, the plateau drops down to the valley. To the east and south, densities decline as the strata thin out. To the north, the plateau drops down fairly suddenly.

Domestic animals

The overall distribution of species at the site is different from the surrounding contemporaneous sites. Caprines occur in very limited quantities at Ljuljaci (3.1%; n=54). These values may be a function of the combination of recovery biases, the forested environment, and the continuation of the trend of increasing frequencies of domestic stock in settlements, first noticed by Bökönyi (1974a; 1974b; 1988) for both Hungary and former Yugoslavia, and are more in accordance with those from Late Neolithic sites. It would appear that caprine exploitation relied quite heavily upon mature individuals. This would indicate an emphasis on production for meat, hides and other primary resources, as well as some secondary products like milk (Greenfield 1986a, 2005).

Among domestic cattle, a different picture of exploitation emerges. They represent 21.6% of the identified assemblage, when corrected for articulations – specimens that can be articulated during analysis are counted as one individual. In the NISP count, 63% of the fragments came from adults, 18% from sub-adults, and 18% from juveniles and younger categories. The main thrust of cattle production appears to have been towards an exploitation strategy that could have provided secondary products such as traction and dairy products. Meat and hides were of less importance, since the slaughter of immature individuals was not emphasized.

Pigs (24.2%; n=428 NISP) are the most numerous domestic animal species found at the site. Most (61.8%) of the domestic remains belonged to immature individuals (infants, juveniles and subadults). Equal numbers of both sexes were identified (in strong contrast to the wild boar pattern). Domestic pig slaughter was geared toward meat production since most of the culled individuals were from immature age classes. Individuals are culled in nearly equal numbers during each age class. This is a pattern common to the region even today, where local villagers slaughter a substantial proportion of immature pigs (juveniles and subadults) during the autumn and winter to reduce the cost of animal feed over the winter (Halpern 1999).

Domestic dogs (n=28 NISP; 1.6% of the TNF/Total Number of Fragments, uncorrected for articulations) are represented in an abundance typical for a Bronze Age site (Greenfield 1986a). Most of the specimens were from adults (90.5%). Dogs may have been eaten occasionally, since almost all the bones were broken and at least one fragment was burned. However, none of the bones had butchering or gnaw marks. The high frequency of gnaw marks on bones from other species at Ljuljaci would indicate that dogs and possibly pigs were important scavengers of refuse. It is very likely that a substantial portion of the original bone assemblage may have been destroyed, by gnawing.

Wild animals

There is a rich variety of terrestrial and aquatic resources in the surrounding region, given the nearby water sources and thick deciduous forest with dense underbrush. The juxtaposition of dissected stream valleys and wooded mountainsides around Ljuljaci would have been the optimal environment for wild animals.

The remains of wild pigs are found at Ljuljaci in surprising numbers (21.4%; n=379). Wild pigs are the second most numerous wild animal species found on the site. Both the long bone epiphyseal fusion data and the tooth eruption and wear patterns indicate that the vast majority of wild pig bones were from adult individuals (92.4%). Mostly older males with large tusks were selected. Some female specimens, based upon measurements and the open root of the tusks, were also found. Meat and hides were probably the most important by-products utilized. Hunting of wild pigs as trophies and for their meat and skins is still widely practiced in the Balkans.

Aurochs were represented by only 27 specimens (1.5% of the TNF). A large variety of body elements are present, including a fairly complete horn core. Other than the phalanges, all the bones are fragmented. All fall into the adult or sub-adult/adult age grouping. This is a fairly typical game animal age distribution. The number of aurochs' bones found at Ljuljaci is unusual for a Bronze Age site, since other coeval sites in the region have yielded few or no bones of the species. This may be due to the retreat of the aurochs to the more heavily forested and mountainous areas around places like Kragujevac. In the more open landscapes to the north and in the major river valleys, aurochs would have been jeopardized by competition from domestic livestock herds and humans trying to protect crops from depredation. Their large size and the hand-collected nature of the assemblage may have contributed to the disproportionate representation at Ljuljaci. At Petnica, which lies in a similar environmental context and whose collection techniques were more rigorous, only a single aurochs' bone was found in the Late Bronze Age Hallstatt A-deposits. In reality, the decline in aurochs frequencies between the two sites is a combination of both chronology and recovery. Few other Early/Middle Bronze Age sites have such a high frequency of aurochs remains. The large size of this species would make its remains easily recoverable under any condition.

Red Deer are the second most important wild species present at Ljuljaci but fourth overall (15.9%; n=282). The age distribution is heavily biased toward adults (84%), typical of hunters who aim for the largest individuals with the most yield. The high frequency of antler tools (over 75% of the antler fragments were worked) illustrates the continued use of this material in the Bronze Age.

As on most other sites in the area during any of the prehistoric time periods, roe deer are minimally represented (1.0%; n=18). Their low importance in the assemblages may be a function of their position on the resource selection scale, due to small size, low density in such environments, and/or recovery bias against the smaller species. Most of the fragments are from adults (91.7%), possibly indicating selection by the hunters for larger prey. Meat, hides, bones and antlers may have been exploited.

Early Horses in the Carpathian Basin

Early Horses in Central Europe

The appearance of the domestic horse is one of the hallmarks of the post-Neolithic. There have been intense debates over the domestic status of horse bones found in the Neolithic collections (e.g. Bökönyi 1974a, 1978; Vörös 1981). If they were domestic, are the bones intrusive or *in situ*? If they are wild, did they belong to ancestors of the European domestic horse or from a wild population that went extinct, not contributing to the process of horse domestication? By and large, a consensus has emerged with the publication of data from Hungary, Ukraine. It points farther east that the ancestors of the early domestic horses were domesticated in the steppes north of the Black Sea during the period of the Cucuteni-Tripolje culture (circa 4000 BC) and probably even farther east (Anthony and Brown 1991; Anthony *et al.* 1991; Bökönyi 1978; Bibikova 1967). They begin to arrive in Eastern and Central Europe about 1,000 years later (Bökönyi 1974a:239). The exact timing is still in doubt and appears to vary considerably depending upon ease of movement and distance between various parts of Europe with the Ukraine. In the plains to the north of the Balkans, they arrive in the Eneolithic (Baden – circa 3300 BC). At first, they are very infrequent. By the beginning of the Bronze Age (circa 2800 BC), they increase in frequency (Bökönyi 1978:30-35).

Early Horses in the Central Balkans

The domestic horse was the last of the livestock species to arrive in the Balkans before Roman times. In the central Balkans, horse bones are not found until the Early Bronze Age. Each of the Eneolithic assemblages so far examined (Petnica, Novačka Ćuprija and Vinca) did not yield any evidence for domestic (or wild) horses. Domestic horse bones appear for the first time in the EBA pit deposits at Novačka Ćuprija and Crkvina, and in the Early/Middle Bronze Age Vatina culture horizon and pit deposits at Ljuljaci and Vinca. They continue to appear in deposits from subsequent periods, albeit in low frequencies. The horse remains from each of the Bronze Age sites in the central Balkans are described below.

Crkvina (EBA)

Two fragments of domestic horse bone were found at Crkvina (2.1%; see Table 2) in a pit. They were among the few bones in the pit that were not burnt. Both fragments were small, hard elements, undamaged and ageable only to the ambiguous sub-adult/adult category (Greenfield 1986a:183, 1986c).

Livade (LBA - Dubovac-Žuto Brdo and related cultures)

Domestic horses are represented by 33 bones, both whole and fragmented (2.54%; see Table 2). Nearly all were found in the cultural horizon (n=32; 97% of horse bones), with only a single bone fragment coming from a contemporaneous feature. The large size of this species, relative to most of the other species at the site, may have contributed to its better preservation. A relatively large fraction of late fusing bone ends were found (6:8 early: late fusing ratio). The bone remains were large and dense enough to survive the forces of erosion and fragmentation. Few bones were chewed (n=3; 9.1%), all of which were found in the cultural horizon. The fragment from the contemporaneous feature was unmodified. The evidence for attrition is somewhat at odds with the late fusing data.

Table 4. Frequency distribution of domestic horse (*Equus caballus*) and cattle (*Bos taurus*) elements from Ljuljaci. Note: All "0" cells can be accounted for in the large mammal category.

