Universitat Rovira i Virgili
Departament d'Història i Història de l'Art
Màster en Arqueologia del Quaternari i Evolució Humana

International Erasmus Mundus Master in

QUATERNARY AND PREHISTORY

Middle Palaeolithic avifaunal remains from Crvena Stijena, Montenegro, Balkan Peninsula

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Academic year 2022/2023

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisors, Juanma and Carmen, for unselfish support and patience during this challenging journey.

Thanks also to Marta Arzarello and Carlos Lorenzo for assistance and advices from the beginning of my admission to this Master, to Chafika Falgueres and David Pleaurdeau for help during my stay in Paris. To all professors from all four institutions - it was an honor to participate in Your classes!

I would like to express my gratitude to my dearest professors Katarina and Draženko from the department of Geology and Paleontology in Belgrade for always being there for me.

Not to forget the amazing people from the Crvena Stijena project - Gilliane, Gill, Eugene, Goran and Baki for letting me be part of their wonderful team. Thank you for the given material and the opportunity to work with it for this thesis.

Thanks to the people who made this journey unforgettable and unique - Victor, Andres, Dani, Alex, Riccardo, Olu and Tamo. Thank you for being and staying friends I could only wish for! And to my friends from Serbia and Montenegro (who were supporting me from 1.615 kilometers away) I would like to say: Hvala ljudi!

Enormous gratitude I owe to my family… Dear mama, tata, ujo - thank you for believing in me and supporting me unconditionally. And last but not the least, to my sister - love you to the moon and back!

Thanks to the Erasmus Mundus project for giving me the opportunity to enroll in this Master program and make all remarkable memories.

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ABSTRACT

Key words: Birds, Avifauna, Palaeolithic, Crvena Stijena

Crvena Stijena site is located near the village Petrovići in Eastern Montenegro. Its 20-meter deep sequence of archaeological deposits spans the Middle Paleolithic through the Bronze Age. The Middle Paleolithic deposits themselves contain one of the longest records of Neanderthal occupation in the region. Avian remains from the deposits of the site have been studied. The inspected material comes from the samples collected in the field during the previous years of research (2019 -2021). Studies have been conducted on bird samples and in this work we provide new data on the bird remains.

1. INTRODUCTION AND MAIN OBJECTIVES

This work corresponds to the written part of the Final Master's Project of the Master's Degree in Quaternary Archaeology and Human Evolution (Erasmus Mundus). With this writing it is intended to obtain for the 36 credits offered by the Universitat Rovira i Virgili.

This work contains six chapters. In this part of the work will be presented the construction of the work.

Beginning with the State of Art, the second chapter includes a short introduction to the Quaternary period, why this period is so important and what is the main goal of this work.

Short summary of Class Aves starts at the beginning of the third chapter, explaining how birds evolved, what are the main characteristics of bird's anatomy and why their remains in the Quaternary deposits are so significant.

In the fourth chapter Crvena Stijena site is described. Geographical position, history of the investigations, stratigraphy, and summary of archaeological remains of Crvena Stijena are given. In order to provide a wider picture of the Palaeolithic period in the immediate environment of the site, this chapter contains descriptions of a few important sites from Montenegro, Serbia and Croatia.

Chapter number five is presenting material, methods and results that have been used for analyzing the avifaunal material of Crvena Stijena. Explanations of bird anatomy and Systematic Palaeontology are given.

Conclusion of the studies is written in chapter number six, together with the future perspectives.

2. STATE OF ART

The Quaternary is the youngest geological period in the Earth's history. As the most recent period it spans over the last 2.6 million years of a geological time. This geological period includes two epochs the Pleistocene (that started 2.6 mya and finished approximately 11700 ya - often considered to be synonymous with the 'Ice Age') and Holocene (that lasts over the last 11700 ya through the present, with more stable and warmer climate). The main changes in the dynamic of physical and biological processes make this period in the development of our planet – climate to be mainly characterized by a strong instability which had a major effect on the boundaries of the coast lines together with the boundaries of the lakes and the sea. Flora and fauna were migrating, constantly moving glaciers started with taking over a bigger space... (Bogićević and Nenadić, 2010).

Indeed, for much of the Quaternary, the land surface of our planet has been covered by greatly expanded ice sheets and glaciers, and temperatures during these glacial periods were significantly lower than those of the present. But the Quaternary has also seen episodes, albeit much shorter in duration, of markedly warmer conditions – known as interglacials (Walker, 1947; Bogićević and Nenadić, 2010). However, rather than being a period of unremitting cold, the hallmark of the Quaternary is the repeated oscillation of the earth's global climate system between glacial and interglacial states (Walker, 1947). The end of the last glaciation is marked with the boundary between the Pleistocene and Holocene (Lang and Wolff, 2011).

With cold and warm cycles, climate oscillations caused significant changes within the ecosystem (Bogicevic and Nenadic, 2010). These changes are a direct consequence of the change in the balance of insolation and radiation, i.e., the amount of heat that the Earth receives and the heat that is released. The flora and fauna, reacting to these changes, changed their habitats and depending on the obstacles of a physical-biological nature, survived, or disappeared in the newly created systems. During the Quaternary human evolution continued developing together with our prehistory and history, and the so called ''new quality'' that manifested itself during this geological period is certainly the emergence of modern humans and their community as the first biofacies system that has become a very powerful geological and geomorphological factor, originating from a very primitive population. In just a few thousand years, anthropogenic influence led to a great transformation of the original natural environment (Bogicevic and Nenadic, 2010).

Establishing the timing of these climatic changes, and of their effects on the earth's environment, is a key element in Quaternary research (Walker, 1947).

As previously mentioned, during Pleistocene glacial and interglacial periods had affected every aspect of our planet: geologically, geographically, biologically… All of the changes during this period had effect on the bird species as well, shaping their current genetic structure and diversity (Carrera et al., 2022).

Birds belong to the phylum Chordata, the subphylum Vertebrata, and the class Aves. With 36 orders, 143 families and over 10,000 species living today Birds are the most diverse class of tetrapod vertebrates and show a marked diversity in morphology, ecology, and behaviour (Prum et al., 2015). Because of their habitat specificity, birds are excellent habitat indicators – because of their precise ecological needs, birds can also give valid insights about past climate, especially through palaeogeography. Also, their considerable significance as bioindicators for the character and state of the environment made birds successfully used in the palaeoecological restorations too (Bolles, 1997; Carrera et al., 2018). And why is paleoenvironmental reconstruction important? First of all, because it helps us to learn something about the environment in which human life took place (and about the challenges it faced as well), the changes that different species led to migrations and/or adaptations to new conditions. It tells about the conditions around the locality - whether the climate was hot or cold, humid or dry; whether there was a forest or an open habitat.

This research presents the systematic palaeoecological analysis of the skeletal remains of birds from Crvena Stijena, one of the longest and best preserved Middle Palaeolithic (MP) site in south-eastern Europe, situated in Montenegro, in the western part of Balkan Peninsula. The goal of the research is to systematically determine the avian assemblage and, based on it, to determine evolution in the avifauna of Crvena Stijena during the Palaeolithic period. The resulting composition of the avifauna has been then compared with the present-day avifauna of the area, in order to observe potential differences.

3. CLASS AVES

The origin of birds involves one of the major evolutionary transitions in the history of vertebrates. A bird is a bipedal, feathered animal with adaptations for active flight, although not all extant birds are capable of flying. They are unique in having feathers that cover and insulate their bodies, which makes it possible to regulate body temperature and facilitate flight (Storer & Usinger, 2003; Kardong, 2018). Most of the birds are active during the day (although there are exceptions that are active during night) (Storer & Usinger, 2003). These and numerous other avian characteristics were, however, sequentially acquired in the more than 160 million years of avian evolution.

The modern birds we see today are the descendants of a group of two-legged dinosaurs known as theropods (Casinos and Cubo, 2001; Storer and Usinger, 2003; Mayr, 2016; Kardong, 2018. Phylogenetically, birds belong to the Archosauria clade (a major group of diapsids that is differentiated by the presence of two openings on each side of the skull; the upper and lower temporal openings, i.e., the post-orbital fenestrae (Fig.1)). Temporal fenestrae are post-orbital openings in the skull that allow muscles to expand and lengthen (for example, Anapsids have no temporal fenestrae, synapsids have one and diapsids have two). This group represents one of the fundamental divisions of vertebrate phylogeny and has been a successful and dominant group ever since its origination in the Late Permian or Early Triassic.

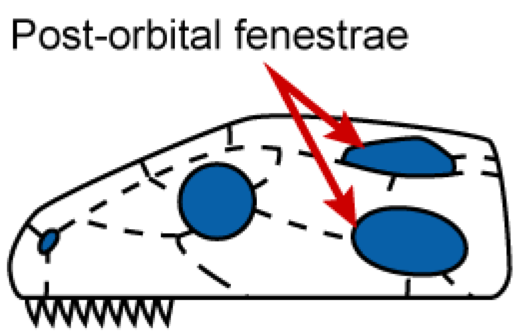

Fig.1. Diapsid skull, red arrows shows the upper and lower temporal openings (https://dinopedia.fandom.com/wiki/Diapsids)

The archosaurs ('ruling reptiles'), are cladistically defined (Fig.2) as a monophyletic group, which includes living crocodilians and birds, as well as about 1000 genera of dinosaurs and pterosaurs (Benton and Clark, 1988).

Evolution of birds began in the Late Jurassic period (160 million years ago), from which fossils of these early birds have been found in the German Solnhofen site and older, northeastern Chinese sites from the Tiaojishan Formation (Mayr, 2016). Numerous studies have examined the large-scale phylogeny of

Archosauria (Gauthier 1986; Benton and Clark 1988; Sereno and Arcucci 1990; Sereno 1991a; Juul 1994; Bennett 1996; Benton 1999, 2004; Irmis et al. 2007a). These studies largely agree that crown-group Archosauria is divided into two large clades: a group consisting of birds and their close relatives (Avemetatarsalia) and a group consisting of crocodylomorphs and their close relatives. Overwhelming evidence shows that birds evolved within the clade Dinosauria, which is further subdivided into two groups: the Saurischia ("lizard hips") and the Ornithischia ("bird hips"). However, despite the names of these groups, it was not the bird-hipped dinosaurs that gave rise to modern birds. Among the recent species only the birds and crocodilians exist today.

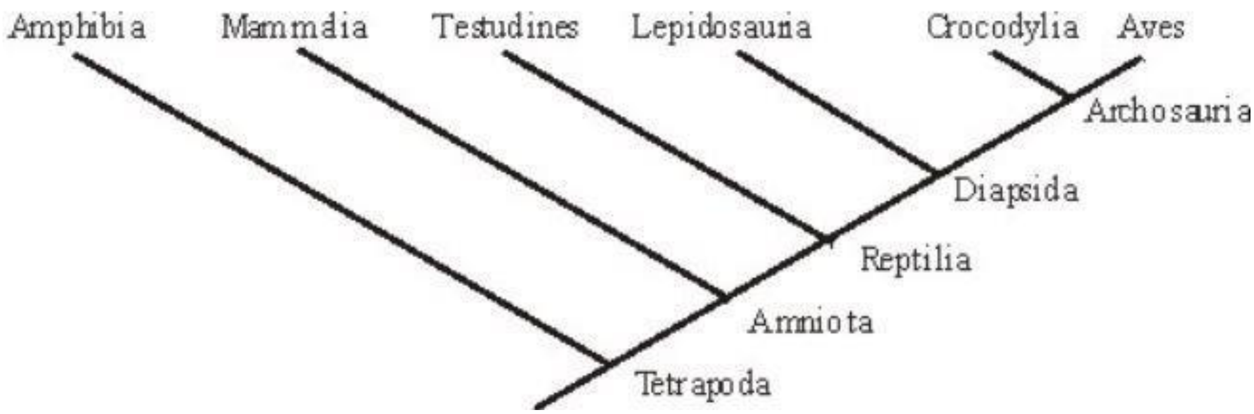

Fig.2. Schematic cladistic relationships of Aves
(https://www.geol.umd.edu/~tholtz/G104/104Y2K/104Lec11.htm)

However, modern birds (Neornites) appeared shortly before the extinction at the end of the Cretaceous (Prum et al., 2015). The evolution of modern birds is characterized by trends of size reduction, skeleton compaction fusion of bones (mainly bones of the skull and distal bones of the limbs), and reduction of the distal bones and muscles of the limbs, which concentrated the muscle mass in the center of gravity bodies (Mayr, 2016). Thus, even though the most obvious characteristic that *seems* to set birds apart from other extant vertebrates is the presence of feathers, we now know that feathers probably appeared in the common ancestor of both ornithischian and saurischian lineages of dinosaurs (feathers in these clades are also homologous to reptilian scales and mammalian hair)(Serjeantson, 2009). While the wings of vertebrates like bats function without feathers, birds rely on feathers and wings, along with other modifications of body structure and physiology. It's important to note that our understanding of bird evolution is continually evolving as new fossil discoveries are made and research advances. The transition from small theropod dinosaurs to modern birds represents one of the most remarkable examples of evolutionary change in the history of life on Earth.

3.1. Characteristics of the Avian Skeleton

Avian evolution is characterized by the formation of compound bones through the fusion of individual skeletal elements, mainly in the skull and distal limb bones.

There are four sections of the skeleton (Fig.3): cranial skeleton (that include the skull, quadrate, and mandible), axial (vertebra, sternum, rib, coracoid, furcula, scapula, and pelvis), anterior appendicular (humerus, ulna, radius, carpometacarpal, cuneiform, scapholunate and anterior phalanges) and posterior appendicular (femur, tibiotarsus, tarsometatarsus, fibula, calcaneus, posterior phalanges, and claws).