	Equus caballus				*Bos taurus*	
Element	NISP	No. of Articulated Specimens	Total	% Horse Bones	NISP	% Cattle Bones
?	1		1	0.85		
Carpal	2		2	1.69	6	1.65
Cranium	2		2	1.69	35	9.62
Femur	4		4	3.39	9	2.47
Fibula			0	0.00		0.00
Humerus	6		6	5.08	21	5.77
Hyoid			0	0.00		0.00
Innominate			0	0.00	27	7.42
Loose tooth	4		4	3.39	35	9.62
Mandible	10		10	8.47	24	6.59
Metacarpal	2		2	1.69	18	4.95
Metapodial	4		4	3.39	2	0.55
Metatarsal	2		2	1.69	30	8.24
Patella			0	0.00		0.00
Phalanx	50		50	42.37	70	19.23
Radius	5		5	4.24	22	6.04
Rib			0	0.00		0.00
Scapula	2		2	1.69	4	1.10
Tarsal	6	1	7	5.93	18	4.95
Tibia	11	2	13	11.02	14	3.85
Ulna	1		1	0.85	16	4.40
Vertebra	3		3	2.54	13	3.57
Grand Total	115	3	118	100.00	364	100.00

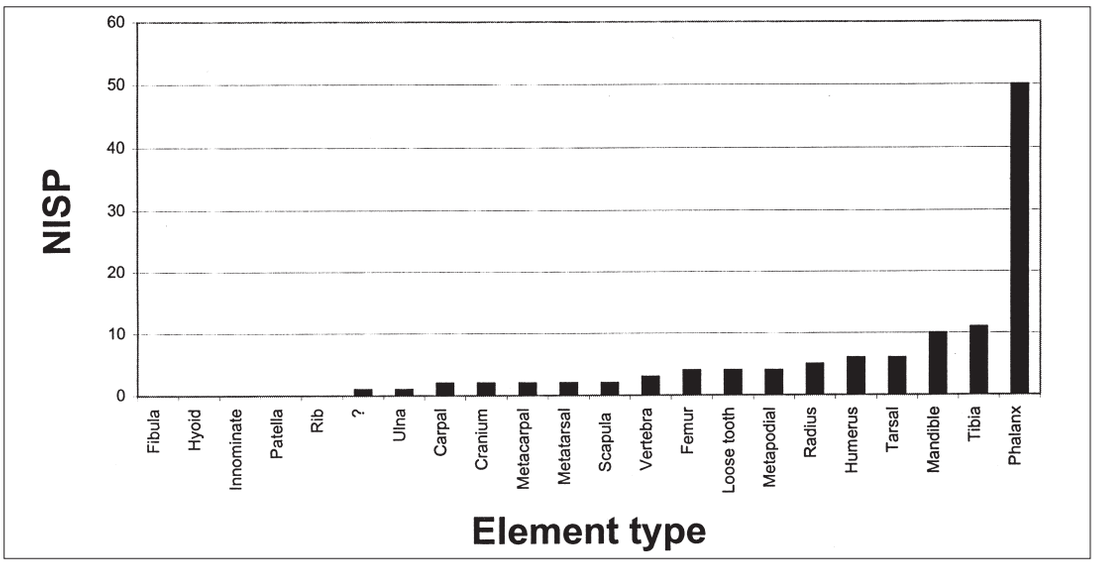

Figure 3. Frequency histogram (NISP) of the distribution of domestic horse bones by major element category, sorted by frequency.

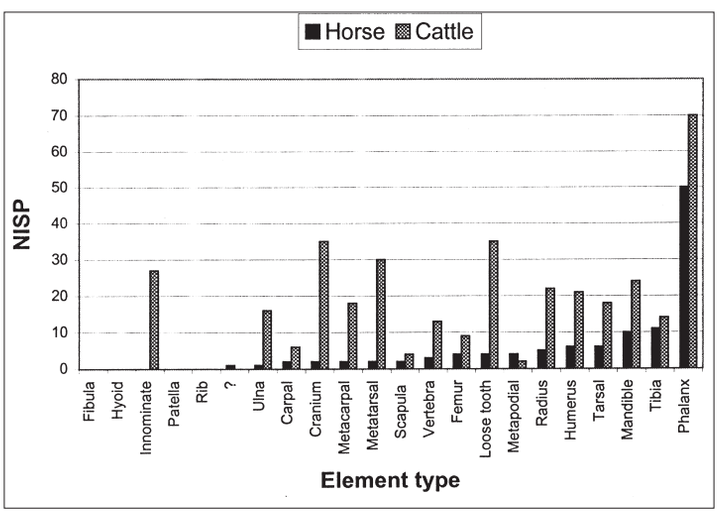

Figure 4. Histogram comparing the frequency (NISP) distribution of domestic horse and cattle bones by major element category, sorted by horse frequency.

Several of the cultural horizon fragments were badly eroded (n=12; 36.4% of the horse bones). Only two out of the seven late fusing elements from the cultural horizon were weathered, in contrast to the early fusing group where more were weathered. It is possible that the lower rates of attrition on the late fusing ends may be due to maturity of the sample. The late fusing elements are represented mostly by adults, whereas the early fusing group may include sub-adults. The adult bones, even though they fuse later, stand up to attrition at a better rate than immature bones. Horses were exploited for traction and transport during the Bronze Age. Sturdy adults were preferred and their bones stood up better to destructive forces of attrition. One of the bones (a distal metatarsal) was modified into an awl as at Ljuljaci. A distal phalanx showed evidence for pathological bone growth, possibly arthritis (Greenfield 1986a:153-4).

Domestic horse is present in only small quantities (n=10; 1.4%; see Table 2). The remains were found only in the EBA pits (n=7) and the cultural horizon above the pits (n=3) (Greenfield 1986a:182, 1986c). All of the long bones were fragmented, as were similarly sized cattle remains. Their large size # produced more fragmented samples among the larger mammals than among the medium- or small-sized mammalian species. Since fragmentation is not enhanced by their large size, the high fragmentation pattern is probably because people were extracting marrow.

All of the late fusing articular condyles were recovered in the pits (n=4). Only the denser early fusing (n=1) and small, hard elements (n=2) were found in the overlying cultural horizon where greater attrition would be expected. One of the late fusing bones from a pit was weathered. None of the others was otherwise damaged or modified. All of the ageable specimens were from adults (n=4) (Greenfield 1986a:182-183).

Petnica (LBA – Hallstatt A/B culture)

Two fragments were found at Petnica in the Halstatt horizon (1.0%; see Table 2). Both were postcranial fragments from adults (Greenfield 1986a:121).

Sarina Medja (LBA – Hallstatt A/B culture)

Domestic horses are found in very small frequencies (n=3; 1%; see Table 2). One loose tooth and two metapodial fragments (2 adults and 1 subadult/adult) were found in Pits 1 and 3, respectively. The piece from Pit 3 was burnt, suggesting that horse bones were, at least occasionally, discarded into fire pits. Charring comes from throwing the bones on the fire or the bones lying just under the surface where the fire is built. It does not address the issue as to whether horses were eaten after their usefulness as a pack,

Table 5. Frequency (NISP) distribution of weathered bones by taxon from Ljuljaci.

		Weathering							
State of Domestication	**Taxon**	**None**	**Light**		**Medium**		**Heavy**		**Grand Total**
		No.	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
Unknown	Unknown	8	500		86		3		597
	Bos sp.		2						2
	Bos/Cervus		41		7		1		49
	Bos/Cervus/Equus		106		16				122
	Mammal - Large		638		73		2		713
	Mammal - Medium		352		18		3		373
	Mammal - Small		9						9
	Ovis/Capra/ Capreolus		21		1				22
	Sus scrofa		19		2		1		22
Total - Unknown		8	1688		203		10		1909
Domestic	*Bos taurus*		321	88.19	43	11.81			364
	Canis familiaris		25	89.29	3	10.71			28
	Capra hircus		1	100.00		0.00			1
	Equus caballus		85	73.91	29	25.22	1	0.87	115
	Ovis aries		8	80.00	2	20.00			10
	Ovis/Capra		39	88.64	5	11.36			44
	Sus scrofa dom.	1	387	92.81	28	6.71	1	0.24	417
Wild	*Bos primigenius*		24	82.76	5	17.24			29
	Capreolus capreolus		13	86.67	2	13.33			15
	Castor fiber		2	100.00		0.00			2
	Cervus elaphus		215	86.35	34	13.65			249
	Lepus europaeus		1	100.00		0.00			1
	Meles meles		9	100.00		0.00			9
	Sus scrofa fer.		312	90.70	32	9.30			344
	Unio sp.		1	100.00		0.00			1
	Ursus arctos		18	85.71	3	14.29			21
Grand Total		9	3149	88.48	389	10.93	12	0.34	3559

draught or riding animal ceased. All of the specimens were adults (Greenfield 1986a; 1995).

Vecina Mala (LBA – Halstatt A/B culture)
Only one fragment of a domestic horse bone was found (3.4%, see Table 2). The single pelvic fragment was unmodified and adult in age. No remains were found at nearby Vrbica (Greenfield 1986a, 1995).

(MBA - Vatin culture)
Eight bones and fragments of domestic horse were found in the Vatin culture pits and occupation horizon at Belo Brdo, the type-site for the Middle-Late Neolithic culture. These represent a very small percentage of the contemporaneous bone assemblage from this phase of occupation at the site (0.64%, see Table 2). One carpal, femur, metatarsal, two isolated teeth, and three tarsal bones were recovered. All are from adults (n=4) or subadult/adult (n=4) age categories (Greenfield, no date).

The Horses from Ljuljaci

Ljuljaci is one of the earliest sites in the central Balkans where domestic horses appear relatively frequently. They are represented by a larger than usual frequency of identified vertebrate remains (NISP = 115; 6.97%, see Table 3).

A wide range of bones was recovered (Table 4, Figure 3). When the elements are sorted by frequency, they can be grouped into three levels. In a group by itself, the most common element type is that of phalanges (42% of NISP). There is a dramatic gap between them and the next major element category, the tibia (11%). The third group represents

Table 6. Frequency (NISP) distribution of *Equus caballus* and *Bos Taurus* elements by size from Ljuljaci.