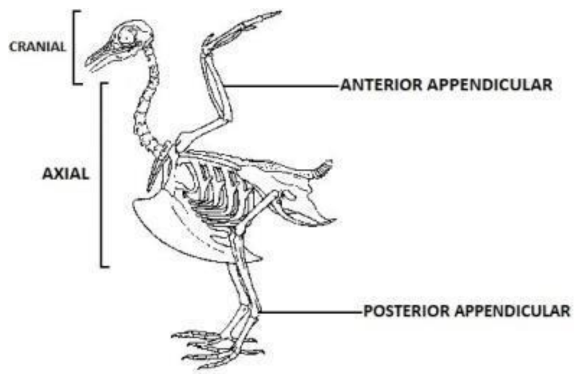

Fig.3. Representation of the different anatomical sections of the skeleton of a fowl (https://www.oiseaux.net/dossiers/ornithopedia/le.squelette.html, modified)

The numerous heterocoelous cervical vertebrae allow for great mobility of the head (Kardong, 2018). Since they are adapted both to flying and bipedalism, Birds are unique within Tetrapoda (Casinos and Cubo, 2001). Most Birds use flight as main means of locomotion and this ability allows them to occupy environments that are not accessible to other animals (Storer and Usinger, 2003; Serjeantson, 2009).

3.2. Class Aves in the Quaternary deposits

There is a wide range of fossil birds among the Quaternary deposits that provide insights into the evolution and distribution of various species during this period, helping to understand how bird populations and ecosystems have changed over time. A large number of skeletal remains of families of crows and eagles have been found in European sites (Negro, 2016). The presence of willow ptarmigan (*Lagopus lagopus*), alpine chough (*Pyrrhocorax graculus)* and brambling (*Fringilla montifringilla*) refers to cold high-mountainous climate, but temperate forms, and the so-called indifferent species predominate in the bird fauna, typically to the very end of Late Pleistocene. Nowadays merlin and brambling are exclusively winter visitors in the Balkans, breeding in Scandinavia and the northern islands of Europe.

Balkan breeders of the pygmy cormorant winters partly inland, partly on or near north-eastern Mediterranean coasts (Cramp, 1998). However, the presence of this lowland species, usually absent from mountainous, arid, and cooler regions, is surprising.

3.3. Class Aves in the Pleistocene and Holocene of the Balkan Peninsula

During the Pleistocene the Balkans came to be an important region with many isolated areas (Jovanović et al., 2022). The bird fauna of the last 1.8 appear in the ecosystems of recent taxa. There are fossil taxa from the Early and Middle Pleistocene however, in the Late Pleistocene, they have almost disappeared in the fossil record. A feature of the period is the alternating cold and mild phases, resulting in bird migration. During the Holocene, the human impact is becoming stronger in bird life, as evidence there is a large number of zooarcheological sites with bird remains.

3.4 Birds in zooarcheology

In the archaeological contexts the presence of small animals is commonplace, especially in caves and shelters - places that often are inhabited by predators such as birds of prey and mammalian carnivores (Rufà et al., 2016). Birds are an integral part of the diet of numerous mammals and birds themselves. One way or another, small animals in caves carry out their regular activities, often in alternation with the activities of hominins (Rufà et al., 2016).

In zooarchaeology avifaunal remains are interesting because of their complex relationship with humans, which is not limited exclusively to nutrition. Thus, there are known findings related to Neanderthals that indicate the use of ornamentation feathers and claws of raptors (Radovčić et al., 2015; Negro et al., 2015 and the references mentioned there). Findings with traces of cutting in most cases are most common on the wing bones. Parts of the body that are not rich in muscles but are the receiving places of large flight feathers, could indicate the collection of feathers from birds, for non-food purposes., reported by Negro et al. (2016). Regarding nutrition, Negro et al. (2016) state that archaeologists believe that flying birds were actually a difficult prey for humans during Middle Paleolithic. However, the findings of anthropogenically modified eagle claws from Krapina (Radović et al., 2015) and Combe-Grenal and Les Fieux in France (Blasco et al., 2014), and continuous finds of pigeon bones with cut marks from Gibraltar over 40,000 years (Blasco et al., 2014) show that Neanderthals were able to hunt and use birds as a constant food source.

4. SITE DESCRIPTION

4.1. Location and geographical conditions

The Balkan Peninsula is bounded by the Adriatic Sea to the west, the Mediterranean Sea and the Marmara Sea to the south, the Black Sea to the east and the Danube, Sava and Kupa Rivers constitute a natural border for this region to the north, making it roughly coincident with the region known as South-eastern Europe (Ruiz-Redondo et al., 2020). Rock-shelter Crvena Stijena is located in Montenegro, in the western part of the Balkan Peninsula, 32 km from the Adriatic coast. Territory of Montenegro with its natural affordances (including mountainous and karst-dominated landscapes) has a high potential for the study of early prehistory. The site appears in the mountainous southwest part of the country, at 700 m above sea level (Fig.4) it is high above the riverbank of Trebišnjica and today overlooks an artificial lake created by damming of the river.

Fig.4. Geographical context of the Crvena Stijena site
(modified from a Google Earth^{TM} satellite image)

As a part of the belt of a Dinaric Mountain, the site is presented as a large opening in a cliff composed of a limestone and dolomite. High presence of the iron oxides causes the red color of this rock-shelter and because of it the site is named Crvena Stijena (literally translated from Serbian means ‘‘red rock’’, Fig.5). It preserves an exceptionally deep (20 m) stratigraphy (Basler, 1975; Gamble, 1999; Baković et al., 2009; Moorley and Woodward, 2011). The Middle Paleolithic layers, which are 10 meters deep, contain one of the longest and best-preserved sequences from this time period in all of Europe (Baković et al., 2009; Moorley and Woodward, 2011). The site has been researched since the fifties of the last century, and numerous studies on its lithic industry have made it a reference site for the Balkans. The rock shelter has a large opening (26 m wide by 15 m high) with a horizontal depth of about 25 m; and the cave surrounding today is partially covered by an open mosaic of low scrub and small localized areas of mixed woodland. The local limestone includes beds of dolomite and extensive folding, fracturing, and jointing make these rocks particularly susceptible to mechanical breakdown (Moorley and Woodward, 2011).

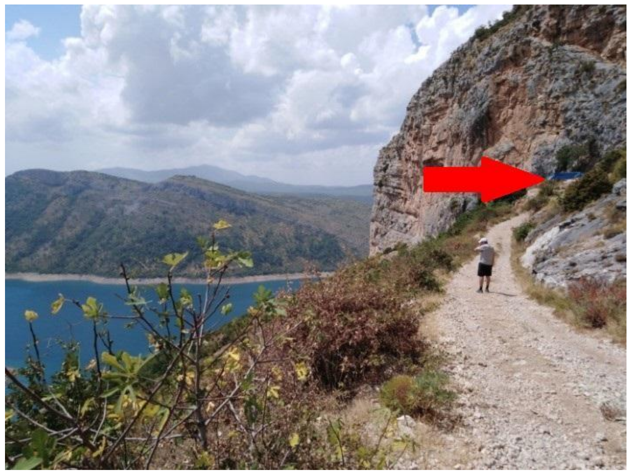

Fig.5. Access to the Crvena Stijena site, red arrow indicates the entrance to the cave

As viewed by the geologists involved in the new research, Crvena Stijena in general offers "one of the longest (>20 m) rockshelter sediment records in Europe" and represent one of the most important sites for understanding the nature of the Middle to Upper Paleolithic transition in the Balkans (Baković et al., 2009; Moorley and Woodward 2011: 683).