	Size Category						
Element	**Whole**	**≥3/4**	**≥1/2**	**≥1/4**	**<1/4**	**Unknown**	**Total**
Equus caballus							
Unknown	1						1
Carpal	2						2
Cranium					2		2
Femur			1	1	2		4
Humerus				2	4		6
Loose tooth		2		2			4
Mandible						10	10
Metacarpal	2						2
Metapodial				3	1		4
Metatarsal	1			1			2
Phalanx	26	18	2	4			50
Radius				2	3		5
Scapula				2			2
Tarsal	1	2	1	2			6
Tibia			1	4	6		11
Ulna			1				1
Vertebra		1		1	1		3
Total	33	23	6	24	19	10	115
% Total	28.70	20.00	5.22	20.87	16.52	8.70	100.00
Bos taurus							
Carpal	6						6
Cranium						35	35
Femur	0			1	8		9
Humerus			2	8	11		21
Innominate				5	22		27
Loose tooth	14	14	3	4			35
Mandible						24	24
Metacarpal	2	2	2	4	8		18
Metapodial				1	1		2
Metatarsal	2	2	1	13	12		30
Phalanx	24	27	8	10	1		70
Radius			1	7	14		22
Scapula			1	2	1		4
Tarsal	6	6	4	1	1		18
Tibia				3	11		14
Ulna			2	8	6		16
Vertebra		1	1	5	6		13
Total	54	52	25	72	102	59	364
% total	14.84	14.29	6.87	19.78	28.02	16.21	100.00

all the remaining elements. This group forms an almost continuous tail without a break in the distribution, from a high of 8% to almost nil. The more common elements include mandibles (8%), carpals (6%), humeri (5%), and radii (4%).

Is this range of elements unique? When compared to a similarly sized taxon and one clearly used for food consumption, such as cattle, the distribution of element frequencies is not at all similar (Figure 4). Many more cranial, mandibular, distal limb elements and others are present in greater proportions than is found for horses. Attritional processes, such as weathering, would have similarly affected cattle and horses because of the size and density of their bones (cf. Lyman 1994). This would imply that the nature of exploitation of horses was quite different. They were not simply butchered for consumption. Other processes must have been involved.

While attritional processes are often assumed to be the same for similarly sized taxa, this is an assumption that must be demonstrated rather than assumed. A comparison of the distribution of weathered bones by taxon (Table 5) shows that most equid bones are only lightly weathered (74%), followed by medium (25%) and finally heavy weathering (1%). In its generalities, this distribution is similar to those from most of the other taxa from the site. However, it differs in its specifics. The horse has the lowest frequency of lightly weathered and highest frequency of medium weathered remains when compared with all of the identified large and the medium-sized taxa, except sheep. This would indicate that equid remains were more exposed to weathering than the rest of the assemblage, apart from sheep, which would further indicate that their remains were not as quickly buried as other taxa. One possible scenario is that the horse carcasses were simply left out to rot and weather away. In addition, the bones of equids were subjected to other forces of attrition. One fragment was burnt and several other fragments were gnawed by dogs or by pigs.

This unique pattern of element preservation is also apparent in the frequencies of whole bones. A larger than usual number of whole elements was recovered (n=33; 28.7% of NISP, Table 6), including a wide variety of elements (carpals, metapodia, phalanges, and tarsals). Horse distal elements are preserved intact in much greater numbers than in comparably sized animals (e.g. cattle).

The vast majority of whole bones are phalanges (n=26). There is a greater frequency for horse digits than for any other large taxon such as domestic cattle at the site. It may signal either the lack of utilization of such elements for food (marrow is the only real thing of food value

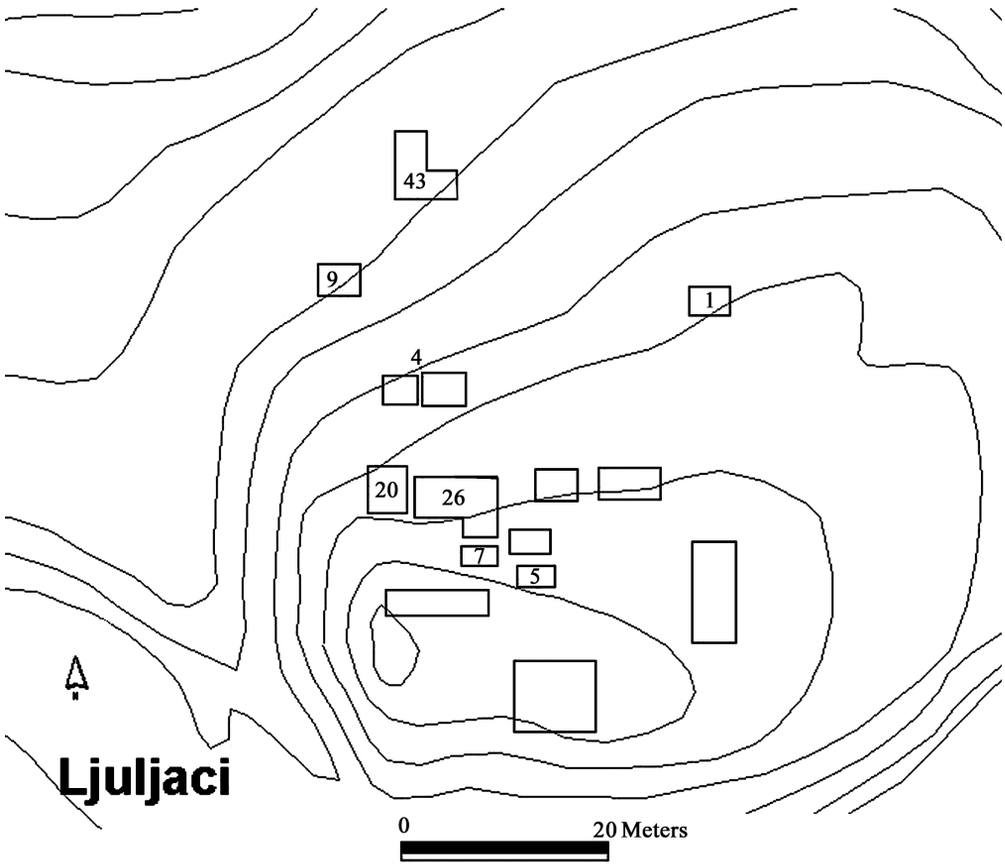

Figure 5. Spatial distribution of equid remains by trench at Ljuljaci..

Table 7. Frequency (NISP) distribution of taxa by trench from Ljuljaci.

Species	6		7		8		9		11		12		13		14		Grand Total
Domestic	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
Bos taurus	13	3.6	107	29.4	84	23.1	0	0.0	13	3.6	60	16.5	36	9.9	51	14.0	364
Canis familiaris	2	7.1	7	25.0	6	21.4		0.0		0.0	1	3.6	9	32.1	3	10.7	28
Capra hircus			1														1
Equus caballus	4	3.5	43	37.4	26	22.6	1	0.9	9	7.8	20	17.4	7	6.1	5	4.3	115
Ovis aries		0.0	1	10.0	3	30.0		0.0		0.0	3	30.0		0.0	3	30.0	10
Ovis/Capra		0.0	12	27.3	9	20.5		0.0		0.0	12	27.3	5	11.4	6	13.6	44
Sus scrofa dom.	8	1.9	95	22.8	122	29.3		0.0	7	1.7	93	22.3	42	10.1	50	12.0	417
Wild																	
Bos primigenius		0.0	7	24.1	8	27.6		0.0	1	3.4	7	24.1	1	3.4	5	17.2	29
Capreolus capreolus	1	6.7	3	20.0	4	26.7		0.0		0.0	2	13.3	2	13.3	3	20.0	15
Castor fiber		0.0	1	50.0		0.0		0.0		0.0		0.0	1	50.0		0.0	2
Cervus elaphus	4	1.6	65	26.1	76	30.5		0.0	11	4.4	38	15.3	31	12.4	24	9.6	249
Lepus europaeus															1		1
Meles meles					4						1		1		3		9
Sus scrofa fer.	30	8.7	61	17.7	88	25.6	2	0.6	5	1.5	82	23.8	41	11.9	35	10.2	344
Unio sp.															1		1
Ursus arctos	1		7		4						3		4		2		21
Grand Total	63	3.8	410	24.8	434	26.3	3	0.2	46	2.8	322	19.5	180	10.9	192	11.6	1650

on the phalanges, apart from tendons) or that the nature of exploitation is different – that they were not used as intensively for food as the other large taxa. One pattern commonly associated with large numbers of whole distal limb bones is hide preparation. The distal limb is cut off and discarded more or less intact without further processing for food preparation.

On the basis of the range of elements and their scattered distribution around the site, it would seem obvious that many of the horse bones represent food remains. The equid bones in general are scattered (Figure 5) and mixed with the remains of all the other more typical food animals found on the site (Table 7). Almost all of the meat-bearing horse bones were broken-up and scattered around the site similar to the distribution of the other meat animals.

Combined epiphyseal and tooth eruption/wear data indicate that most of the specimens belonged to adults (n= 22; 81.5%, see Table 8), in addition to four sub-adults (15%) and only one juvenile (3.7%). When the tooth eruption and wear sample is separately examined, all of the remains came from adults, and all of the adults (except one young adult) came from older individuals (Greenfield 1986a, table 53). This is an age distribution that would imply that horses were exploited largely as adults. Using mortality profiles developed from modern herds (Payne 1973), horses would have been exploited for uses such as traction and transport (Greenfield 1988). It is possible that they were used for milking, since fermented mare's milk is an important resource, even today in the steppes. However, there are so few specimens of horses in the central Balkan sites that it is probably an indication that they were not present in large herds. Hence, it is unlikely that there would have been sufficient numbers of horses to have allowed milk production to become a major food resource.

Few of the bones were measurable (Table 9), but they appear to have been of small stature. A comparison of the horse remains from Ljuljaci and other central Balkan assemblages with those from other Bronze Age sites in the Carpathian Basin indicates that, for the most part, those in this study fall into the smaller end of the size range. Overall horses are not particularly large during the Bronze Age (Bökönyi 1974a, 1978). This is apparent for almost all elements that were measured. In the scapula, Mala Vrbica-Livade is toward the bottom of the scale (Figure 6). In the distribution of humerus distal breadth measurements, the data from Ljuljaci and Novačka Ćuprija cluster toward the bottom of the scale. However, a single humerus specimen from Ljuljaci is in the middle of the range (Figure 7). The measurements of distal breadth of the radii from Ljuljaci and Novačka Ćuprija display a similar pattern (Figure 8). Measurements of the proximal breadth of the metacarpus come from three sites – Novačka Ćuprija, Vinca and Ljuljaci (Figure 9). The data from all three sites fall into the small end of the range. Measurements of the depth of the distal tibia from Ljuljaci indicate the presence of large and small horses at the site (Figure 10). In this case, the large Ljuljaci specimen is almost at the top of the size range for

Table 8. Frequency (NISP) distribution of taxa by age groups from Ljuljaci.

	Age Category															
		Immature	Fetus/ Infant	Infant	Infant/ Juvenile	Juvenile		Juvenile/ Sub-adult		Sub-adult		Sub-adult/ Adult	Adult		Grand Total 1	Grand Total 2*
Taxon	No.	No.	No.	No.	No.	No.	%	No.	%	No.	%	No.	No.	%	No.	No.
Domestic																
Bos taurus	1			1	1	22	17.1	1		19	14.7	234	85	65.9	364	129
Canis familiaris	1									2	9.5	6	19	90.5	28	21
Capra hircus												1		0.0	1	0
Equus caballus	2					1	3.7			4	14.8	86	22	81.5	115	27
Ovis aries	1		3									4	2	40.0	10	5
Ovis/Capra	2				1	5	16.7	3		3	10.0	12	18	60.0	44	30
Sus scrofa dom.	20	1	5	5	3	61	24.7	12		65	26.3	149	96	38.9	417	247
Wild																
Bos primigenius												23	6	100.0	29	6
Capreolus capreolus										1	11.1	6	8	88.9	15	9
Castor fiber												2		0.0	2	0
Cervus elaphus	1					8	5.9			9	6.6	112	119	87.5	249	136
Lepus europaeus										1	100.0			0.0	1	1
Meles meles	3												6	100.0	9	6
Sus scrofa fer.								2	1.2	11	6.8	182	149	92.0	344	162
Ursus arctos										2	15.4	8	11	84.6	21	13

*Percentages are based on the total minus the indeterminate and sub-adult/adult.

Table 9. Measurements of domestic horse bones from central Balkan assemblages.
All measurements are based on von den Driesch (1976), unless otherwise specified, and are in millimeters.

Site	Period	Sector	Sonda/ Pit	Level/Unit	Detailed Provenience	Bone #	Element	Measurements								
								GH	**GB**	**BFd**	**Lmt**					
Ljuljaci	EBA-MBA		7a	3	CM 90E (19/8/76), box 20	25	Astragalus	63	59.1	53.6	64.8					
Ljuljaci	EBA-MBA		14	5	CM 76A and 77A (23/8/77), box 10	43	Astragalus	61.2	64.5	57.7	60.8					
Novacka Cuprija	EBA		5	3		2	Astragalus	58.5		52.4*	59.5					
								GL	**GB**							
Vinca-Belo Brdo	MBA	II	D2	7		7	Calcaneus	113	54.2							
Vinca-Belo Brdo	MBA	II	Pit 20			25	Calcaneus	113	54.3							
								Bd	**BT**	**Greatest depth of distal end**						
Ljuljaci	EBA-MBA		7a	3	CM 90E (19/8/76), box 20	23	Humerus	70.3	69.4							
Ljuljaci	EBA-MBA		7b	4	CM 92E (19/8/76), box 5	6	Humerus		72.7							
Ljuljaci	EBA-MBA		12	7	(25/8/77), box 23	2	Humerus	76	70.8	79.1						
Novacka Cuprija	EBA		23	39		4	Humerus	72*	71*							
								LA	**LAR**	**SH**	**SB**	**LFo**				
Vecina Mala	LBA		1	1		6	Innominate	65.6	58.6	42.9	25.6					
Novacka Cuprija	EBA		25	12		2	Innominate	59	54.3			59*				
Mala Vrbica-Livade	LBA		14	5		1	Innominate	81	60.5							
Mala Vrbica-Livade	LBA		21	3		21	Innominate	66	59							
								GL	**Bp**	**Dp**	**SD**	**DD**	**Bd**	**Dd**		
Vinca-Belo Brdo	MBA	II	B2	5		75	Metacarpus 3		48.5	34.1						
Novacka Cuprija	EBA		23	13		1	Metacarpus 3		47.2	32						
Ljuljaci	EBA-MBA		12	6	Zone 1, CM 55A (/8/77), box 1	33	Metacarpus 3	208	47	31.2	32	20.8	47.4	34.5		
Ljuljaci	EBA-MBA		7	1	CM 16E, 21E & 22E, (10/8/76), box 3	13	Metatarsus 3	253	53.5	46	23.6	26	52.4	34		
Mala Vrbica-Livade	LBA		22	3		4	Metatarsus 3						47.7	43		
								GL	**PL**	**L1**	**BP**	**BFp**	**SD**	**CD**	**Bd**	**BFd**
Ljuljaci	EBA-MBA		7	1	CM 16E, 21E & 22E, (10/8/76), box 3	4	Radius								73.3	
Novacka Cuprija	EBA		41	9		1	Radius								72.2	63.1
Novacka Cuprija	EBA		36	6		1	Radius	280	271.2	270	60*	55.5	30.7	93	55.5	49
								BG								
Mala Vrbica-Livade	LBA		9	0		27	Scapula	44.7								
								Bd	**Dd**							
Ljuljaci	EBA-MBA		7b	4	CM 92E (19/8/76), box 5	15	Tibia		40.7							
Ljuljaci	EBA-MBA		12	4	Zone 1, CM 25A, 29A, (18/8/77), box 6, 8	30	Tibia	80.9	49.2							
								DPA	**BPC**							
Ljuljaci	EBA-MBA		7a	3	CM 90E (19/8/76), box 20	1	Ulna	66.3	53.7							

*Measurement estimated.

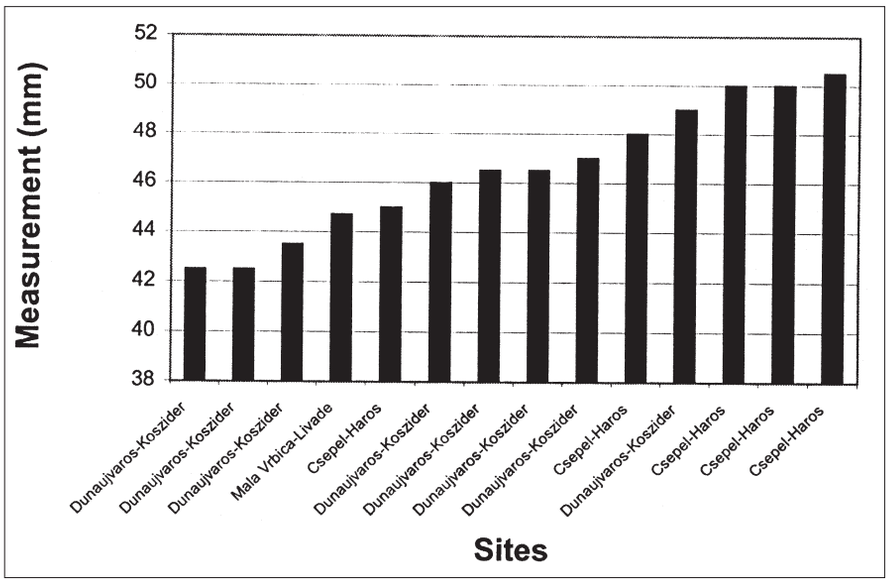

Figure 6. Histogram comparing the distribution of measurements of domestic horses from Bronze Age sites in the Carpathian Basin - breadth of the glenoid fossa of the scapula (Bökönyi 1974a; Greenfield 1986a, b, c, n.d.).

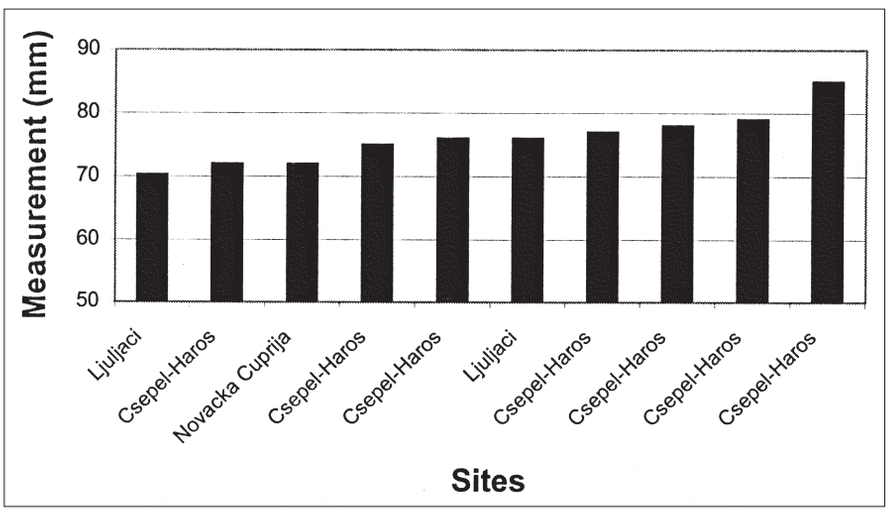

Figure 7. Histogram comparing the distribution of measurements of domestic horses from Ljuljaci and other Bronze Age sites in the Carpathian Basin - breadth (BT) of the distal humerus (Bökönyi 1974a; Greenfield 1986a, b, c, n.d.).