4.2. Research history

Crvena Stijena was discovered in 1954 and yielded the first traces of Paleolithic and Mesolithic occupation in Montenegro (Basler, 1975). The site has been the subject of two major research projects between the 50s and 60s (Mihailović, 2009). With its 20 meters of cultural stratigraphy, Crvena Stijena offers one of the key regional yardsticks for the Middle Paleolithic (levels XXXI to XI), Upper Paleolithic (levels X to V), Mesolithic (level IV with sub phases IVb1, Ivb2, and Iva) and levels I to III as later prehistoric periods (Borić et al., 2021).

First research project was from 1955-1958 and the second one 1960-1964, and during these two projects an enormous volume of the sedimentary infilling of the site was excavated. The investigation held in the 1955 and 1956 were under the directorship of A. Benac (National Museum of Bosnia and Herzegovina in Sarajevo) and after that and until 1958 director of excavations was M. Brodar (Institute of Archaeology, Slovenian Academy of Sciences and Arts in Ljubljana). The Upper Palaeolithic, Mesolithic, Neolithic and Eneolithic layers of the site had been investigated during this period (Benac and Brodar 1957; Brodar, 1958; Benac 1957). During the first year of excavations layers I-V which spanned the period from the Bronze Age to the Epipaleolithic were revealed (Benac, 1955; Brodar, 1955). The excavations continued and reached a depth of 9.5 m, to the Middle Paleolithic layers. Until 1958 the excavations reached layer XVIII, at a depth of almost 12 m and over 3,000 artifacts from layers XII-XVIII were found (Brodar, 1962).

The investigations of the Middle Paleolithic layers were between 1960 and 1963 under the directorship of D. Basler from National Museum of Bosnia and Herzegovina in Sarajevo. Basler significantly expanded and deepened the excavation area. His plan was to place a deep sounding into the Middle Palaeolithic? Deposits. By 1963 almost all Mesolithic and Lower Paleolithic layers were removed, with a depth of over 20 meters, and archaeological deposits in XXXI layers (although he still did not reach the bedrock at the bottom of the shelter). The results of this research were published by Basler in 1975 in a monograph that contained data on archaeological data, sedimentology, and geochronology. However, it was noted that Basler selectively collected artefacts which made it more difficult, if not impossible, to conduct technological analysis of incomplete collections, so Basler's sets cannot be reliably used for inferences about technology (Mihailović and Whallon, 2017). In contrast, Brodar seems to have excavated and preserved all the artifacts more slowly and carefully. The archaeological sequence revealed by these earlier excavations at Crvena Stijena is, as aforementioned, extremely long, one of the longest from any rock shelter site in Europe (Baković et al., 2009).

After a long break, excavations of Middle Paleolithic layers at Crvena Stijena had been continued - from 2004 - 2015 under the directorship of R. Whallon from University of Michigan Museum of Anthropological Archaeology, with a partial support from the National Geographic Society (Mihailović and Whallon, 2017). Whallon's team explored the sediments above Balers deep sounding for *in situ* remains, focusing on removing the sterile overburden to enable systematic, controlled excavation of the sizable *in situ* Middle Paleolithic layers (Tostevin and Monnier, 2017). Along with a detailed study of techno-typological aspects of the chipped stone industries from the Upper Palaeolithic and Mesolithic levels, Dragoslav Mihailović (2009) provided a useful synthesis of the first excavation phase at Crvena Stijena (Borić et al., 2021). In 2010 Whallon began a project to test the hypothesis that Neanderthals carnivory (Bocherens, 2009) required socioeconomic adaptations such as the preservations of meet by drying or smoking (Tostevin and Monnier, 2017). Based upon TL, ESR, and AMS ^{14}C dates (Maercier et al., in prep) this project has yielded the first absolute chronology for the site. Whallon summarized the results in a monograph that was published by Montenegrin Academy of Science and the Arts (Podgorica) in 2017. The National Museum of Montenegro began new archeological work with Gilliane Monnier and Gilbert Tostevin from the University of Minnesota in 2016, and it is still ongoing. Research is focusing primarily on the Middle Palaeolithic sequence (Fig.6) with the main goal to obtain a wider picture about Neanderthal and how their dietary strategies have been changed with climate (Whallon, 2017).

Fig.6. Excavations in the Middle Palaeolithic sequence of layer M5

Crvena Stijena is one of the first sites in this region where the interdisciplinary investigations had been undertaken - including the analyses of the sediments and macrobotanical remains, macro and micro fauna, identification of raw materials and C14 dating. The results have been presented in detail in many reports, studies and dissertations as well as in the monograph on this site (Basler, 1975; Whallon, 2017).

4.3. Palaeolithic sites in Balkan Peninsula

Quaternary record of birds on the Balkan Peninsula is still insufficiently studied. More interest in Palaeolithic in Balkan Peninsula started recently, in general, investigation for sites in this part of Europe are relatively young (Monnier, 2006). Beside Crvena Stijena, there are sites in Montenegro with Middle Palaeolithic layers that were currently explored such as Mališina Stijena and Trebački krš (Bogićević and Dimitrijević, 2000). In Serbia, especially during the past decade, many new sites have been revealed: The Balanica cave complex, Pešturina cave, Smolućka cave, etc. (Mihailović et al., 2014; Mihailović and Bogićević, 2016). The famous sites from Croatia are Krapina and Vindija cave in NW, Šandalja and Mujina Cave in the south part of the country (Radovčić et al. 1988; Ahern et al. 2004, Karavanić et al. 2008). In order to better understand the Middle Palaeolithic in Balkan Peninsula, in this chapter will be a short summary of previously mentioned sites (Fig.7).

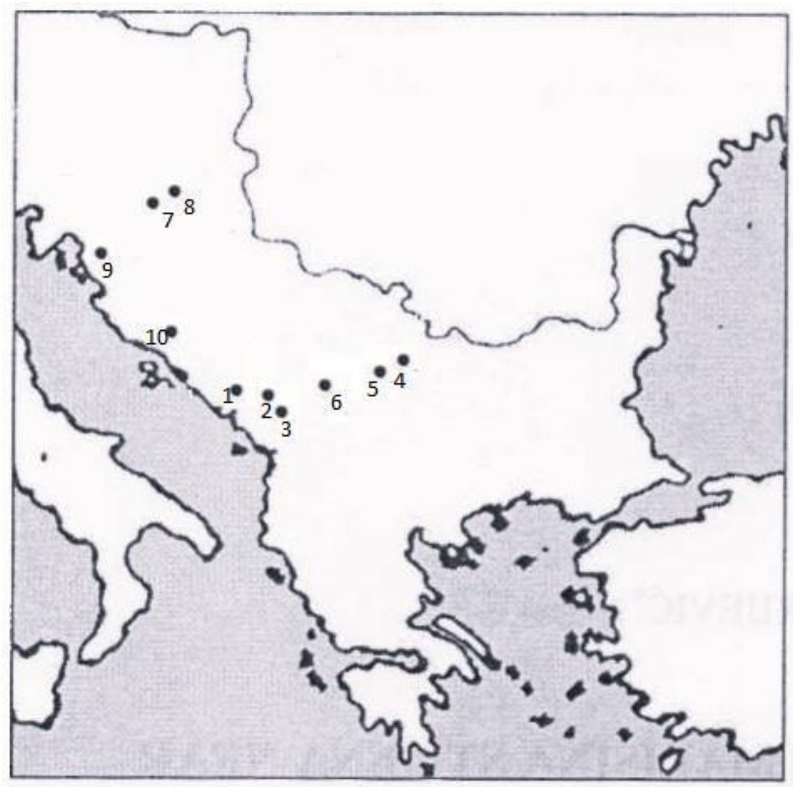

Fig.7. Locations of Paleolithic sites in the Balkan Penninsula ((1)Crvena Stijena; (2)Mališina Stijena; (3)Trebački krš;(4)Balanica cave complex;(5)Pešturina;(6)Smolućka;(7)Krapina;(8)Vindija;(9)Šandalja;(10)Mujina)

Mališina Stijena is located in the gorge of the river Ćehotina, in the north of Montenegro. It was excavated in the 1980s by archaeologists from Serbia **(**Radovanović, 1986), something less than three decades after, in 2017, the excavations were continued by a Montenegrin-Russian team (Derevianko et al., 2017; Derevianko et al., 2019). Four archaeological levels were defined, and fauna remains are found in all layers. Fauna is represented by large and small mammals, birds, fish, and small number of amphibian remains and gastropod shells). Birds in the deposits are represented by a large number of species, but relatively small number of specimens: species were mostly identified based on only one or several bones (Bogićević and Dimitrijević, 2000). Bogićević and Dimitrijević analyzed and described fauna from this site, among the material from campaigns that has been held during 80s, bird remains of several species were described. Among 37 identifiable remains, only 3 species (3 fragments in total) were found in the Middle Palaeolithic layers: *Anas sp*. (duck), *Pyrrhocorax graculus* (alpine chough) and *Corvus frugilegus* (rook) (Bogićević and Dimitrijević, 2000). The rest of bird remains that has been distinguished are: *Lagopus lagopus* (swamp snow partridge), *Lagopus muta* (alpine snow partridge), *Alectoris graeca* (Greek partridge), *Gallinago gallinago* (common snipe), *Falco* sp. (falcon), *Larus* sp. (gull) and *Turdus merula Linnaeus (blackbird)* (Malez V., 1983; Malez et al., 1988; Bogićević and Dimitrijević, 2000; Gál et al., 2003). Remains from Mališina Stijena do not indicate any preference or selective hunting by humans (Malez et al., 1988).

Trebački krš site is situated in north-eastern Montenegro, is an abri 30 m wide and 6m deep. According to Dimitrijević (1999) three geological layers were distinguished and avifaunal remains have been identified from two layers and among rich fauna, 44 bird bones have been identified. The most characteristic is the absence of large and rarity of medium sized species, as well as the absence of common representatives of Corvidae or Falconidae families. Most of the remains that were present are small birds from the order Passeriformes (Dimitrijević, 1999).

Birds from Trebački krš and Mališina Stijena presumably originate from prey of predators that lived at the sites (Bogićević and Dimitrijević, 2000).

Serbia

In Serbia between 2010-2012 several new Upper and Middle Palaeolithic sites were revealed. These sites were determined on the basis of surface findings such as: The Balanica cave complex and Pešturina cave (Mihailović et al., 2014; Mihailović and Bogićević, 2016).

Balanica cave complex is situated 10 km east of Niš at the exit of the Sićevo gorge. This complex comprises two caves: Velika and Mala Balanica cave. In Mala Balanica, a mandible of *Homo erectus* was found (dated to 525-400,000 BP) and a lithic industry has been found in layers in both caves (layers 2a-2c in Mala Balanica and layers 3a-3c in Velika Balanica).

Not far from Balanica - on the eastern edge of the Niš basin another cave is located, Pešturina cave. This cave is located in the karstic limestone area of Jelašnica gorge in SE Serbia, which formed due to intensive cutting of the river flow into the limestone rock mass of Suva Planina Mountain slopes (Rakić and Dimitrijević 1973; Vujisić and Navala 1980; Anđelković 1982; Majkić et al. 2017; Jovanović, 2021). Pešturina cave represents a previously unexamined Late Pleistocene site in the region, located in the central part of the Balkan Peninsula (Boev and Milošević, 2020). Excavations revealed two layers of the Middle Palaeolithic (3 and 4) containing abundant fauna but small quantities of artefacts. Avian remains were collected from the deposits spanning between late MIS 5 to MIS 3. Most of the taxa identified at the cave are stenotypic for forests, followed by those inhabiting grassland and rocky habitats. The avifauna of the MIS 3 environment (layers 2 and 3) is represented by some steppe *Perdix perdix* (grey partridge) and *Alauda arvensis* (skylark), and some forest taxa like *Picus canus* (grey headed woodpecker), *Pyrrhula pyrrhula* (bullfinch), *Anthus trivialis* (tree pipit)(Boev and Milošević, 2020). An interesting record is the

Oriolus oriolus (golden oriole), a species that is typically a bird of open broadleaf forest, but also lives in forest steppes (Harrison, 1982; Boev and Milošević, 2020).

Smolućka Cave is located about 15 kilometers northeast of the town of Tutin, in the area of the village of Crkvine in south-eastern Serbia. Mountains that are the dominant form of landscape, are associated with the Dinaric Alps by their origin and geological composition (Jovanović, 2021). From 1984 to 1987, the Archeological Institute of Belgrade organized excavations in this cave and the site yielded over 200 Middle Palaeolithic artifacts that were found in the Pleistocene layers (Jovanović 2021). The position of the cave could have been attractive to the Middle Palaeolithic people. The cave is dry with small temperature changes, with a large and bright first room and a platform/talus in front of the entrance suitable for everyday activities and offering a good view of the surroundings, which must have surrounded the cave also during the Middle Palaeolithic (Šarić 2013).

Croatia

Palaeolithic sites of Croatia are especially important because of the association between lithic industries and fossilized hominin remains. From the most famous sites (Krapina and Vindija) artifacts and hominin fossils have been analyzed and described in numerous publications (Radovčić et al. 1988; Ahern et al. 2004, Karavanić et al. 2008). The southern part of Croatia (Dalmatia) is known from Mujina Cave, only locality from the Middle Palaeolithic that was systematically explored (Karavanić et al. 2008).