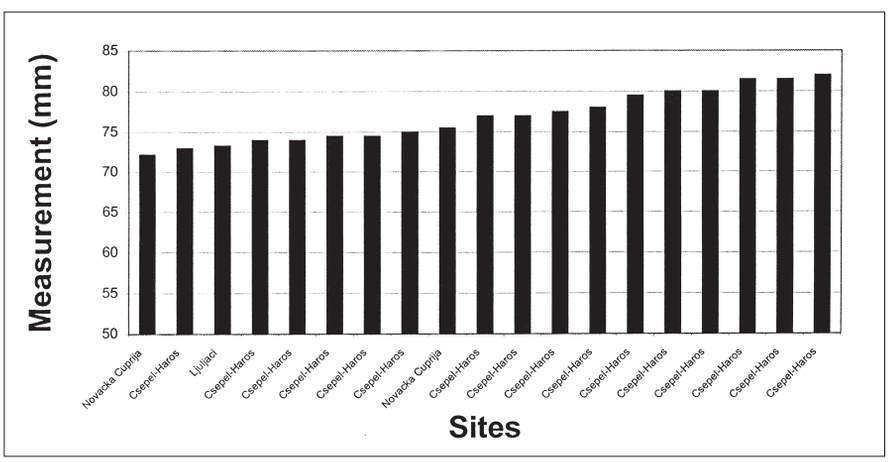

Figure 8. Histogram comparing the distribution of measurements of domestic horses from Ljuljaci and other Bronze Age sites in the Carpathian Basin - breadth of the distal radius (Bökönyi 1974a; Greenfield 1986a, b, c, n.d.).

horses from the entire region. The size range for horses is remarkably consistent throughout the central Balkans: small- to medium-sized animals dominate, with an occasional large-sized horse. The data from the widely separated sites consistently cluster together and do not show any temporal trends. Given that horses are only slightly sexually dimorphic and the fact that most sites only have the smaller size range, it is more likely that more than one breed might be present at Ljuljaci – a large and small form. It is unlikely that the other sites had only female horses present, while the consistent division of the Ljuljaci data would indicate the presence of both male and female horses at the site.

The equid bones were scattered across much of the site at Ljuljaci, but most were found in three trenches, 7, 8 and 12 (Table 4). These trenches are associated with houses in the center and at the northern edge of the site. Is it possible to interpret these distribution patterns in terms of ancient behavior? Unfortunately, it does not appear to be the case for several reasons. First, none of the data can be directly associated with a particular house, given the limited provenance information that was available during analysis (Greenfield 1986a, appendix C). This may not be such a problem considering the residential stability at the site. Houses appear to be rebuilt over and over again, one above the other (Bogdanović 1986). As a result, areas of occupation appear to have retained their function over time. Second, and more importantly, the variation in frequencies of equid bones in each trench correlates with other major taxa. For example, the frequency of equid bones rises and falls in particular trenches at similar rates to those from other large taxa (e.g. domestic cattle and wild pigs, see Figures 11 and 12). As a result, these data can be interpreted either as meaning that the occupants of the houses associated with faunal

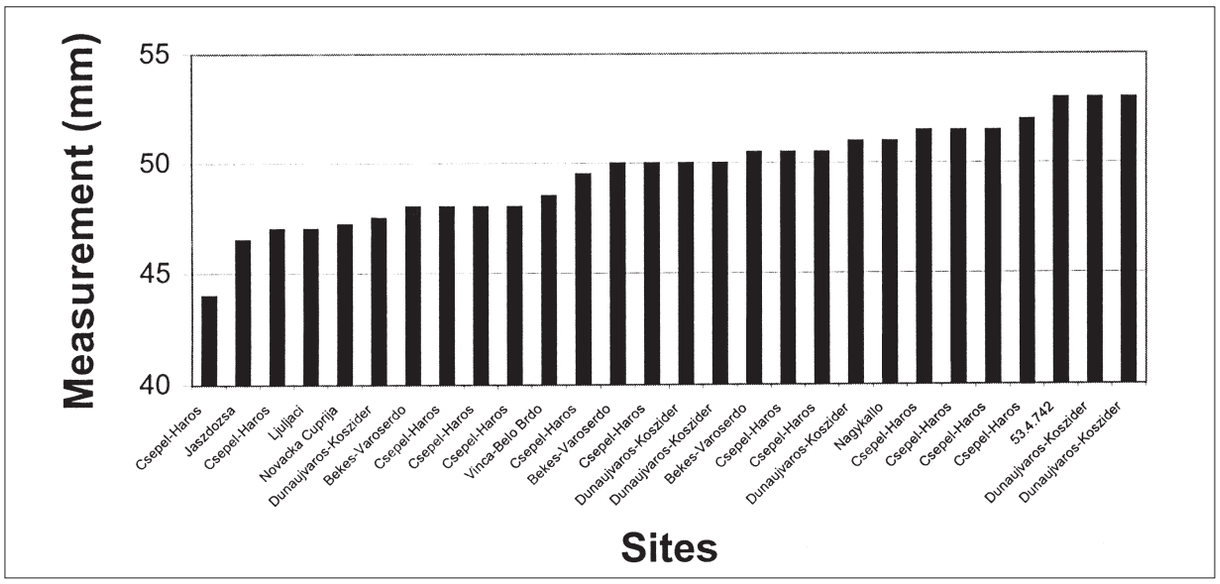

Figure 9. Histogram comparing the distribution of measurements of domestic horses from Ljuljaci and other Bronze Age sites in the Carpathian Basin - breadth of the proximal metacarpus (Bökönyi 1974a; Greenfield 1986a, b, c, n.d.).

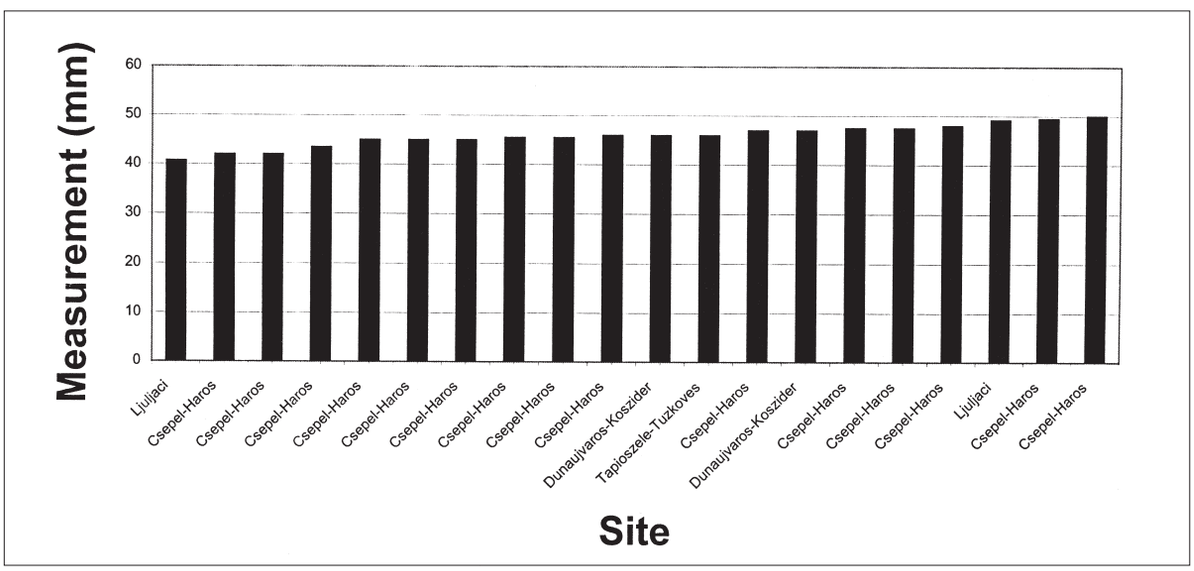

Figure 10. Histogram comparing the distribution of measurements of domestic horses from Ljuljaci and other Bronze Age sites in the Carpathian Basin - depth of the distal tibia (Bökönyi 1974a; Greenfield 1986a, b, c, n.d.).

remains from these trenches ate proportionately more large-sized animals than in the surrounding houses, or that the large bone concentrations are because these areas were in fact middens. The latter option is more likely to be the case since almost all taxa follow this pattern. In either case, the pattern indicates that horse remains cannot be preferentially associated with one or more parts of the site, and by implication with areas with differential status.

Why were equid remains disposed of in an unusual manner on the site? The data show that they were more exposed to weathering, have more whole bones, tend to be older adults, etc. This can be taken to indicate that equids were exploited, but not primarily as a food animal. Even if they were not used as intensively for food, there is no evidence that their remains were venerated and purposely buried. They were for the most part disarticulated and scattered with the remains of other animals in dense middens.