Vindija Cave was formed as a large underground cave made of sandstone and limestone. This site was excavated for 30 years by Vuković and continuously from 1974 to 1986 by Malez (Janković et al., 2016). The deposits are divided into 14 stratigraphic units belonging to the Pleistocene and Holocene (Janković et al., 2016). The remains of the human skeleton were found in both the Middle Palaeolithic period (unit I and level G3) and the transitional or younger Palaeolithic period (levels G1, Fd, unit D) (Ahern et al., 2004). The remains from levels G3 and G1 are Neanderthal - the six specimens from level G1 represent the latest Neanderthals in Europe (Smith and Ahern, 1994; Smith et al., 1999; Ahern et al., 2004). Recently determined single amino acid AMS dates showed that all these Neanderthals are older than 44,000 BP (Ahern et al., 2004).

Šandalja was discovered through quarrying activities in Valtura near Pula in 1962 (Malez, 1964); it was excavated by Malez from 1962 to 1989 (Sršen et al., 2013).

Krapina site is located in the Hušnjak hill, and it is recognized as a site rich in Neanderthal bones and teeth, tools and the animals they hunted. The site was investigated by Dragutin Gorjanović-Kramberger, a Croatian paleontologist, from 1899 to 1905 (Janković et al., 2016). More than 1,100 human skeleton fragments were found in a 9 m sequence and have been dated by electron spin resonance (ESR) to around 130,000 BP (Rink et al., 1995). These remains have been intensively studied and appear to belong to a related population of Neanderthals with distinct anatomical features (Frayer, 2006). It is interesting that the bones are very fragmented and there are marks on them that have been interpreted as cannibalism (Gorjanović-Kramberger, 1906; Smith, 1976; Patou-Mathis, 1997; White, 2001). Gorjanović-Kramberger and his assistant collected hundreds of Neandertal bones and teeth, more than 800 stone tools and almost 2800 animal remains ()Radovčić et al., 2015). Analysis of the fauna shows that the Neanderthal population in Krapina hunted the large bovids and rhinoceros and the cave bear (*Ursus spelaeus*) also occurs in the strata (Patou-Mathis, 1997). Avifaunal remains from this site are especially important for understanding symbolic behaviour of Neanderthals.

Mujina Cave with age of cca 45-39 kya is closest to the fauna from Crvena Stijena. This site is located on the karst terrain of the Dalmatian coast and was explored from 1995 to 2003. Thick deposits inside the cave appear to have been deposited over a short period of time, ESR and AMS date the sequence to between 39,000 - 47,000 BP (Karavanić et al., 2008). Analysis of animal remains that Karavanić described shows that prehistoric people were focused mostly on hunting deer and large bovids (based on traces of cuts and cracking of long bones for marrow extraction). Bird remains are scattered throughout the various levels at Mujina cave, and they indicate different micro-habitats in the surroundings of the cave, which were forests, rocky and open landscapes. The majority of identified taxa are adapted to a moderate climate with the exception of *Lagopus lagopus* (willow grouse) boreal, *Fringilla montifringilla* (brambling) tundra, *Pyrrhocorax pyrrhocorax* (red-billed chough) high mountain/alpine, and *Alectoris graeca* and *Columba livia* (rock partridge and rock dove) Mediterranean climate (Karavanić et al., 2008).

4.4. Stratigraphy and datation of Crvena Stijena

The stratigraphy of Crvena Stijena is characterized by the alternation of geological and anthropogenic horizons (Whallon, 2017). The geological structure in the immediate and further area surrounding Crvena Stijena is made up exclusively of sedimentary rocks (Ćulafić, Whallon, 2017).

Sedimentological description and radiometric dating are detailed in Morley (2017) and Mercier et al. (2017), but in summary, the sequence can be divided into three primary lithofacies that describe similar modes of deposition. According to sedimentary sequence (Fig.8) from top to the base is comprised by:

• Lithofacies 1 (Layers XIII–X): the upper c. 3.0 m thick of well bedded and coarse orange limestone gravels in a sandy matrix. The color of the matrix is predominantly orange. The matrices of these gravel beds are clean and relatively homogeneous, archaeologically sterile (i.e., free from charcoal and bone inclusions). In the upper part of Lithofacies 1 is layer XI. This layer of ash is c. 100 mm in thickness and has been seen to extend laterally for more than 5 m across the site. Geoarchaeological and micromorphological analyses have revealed that Stratum XI, as Brunnaker (1975) had suspected, is a volcanic tephra deposit. A comparison with data from tephra samples from other sites in the Mediterranean shows that the Crvena Stijena ash has a geochemical signature indicating a Campanian-Ignimbrite origin ((CI) eruption at 39.3 ka, southwest mainland Italy). It has been identified as the Y5 that is widespread in the eastern Mediterranean (Baković et al, 2009; Morley and Woodward 2011). According to Baković preliminary report (2009), all the archaeological layers above the Stratum XI tephra had been essentially completely removed by the previous excavations.

• Lithofacies 2 (Layers XXIV–XIV): comprises a thick body of sediments present from 3.0 m down to 8.75 m below datum. This thick suite of sediments displays significant variability in terms of grain size of individual beds, characterized by much finer-grained material than found in Lithofacies 1 and 3. The predominance of anthropogenic material in the form of ash, charcoal, bone fragments and occasional burnt flints defines this part of the succession. Many of the individual layers are relatively fine grained, but some coarse gravel units are interstratified within these layers and are frequently free of anthropogenic detritus. The bulk of the sediments in these lithofacies have a dark color ranging from yellowish brown to brownish black.

• Lithofacies 3 (Layer XXV): comprises the lowermost 0.75 m of the studied sequence. Marked by an abrupt shift from the cultural layers above to archaeologically sterile, it contains negligible quantities of charcoal but no faunal material. The magnetic properties of this layer show very low concentrations of magnetic minerals.

According to Mihailović and colleagues (2010), underneath the tephra layer mixed with éboulis could be followed, beneath which was noted a level with charcoal and coarse éboulis which could correspond to M2 and M3.

Layer M4 correspond to Basler's layer XIV is divided, starting with the level with charcoal at the surface (layer M4a), followed by a level of baked sediment (M4b) and a level with ash (M4c) and layer M5 to Basler's layer XV.