The prevalence of whole distal limb bones is often used as evidence for "schlepping" (Perkins and Daly 1968), differential attrition by natural processes, such as erosion (Lyman 1994), and other phenomena. There is no evidence for a "schlepp" effect – the transport of horse carcasses from distant kill sites. All parts of the horse skeleton are present in the site.

Roles of Horses in Central Balkans

The major roles of early domestic horses in the Balkans may have been for transportation and traction. The age distribution of horse remains at all sites is heavily

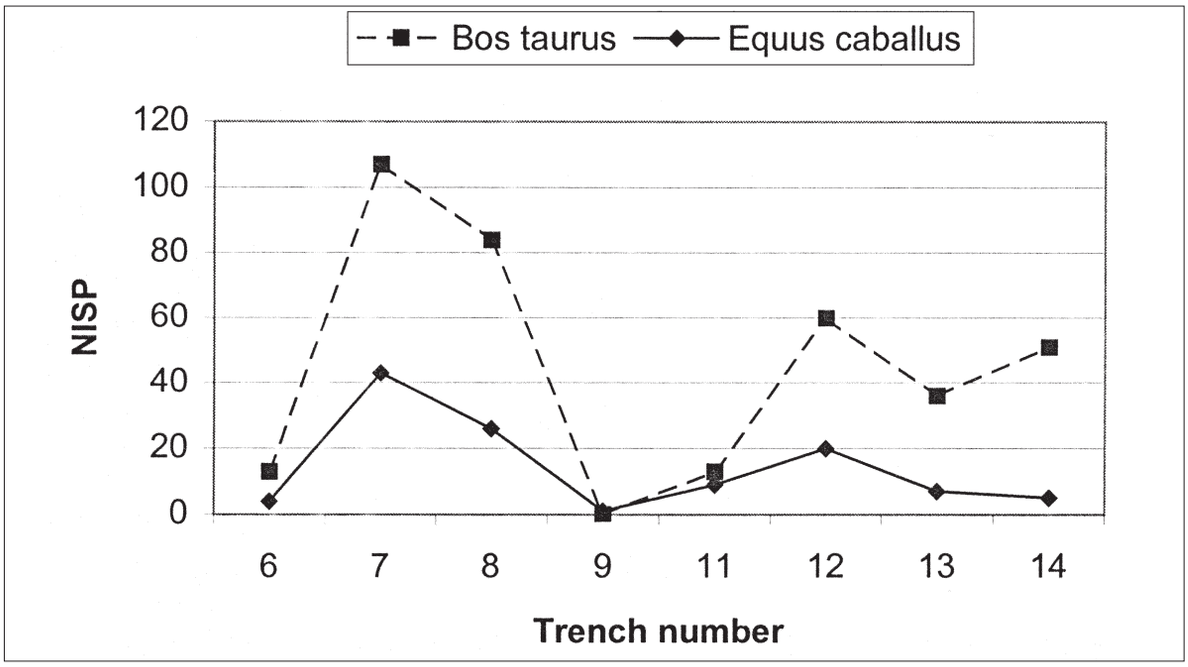

Figure 11. Frequency distribution (NISP) of domestic cattle and horses by trench at Ljuljaci.

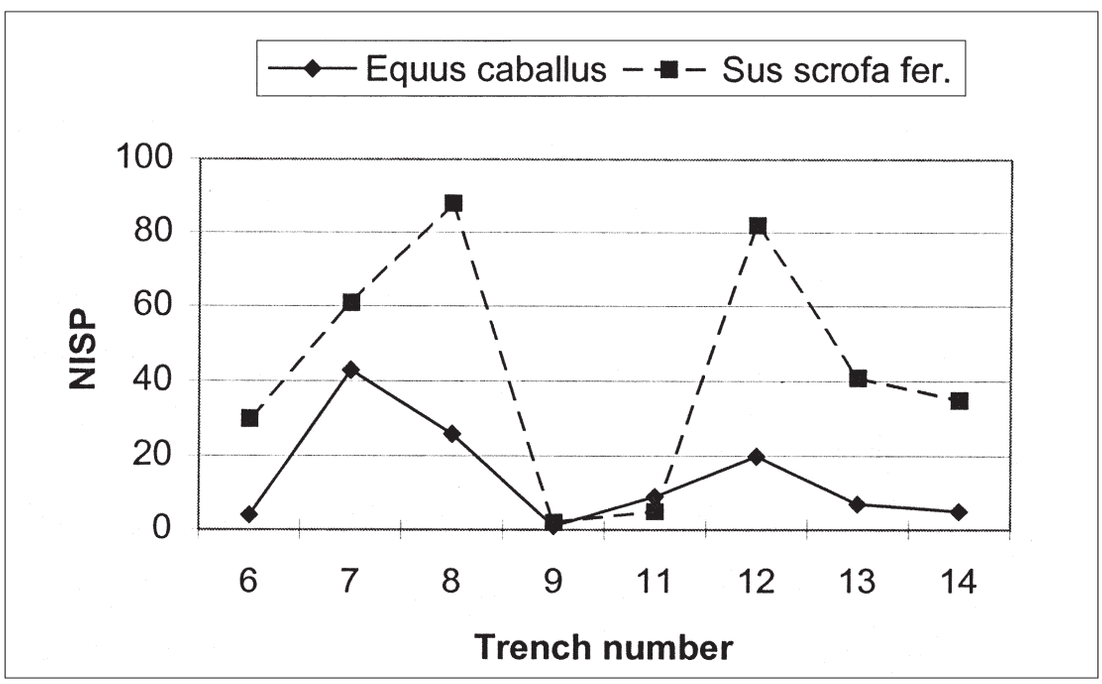

Figure 12. Frequency distribution (NISP) of domestic horses and wild pigs by trench at Ljuljaci.

dominated by adults. Occasionally a few sub-adults and even less commonly a juvenile or two are also found. Such an age distribution would have been unlikely if they were being raised as a food resource, where it is expected that larger proportions of younger animals would be slaughtered if the stock breeders were emphasizing meat production (Payne 1973; Greenfield 1988; Munson 2000). Instead, an age distribution where juveniles and sub-adults represent a miniscule proportion of the remains is in accordance with expectations for their use for traction and transportation. These frequencies are similar to those for the "wool" herd production profile for sheep (Payne 1973; Greenfield 1988). The abysmally low frequencies for immature animals in central Balkan assemblages can be somewhat corrected for by attrition indices suggested by Munson (2000). However, the application of such indices would only increase the proportion of juvenile and subadult individuals to the levels already predicted for a "transport and traction" mortality profile proposed for cattle (Greenfield 1988). The appearance of wheeled vehicles, plows and horse "bits" in the archaeological record of Eastern and Central Europe (Anthony and Brown 1991; Anthony *et al.* 1991; Piggott 1981; Sherratt 1980) and during the Eneolithic and Bronze lends credence to this hypothesis.

It is difficult to directly correlate the age distribution in the central Balkan samples with those from other studies in Eastern Europe (e.g. Levine 1990) because I did not code for tooth wear and eruption in my samples. The reason was that there were so few teeth found intact within mandibles that I had to rely upon more traditional bone epiphyseal fusion in order to age the horse remains. As a result, the age distribution from central Balkan sites is similar to those from the early domestic horse sites in the Ukraine, such as Dereivka, where horses were clearly exploited as a meat resource (Levine 1990). The difference is that there is no wild population of horses that can be exploited in the central Balkans and all of the horses belong to domesticated animals.

Ljuljaci as a High Status Settlement

The Nature of Elite Settlement Sites – How to Define Them

What are the signs that Ljuljaci is a high status or elite settlement? Archaeologists commonly use a number of indicators in order to identify high versus low status sites in a settlement system (Renfrew and Bahn 1991; Webster *et al.* 1997).

1 Settlement location – where settlements are removed from the normal distribution (often on heights overlooking regions);
2. Settlement type – where settlements have distinguishing architectural features, such as some kind of natural or humanly made fortification;
3. Artifactual inventory – where differential access to goods and services is often used to distinguish elites in the archaeological record.

A. Trade goods – where the presence of non-local goods can be interpreted as an indicator of the presence of local elites in incipient stratified societies.
B. Valuable local goods – where locally available but valuable and rare goods are differentially available (e.g. metallurgy – through cut mark analysis).

4. Subsistence economy – where there is differential utilization of food resources that is not a function of local availability; elites may eat differently and there should be a special type of food residue (Chaplin 1971).

As will be shown below, Ljuljaci is anomalous in many respects from the surrounding sites. Its assemblage, location, and type of site all allow one to argue that it is a high status settlement.

Gradina

During the Eneolithic and Bronze Age, a new type of site appears in the archaeological record – hilltop and often, fortified settlements (called *gradina* in Serbian). Ljuljaci is a classic example of a *gradina*. It is located on a relatively flat hilltop, with limited access and was probably surrounded by a palisade. Usually only one such site is occupied in each valley system (Greenfield 2001).

Ljuljaci seems to have been a much more intensively and organized community than would be expected by comparison with other contemporaneous sites. Several houses are occupied in each phase of the community and houses are rebuilt in the same locations. The houses are arranged in rows across the site and are separated by open spaces. Other sites lend the impression of single or at most a few households inhabiting the locality at any one time, with few if any differences among them (Bankoff and Greenfield 1984; 1986a).

There does not appear to be any substantial difference in remains among houses (Bogdanović 1986). Therefore, it is impossible to distinguish structures on the basis of function or status of the occupants at Ljuljaci.

Evidence for Metallurgy

Differential access to valuable goods is often considered to be a hallmark of high status or elite settlements. The only evidence for early metals, found on the site, was limited to two bronze daggers (Bogdanović 1986). This is a common situation on sites from this region and period probably due to the rapid weathering of metals in this region.

My research in recent years on the origins of metallurgy can be used to investigate this hypothesis from a different direction. I (Greenfield 1999, 2000a, 2000b, 2002a, 2002b) attempted to identify the transition from a stone to a metallurgical technology in the subsistence economy of the region through the analysis of butchering cut marks on animal bones. A series of tests were conducted to determine if it was possible to systematically distinguish between stone and metal cut marks. The results were then applied to two prehistoric sites from the central Balkans (Petnica and Ljuljaci) in order to monitor the origins of metallurgy in a region.

The differential access to valuable and rare goods can be summarized as follows. The incidence of metal cutting implements was minimal prior to the Bronze Age. They were present in the later Neolithic, but in such small quantities that they can probably be attributed to the occasional drift downwards of material into lower stratigraphic levels or misidentification of the type of cutting instrument. Metal cut marks began to appear in some quantity at the end of the Neolithic (D culture, 4000-3300 BC, calibrated). This is the period of earliest metallurgy in the Balkans. Large copper veins were mined in nearby eastern Serbia and metal axes and other implements appeared in sites throughout the region. During the Eneolithic, the frequencies of metal tools remained low (13%). The numbers of metal cut marks increases slowly during the Early Bronze Age (2800-2100 BC), but more dramatically during the Middle Bronze Age (2100-1600 BC). Bronze tools become more effective for butchering from later in the Early Bronze Age (and particularly from the Middle Bronze Age), coinciding with the widespread adoption of high tin-

bronze tools (Branigan 1974; Coles and Harding 1979: Tylecote 1992). Ljuljaci overlaps the end of the Early and first half of the Middle Bronze Age.

During the Bronze Age, there is a difference in proportions between high and low status sites. In high status sites, the incidence of bronze cutting tools is dramatically higher (84%) than in lower status sites (41%). This can be seen by a comparison of the data from Ljuljaci and Petnica. At Early-Middle Bronze Age Ljuljaci, metal cut marks dramatically increase in frequency over that of previous periods (84% of cut marks). At Late Bronze Age Petnica, the number of metal cut marks at Petnica is half of that found at E-MBA Ljuljaci (41%) (Greenfield 2002b, table 4). Stone tools remain important at Petnica even though high tin-bronze knives are typical of this period and are effective cutting tools. The difference in the proportion of cut marks between the two sites is probably a function of their relative position within the regional settlement system. Ljuljaci is a regional center, with dramatic evidence for high status residences. Petnica is a small, undistinguished farming settlement. Therefore, it is not surprising that access to high tin-bronze metal cutting implements was greater and earlier at Ljuljaci than at Petnica.

Trophy Hunting

At Ljuljaci, an unusual number of large trophy type wild species was hunted. At most Bronze Age sites, the frequency of aurochs, red deer, and wild pigs tends to be relatively low. They are all present in higher than usual frequencies at Ljuljaci. In particular, the remains of wild pigs are found in high frequencies (21.4%). In fact, it is the most numerous wild animal species found on the site. This observation is made even more interesting because of the unusual concentration of boar remains found in Sonda 12, *otkop sloj* (excavation levels) 2-7. Mandibles of 29 older wild males were clustered around a single structure (Figure 13). All the mandibles were broken in the same way (behind the canine or P_1), are of approximately the same age and size, and are not associated with many other possibly articulating elements. This part of the body was largely limited to this area of the site. The same activity was conducted in the same location at the site over its entire life span since the concentration was found repeatedly in each excavation unit. Only a few bones from both domestic and wild pigs were found in the same units.

This is the only case for the region where such an unusual concentration of wild boar remains was found when the site is compared to similar deposits in other neighboring and contemporaneous localities. Some explanations for this that could be posed include:

1. Stock breeding. A selective age and sex profile may indicate attempts to limit genetic contamination or disruption of domestic herds and crops by the removal of wild males in the neighborhood (e.g. Halpern 1967; 1999);
2. Period "ritual" slaughter. In the ethnographic and historical record, one finds examples where the forests are periodically "cleansed" of wild boars as part of the cycle of "ritual" activities (Rappaport 1967; Homer – Odyssey); and
3. Idiosyncratic modes of behavior. This might include the collection of trophies by Bronze Age elite's. In the Aegean, hunters would preferentially hunt fierce wild animals, such as boars, and decorate their armor with their remains (e.g. tusks - Snodgrass 1984).

Figure 13. Photograph of wild pig mandibles from Ljuljaci.

If the first option (stockbreeding) were likely, this pattern would expect to be found elsewhere in the region. However, it is not. The same could be said of option 2 (periodic slaughter). However, the dearth of female wild mandibles from this site may indicate that both options 1 and 2 are unlikely since females are likely to be killed as well. Option 3 (trophy collecting by high status individuals) may be the best explanation for this regionally anomalous pattern. All of the mandibles were associated with a single structure (in Trench 12) and are the largest individuals in the sample.

Part of the role that the elite played in these societies may have involved exclusive rights to the hunting of certain species, such as boar. This is not unlike the situation existing in Medieval Europe. Such species were very dangerous. A successful hunt may have been a sign of exceptional prowess. The unusual deposit of boar mandibles at Ljuljaci may simply be the archaeological manifestation of such displays in prowess.

Presence of Horses

Ljuljaci is distinguished from other contemporaneous sites by the frequencies of domestic horse remains. It has substantially greater frequencies and diversity of horse remains than found elsewhere. Ljuljaci produced an exceptionally large number of horse bones (about 8% of the NISP of the faunal assemblage). While the remains of horses became a common feature of the zooarchaeological record in settlement sites, their frequencies remained exceptionally low and numerically insignificant overall. All of the other sites, including the later ones, yielded values of 4% or less. Also, only at Ljuljaci is there any evidence that some settlements had a superior role to play in the regional settlement system.

Conclusions

With the advent of the post-Neolithic (Eneolithic and Bronze Age), only a single new species makes its appearance in the faunal record – the domestic horse. It represented a new feature on the domestic landscape and helped to revolutionize society by making communication, transportation and warfare more efficient. Horse remains are found in very low frequencies at most sites. However, at a few sites, especially those considered regional centers, horses are found in higher numbers.

Ljuljaci is one of the few settlement sites from the earlier half of the Bronze Age where substantial architectural remains have survived and a large animal bone assemblage has been collected. It is relatively unique in comparison to sites in the surrounding region in terms of its location, nature of settlement, and assemblage. It is a fortified hilltop settlement, with evidence for organized activities. The occupants had access to valuable goods, such as metallurgy, at higher rates than surrounding settlements. The special nature of Ljuljaci is emphasized by the faunal remains, as well – the exceptionally numerous horse and wild boar bones found at the site. These qualities are not found in similar quantities anywhere else in the study region.

The implications of these finds are clear. Early domestic horses in the central Balkans are preferentially associated with elite settlements. This is not surprising considering the evidence in the historical sources from the Aegean, such as the Iliad (Clutton-Brock 2003). Few individuals would have access to horses. Part of the role that elites played in these societies may have involved control over modes of transportation, such as horse herds and carts. Both are expensive to acquire and maintain.

The appearance of domestic horses after the termination of the Late Neolithic implies that their diffusion through the region and acceptance as a new mode of traction and transportation were both causes and consequences of the changes in post-Neolithic society, subsistence and settlement. The appearance of Garašanin 1973 leads one to wonder about the relationship between them (cf. Bökönyi 1978). While the tumuli may represent the funerary remains of an emerging elite, few tumuli have produced horse skeletons. In comparison to mortuary rituals in later periods, the Bronze Age horses would appear to be too expensive to slaughter as part of the funerary ritual.

Acknowledgments

This paper is the result of my lengthy research on the paleoeconomy of the central Balkans, beginning in 1977. As a result, it is impossible to acknowledge all of the sources for my funding over the years, but they include the Fulbright-Hays Fellowship, International Research and Exchanges Board, U.S. National Science Foundation, Social Science and Humanities Research Council of Canada, Universities of Belgrade and Manitoba, Indiana University, and the Wenner-Gren Foundation for Anthropological Research. The field work to collect the data from Ljuljaci was conducted in 1982 with the gracious efforts of the late Dr. Sándor Bökönyi, the late Prof. Dr. Dragoslav, Prof. Dr. Milutin Garašanin, Dr. Milenko Bogdanović, Vesna Jeremenko, and the many other friends and colleagues too numerous to mention in old Yugoslavia. Finally, without the support of my family, I would never have been able to bring this paper to fruition. Any errors, however, remain my own fault.

References Cited

Anthony, David W. and Dorcas Brown
1991 The Origins of Horseback Riding. *Antiquity* 65: 22-38.

Anthony, David W., Dimitri Telegin and Dorcas Brown
1991 The Origins of Horseback Riding. *Scientific American* 265:94-100.

Bankoff, H. Arthur and Haskel J. Greenfield
1984 Cultural and Ecological Change during the Later Prehistory of Southeastern Europe. *Balcanica* (Institute of Balkan Studies, Belgrade) 15:7-31.