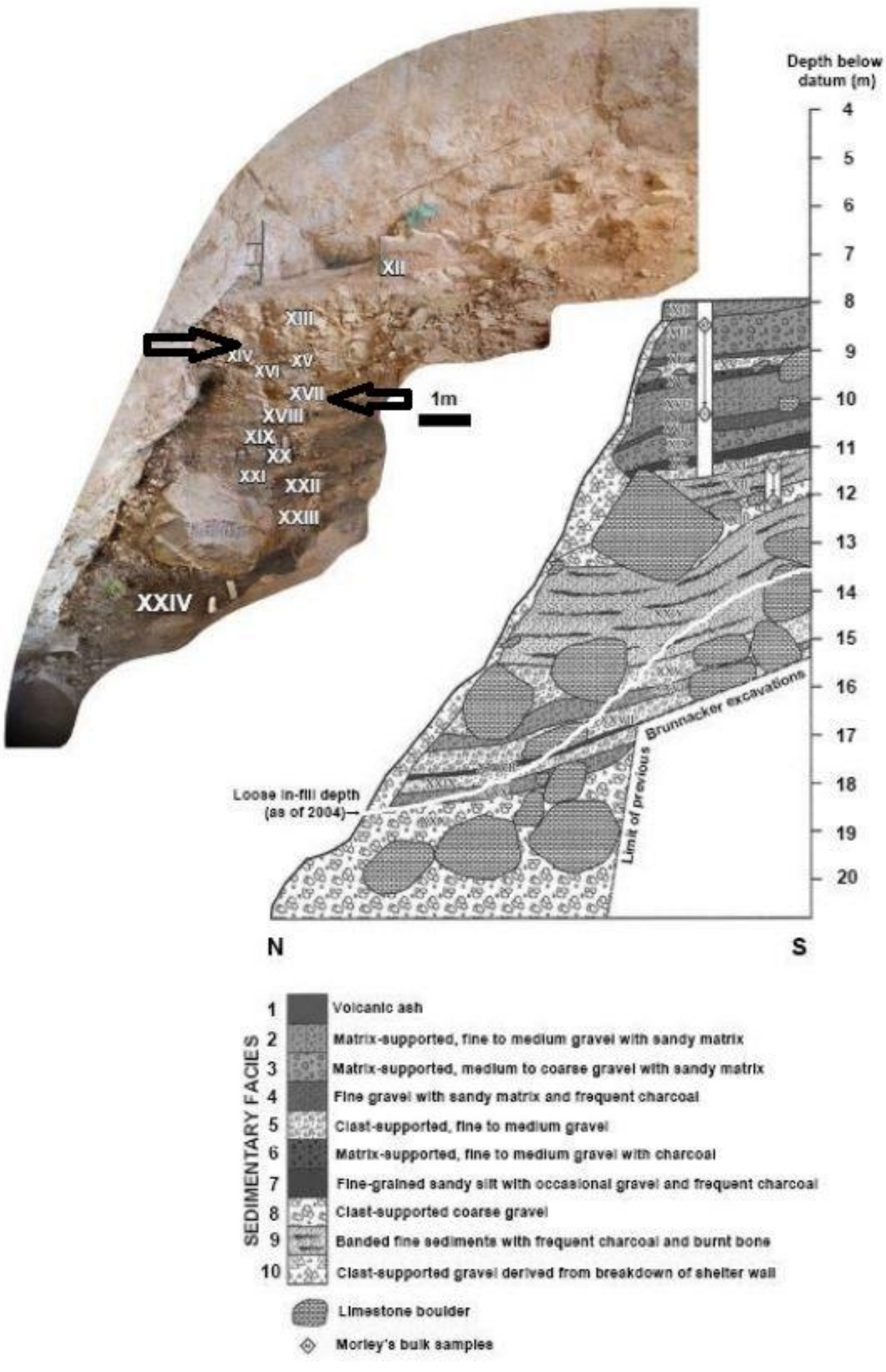

Fig.8. Composite section through the sedimentary sequence at Crvena Stijena, arrows are showing position of MPlayers (Baković et al., 2009, modified)

4.5. Archeological remains

Besides the avifaunal remains that were examined for this work, Crvena Stijena is very rich in archaeological remains. From the previous campaign and recent campaigns (2017-2023) all material that has been recovered can be grouped into several categories (lithic, charcoal and faunal remains). Short information of this material will be presented in this chapter.

4.5.1. *Macro vertebrates remain.*

The macro vertebrate remains in Crvena Stijena are well preserved and numerous, although very fragmented. Rakovec in 1958 studied the fauna from stratum V-XI. The faunal remains are not concentrated only in the next to last stratum, which is stratum XXX (i.e., only level XXX does not have a concentration of faunal remains) (Malez, 1975). According to Morin and Soulier (2017) for the remains of Middle Paleolithic 65-80% of the studied faunal assemblage in the layers belongs to Deer (*Cervus elaphus*). Goats (*Capra ibex /caucasica*) are the next common taxon, followed by fallow deer (*Dama dama*). Large ungulates (*Bos, Equus*) are rare, except in layer XXIV. Evidence of human interaction with fauna is extensive. Morin and Soulier (2017) indicate that the characteristics of faunal assemblages (from layers XXIV and M5-M1) prove that people transported meat parts of deer, ibex and other animals to the site where they were butchered and processed for marrow extraction.

4.5.2. *Micro vertebrates remain.*

More focus on micro vertebrate remains started recently, especially from 2017-2019. During this period, more than 100 small vertebrate remains were extracted from sediment fractions. Materials have been studied by Dr Katarina Bogićević, Dr Dragana Đurić, Dr Mihailo Jovanović and Ms Aleksandra Savković. Although results of these studies are not published yet, preliminary results have been presented at the SAA symposium (88th Annual Meeting of the Society for American Archeologists) that was held in April 2023 in Portland, Oregon. Short review of studied material will be presented in this chapter. Material that has been found and examined is from layer M4b, M4c and M5. More than 50 remains were found in layer M4c and at least 110 in layer M5. Of these, 103 could be determined to the genus/species/family level (48 in M4b layer, 10 in M4c layer, 45 in M5 layer). The remains of small mammals and herpetofauna (reptiles and frogs) have been completed up to the genus or family level. A total of at least 10 small mammal species (8 rodent species, 2 insectivorous species) and 10 herpetofauna species (2 frog, 3 lizard and 5 snake species) were found.

Among small mammals, the most common species in both studied layers (M4 and M5) is *Chionomys nivalis* (characteristic for rocky areas) followed by *Microtus arvalis/agrestic s*(more known for open habitat). *Chionomys nivalis* lives at higher altitudes today and in the Pleistocene, it descended to lower altitudes and was much more common than it is today. The studied micro vertebrate assemblage is different from the current one in the area of the site. There are no *Chionomys* at all in the vicinity of the Crvena Stijena, however, the most common species in this area today is *Dinaromys bogdanovi*. Also, in the present-day mammal fauna of the Crvena Stijena surroundings, inhabitants of forest areas prevail, while they are rare in layers M4 and M5. The percentage of species that prefer a warm climate is highest in the M5 layer (24.9%) and lowest in the M1 layer (6.6%). In layer M4, this percentage is 18.6%.

Species/taxa	layers					
	M4b	M4c	M4c/M5	M5 red	M5 yellow	M5
Chionomys nivalis			1 (1)*	4 (7)	4 (6)	11 (21)
Microtus arvalis/agrestis		2 (4)		8 (14)	3 (5)	13 (23)
Microtus subterraneus				1 (1)		2 (4)
Dinaromys bogdanovi	1 (1)		1 (1)	2 (4)	1 (2)	5 (8)
Arvicolidae indet.		(2)		(5)	(1)	(61)
Apodemus sp.		2 (2)			1 (1)	2 (3)
Crocidura sp.			1 (1)	1 (1)	1 (1)	3 (6)
Soricidae indet.					1 (1)	
Ochotona sp.				1 (1)		
bats				+		+
	1	8	3	33	17	126

Table1. Small mammals distribution in the layers.