Bankoff, H. Arthur, F. A. Winter and Haskel J. Greenfield
1980 Archaeological Survey in the Lower Morava Valley. *Current Anthropology* 21 (2):268-269.

Bibikova, V. I.
1967 K isucheniyu drevneishih domashnih loshadei. *Bjulleten' Moskovskogo Obscestva Ispytatelej Prirody.* Otdel Biologiceskij 72(3):106-118.
1975 Formen der Viehzucht bei den äneolithischen Stämmen stüdosteuropas. In *Moderne Probleme der Archäologie VII. Tagung der Fachgruppe Ur- und Frühgeschichte vom 10. bis 12. Mai 1973 in Dresden*, edited by K.-H Otto and H.-J. Brachmann, pp. 237-245. Akademie-Verlag, Berlin.

Bogdanović, Milenko
1986 *Ljuljaci. Naselje Protovatinske I Vatinske Kulture*. Narodni Muzej, Kragujevac, Serbia.

Bökönyi, Sandor
1974a *History of Domestic Mammals in Central and Eastern Europe*. Akademiai Kiado, Budapest.
1974b The Vertebrate Fauna. In *Obre I and II. Neolithic Sites in Bosnia*, edited by Marija Gimbutas, pp. 55-154. Wissenschaftliche Mitteilungen des Bosnisch-Herzegowinischen Landesmuseum (Arheologie 3, part B), Sarajevo.
1978 The Earliest Waves of Domestic Horses in East Europe. *Journal of Indo-European Studies* 6(1-2):17-78.
1988 The Neolithic Fauna of Divostin. In *Divostin and the Neolithic of Central Serbia,* edited by Alan McPherron and S.D. Dragoslav, pp. 419-446. University of Pittsburgh, Ethnology Monographs No. 10.

Branigan, Keith
1974 *Aegean Metalwork of the Early and Middle Bronze Age*. Clarendon Press, Oxford.

Chaplin, R. E.
1971 *The Study of Animal Bones from Archaeological Sites.* Seminar Press, New York, NY.

Clutton-Brock, J.
2003 Horses in History. In *Horses through Time,* edited by Sandra L. Olsen. Roberts Rinehart Publishing, Lanham, MD.

Coles, John M. and Anthony F. Harding
1979 *The Bronze Age in Europe.* St. Martins Press, New York, NY.

Dragoslav, S.
1965 Milica Gradina, Ljuljaci, Kragujevac. *Arheološki Pregled* 7:54-55.

Ecsedy, Istvan.
1979 *The People of the Pit - Grave Kurgans in Eastern Hungary.* Akadémiai Kiadó, Budapest.

Ehrich, Robert and H. Arthur Bankoff
1991 East-Central Europe. In *Chronologies in Old World Archaeology*, Vol. 1, edited by Robert Ehrich, pp. 375-394. 3rd edition. University of Chicago Press, Chicago, IL.

Garašanin, Milutin
1972 *The Bronze Age of Serbia.* National Museum, Belgrade.
1973 *Praistorija na Tlu SR Srbije.* Srbska Knjuževna Zadruga, Belgrade, second edition.
1983 The Bronze Age in the Central Balkans. In *The Cambridge Ancient History,* Vol. 3, part 1, pp. 163-186. Cambridge University Press, Cambridge.

Govedarica, Blagoje
1982 Neue Aspekte zu Erforschung von Fundplatzen des Typs Gradina im Nordwesten Balkans. *Acta Archaeologica Carpethica* 23:4-27.

Greenfield, Haskel J.
1986a *The Paleoeconomy of the Central Balkans (Serbia): A Zooarchaeological Perspective on the Late Neolithic and Bronze Age (ca. 4500-1000 BC)*. BAR International Series 304, Volumes 1 and 2, Oxford.
1986b Fauna: Kičmenjaci. In *Ljuljaci: Naselje Protovatinske I Vatinske Kulture,* edited by Milenko Bogdanović, pp. 75-78. Narodni Muzej, Kragujevac, Yugoslavia.
1986c Eneolithic-Late Bronze Age. *Zbornik Radova Narodnog Muzeja* 12:63-74.
1988 The Origins of Milk and Wool Production in the Old World: A Zooarchaeological Perspective from the Central Balkans. *Current Anthropology* 29:573-593.
1995 Sarina Medja, Vrbica, and Vecina Mala: The Zooarchaeology of Three Late Bronze Age/Early Iron Age Transition Localities Near Jagodina, Serbia. *Starinar:* new series 45-46:133-142.
1999 The Origins of Metallurgy: Distinguishing Stone from Metal Cut Marks on Bones from Archaeological Sites. *Journal of Archaeological Science* 26:797-808.
2000a Monitoring the Origins of Metallurgy: An Application of Cut Mark Analysis on Animal Bones from the Central Balkans. *Environmental Archaeology* 5:119-132.
2000b Animal Bone Fragmentation and the Origins of Metallurgy in the Central Balkans. In *Technology, Style and Society. Contributions to the Innovations Between the Alps and the Black Sea in Prehistory*, edited by Lolita Nikolova, pp. 93-96. BAR International Series 854, Oxford.
2001 The Early Bronze Age of Central Europe. In *The Encyclopedia of Prehistory: Human Area Relations Files*, edited by Peter Peregrine and Melvin Ember, pp. 139-156. Kluwer Academic/Plenum Publishers, New York, NY.
2002a Distinguishing Metal (Steel and Low-tin Bronze) from Stone (Flint and Obsidian) Tool Cut Marks on Bone: An Experimental Approach. In *Experimental Archaeology*, *Replicting Past Objects, Behaviors, and Processes*, edited by

James Mathieu, pp. 35-54. BAR International Series 1035, Oxford.

2002b Origins of Metallurgy: A Zooarchaeological Perspective from the Central Balkans. In *Eureka: The Archaeology of Innovation. Proceedings of the 27th Annual Chacmool Conference*, edited by R. Harrison, M. Gillespie, and M. Peuramaki-Brown, pp. 430-448. The Archaeological Association of the University of Calgary, Calgary.

2005 A Reconsideration of the Secondary Products Revolution: 20 Years of Research in the Central Balkans. In *The Zooarachaeology of Milk and Fats (Proceedings of the 9th ICAZ Conference, Durham 2002)*, edited by Jacqui Mulville and Alan Outram, pp. 14-31. Oxbow Press, Oxford.

no date Report on the Vertebrate Fauna from the 1982 Excavations at -Belo Brdo. Manuscript on file at the University of Manitoba, Winnipeg, Manitoba.

Halpern, Joel

1967 *A Serbian Village*. 2nd edition. Columbia University Press, New York, NY.

1999 The Ecological Transformation of a Resettled Area: Pig Herders to Settlement Farmers in Central Serbia (Šumadija, Yugoslavia). In *Transhumant Pastoralism in Southern Europe: Recent Perspectives from Archaeology, History, and Ethnography*, edited by László Bartosiewicz and Haskel Greenfield, pp. 79-98. Archaeolingua Publishers, Series Minor 11, Budapest.

Levine, Marsha

1990 Dereivka and the Problem of Horse Domestication. *Antiquity* 64:727-740.

Lyman, R. Lee

1994 *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.

Munson, Patrick

2000 Age-correlated Differential Destruction of Bones and Its Effect on Archaeological Mortality Profiles of Domestic Sheep and Goat. *Journal of Archaeological Science* 27: 391-407.

Olsen, Sandra

2000 The Exploitation of Horses at Botai, Kazakhstan. In *Prehistoric Steppe Adaptation and the Horse,* edited by M. Levine, C. Renfrew, and K. Boyle, pp. 83-103. McDonald Institute Monographs, Cambridge.

Payne, Sebastian

1973 Kill-Off Patterns in Sheep and Goats: The Mandibles from Aşvan Kale. *Anatolian Studies* 23:281-303.

Perkins, Dexter, Jr. and Patricia Daly

1968 A Hunters' Village in Neolithic Turkey. *Scientific American* 219 (5):96-106.

Piggott, S.

1981 *The Earliest Wheeled Transport: From the Atlantic Coast to the Caspian Sea*. Cornell University Press, Ithaca, New York.

Rappaport, Roy A.

1967 *Pigs for the Ancestors.* Yale University Press, New Haven. CT.

Renfrew, Colin and Paul Bahn

1991 *Archaeology: Theories, Methods and Practice*. Thames and Hudson, London.

Sherratt, Andrew

1980 Plow and Pastoralism: Aspects of the Secondary Products Revolution. In *Patterns of the Past*, edited by Ian Hodder, Norman Hammond, and Glynn Isaac, pp. 261-305. Cambridge University Press, Cambridge.

Snodgrass, A. M.

1984 *Wehr und Waffen im Antiken Griechenland (Arms and Armour in Ancient Greece)*. Zabern Kulturgeschichte der Antiken Welt, Band 20. Verlag Philipp von Zabern, Mainz am Rhein.

Tylecote, R. F.

1992 *A History of Metallurgy*. 2nd edition. The Institute of Metals, London.

von den Driesch, Angela

1976 *Bone Measurement for Archaeologists*, Peabody Museum, Bulletin No. 1. Harvard University, Cambridge, MA.

Vörös, Istvan

1981 Wild Equids from the Early Holocene in the Carpathian Basin. *Folia Archaeologia* 32:37-63.

Webster, David L., Susan Toby Evans, and William T. Sanders

1997 *Out of the Past: An Introduction to Archaeology.* Mayfield Publishing Company, London.