First number indicates MNI (minimal number of individuals), number in bracket – total number of fragments.

The herpetofauna of the Crvena Stijena in layer M5 is very similar to today's fauna of the wider area. There are several species in this layer that prefer warmer, open, and sunny biotopes (*Vipera ammodites, Zamenis situla, Lacerta viridis*) and some of them live in drier steppe habitats (*Lacerta. agilis, Bufotes viridis*). However, *Zootoca, Vipera berus* and *Lacerta agilis* are generally considered to be glacial species, but their recent distribution shows a great tolerance for much warmer habitats.

The poverty of herpetofauna remains in the M4 layer may be the consequence of a colder climatic period, when representatives of this group were less available to predators. Since herpetofauna is very dependent on climatic conditions, the M5 layer can be considered the “warmest” and the M1 layer the “coldest” (although the low number of remains in the M1 layer can also be explained by the method of collection of material - large remains prevail, probably due to collection by hand in the field, instead of by picking from the sifted sediment samples).

layer	taxon	Number of fragments
	Bufonidae indet.	
	Bufotes viridis group	
	Ranidae (only a few fragments)	
	?*Pelobates*	**Frogs** 33
	Lacertidae indet. (vertebrae)	
	Lacertidae indet. (skull bones): possibly some Mediterranean forms (*Dinarolacerta, Dalmatolacerta* or similar)	
M5	*Lacerta/Podarcis* sp. (possibly *L. agilis*)	**Lizards** 35
	Viperidae:	
	Vipera "berus" group	
	Vipera ammodytes	
	Colubridae:	
	Coronella austriaca	
	?*Zamenis situla*	**Snakes** 54

Table 2. Different herpetofauna in layer M5

Overall, it can be concluded that the fauna of the M5 layer (both small mammals and herpetofauna) originate from the warmer period than the fauna of the M4 layer. In both strata, forms that live on rocky ground and those that live in open habitats (grasslands and meadows) were predominant, and a smaller number of forest inhabitants were also present.

4.5.3. *Human remains*

In south-eastern Europe, the number of studies that focus on the foraging strategies of Neandertals and early modern humans has expanded over the last two decades (Dimitrijević, 1999; Miracle, 2005; Brajković and Miracle, 2008; Starković, 2009, 2012; Miracle et al., 2010; Stiner et al., 2012; Borić et al., 2012, 2014; Marín-Arroyo, 2014; PilaarBarch and Miracle, 2015; Starkovich and Ntinou, 2015; Hauck et al., 2017; Morin and Soulier, 2017). Evidence of human interaction with the fauna is extensive and cutmarks are especially common on red deer elements (Morin and Soulier, 2017). According to Preliminary report of excavations held in 2004-2006 (Baković et al., 2009) a noticeable amount of sediment had fallen or washed down from the level of Basler's (1975) Strata XXII–XXVII. This was the south face of the profile of the deep Middle Palaeolithic layers. Following the same authors, in order to clear away the fallen sediment for geological sampling (even though it was no longer in situ and could not provide a precise stratigraphic context for the materials found in it) some of the material was collected and carefully screened. Among this screened material a complete Neanderthal tooth (Fig.9) was recovered

(Baković et al., 2009). This is an encouraging sign that other human remains from the Middle Palaeolithic may possibly be found in further excavations of these lower strata.

Fig.9. Neanderthal tooth found among screened material (from Baković et al.,2009)

4.5.4. *Lithic*

According to Baković (2009), during the cleaning of the excavation area at the entrance to the shelter in 2005, over 3000 flaked lithic artifacts and several dozen bones and antler artifacts were found. These artifacts were found largely through screening. These finds come from the western side of the shelter, where the Holocene layers had been mixed with sediment thrown out from the earlier excavations, and since they were not recovered from a closed stratigraphic context, they cannot be used to draw conclusions about technological characteristics of any specific chronological or cultural phases at Crvena Stijena.

4.5.5. *Avifauna from previous research campaigns*

According to Malez (1983), among many bird species that have been found in Crvena Stijena during the excavations during the 70s, birds with a presumably economic value are common. Plenty of ornithological skeletal remains that were described (*Cygnus cygnus, Falco tinnunculus*, *Lagopus muta*, *Lagopus lagopus, Perdix perdix*, *Columba livia*, *Pyyrhocorax graculus*, *Corvus monedula* and *Corvus corax)* was collected from the sediments IX, X, XI and XIII (Malez, 1983). The size of birds ranges from little perching birds to middle sized species (such as ducks and falcons). However, large species such as big galliformes and vultures (which are more characteristic to the forestry and high mountainous regions) are completely absent (Malez, 1983; Bogicevic and Dimitrijevic, 2000).

It is interesting that the Pleistocene sediments from the whole former Republic of Yugoslavia remains of *Cygnus cygnus* (Fig.10) are extremely rare (Malez, 1983). There is no doubt that remains of this species come as a hunting prey of the Paleolithic inhabitants of the site (Malez, 1983). It is familiar that today this bird is present only in the north of Europe, however during the last glacial maximum the area was moved to the south, as evidenced by the discovered remains.

Fig.10. Some of the birds described during the previous research and their prefered habitat (shown up - Cygnus cygnus that prefer aquatic habitat with emergent vegetation; down - Pyyrhocorax graculus and rocky open air area, photo modified)

Compared with the previously known Palaeolithic sites in Montenegro which yielded bird remains, like Mališina Stijena and Trebački Krš (Dimitrijević et al., 2000), bird remains of Crvena Stijena show many differences. For example, small-sized species and especially small-sized passerines are not common as in Trebački Krš. According to Malez (1983), based on the previous researches the avifauna in Crvena Stijena was exclusively composed of large and medium sized birds, often interpreted as hunting remains. On the contrary to the previous studies of the earlier fossils from Mališina stijena, either the systematic or the osteologic composition of the present material does not indicate any preference or selective hunting by humans or animal predator (Malez et al., 1988). Owls were absent in this faunal complex as well.

5. MATERIAL, METHODS AND RESULTS

The material included in this work consists of unpublished bird fossil remains recovered from the M4 and M5 layers of Crvena Stijena site. The remains were recovered during the field campaigns 2019 -2021. Samples were sifted in the field through sieves and then picked out from the collected sediment under a magnifying glass with low magnification (Fig. 11). The remains have been photographed using a photo camera Nikon Coolpix and IphoneSE and measured using a digital calliper.

The laboratory work was carried out in the Institut Catalá de Paleoecologia Humana i Evolució Social (IPHES) and in the laboratory of Crvena Stijena in a village Petrovići in Montenegro. Identifications are based on the direct analysis of the fossil bones.

All anatomical and taxonomic data with some of the taphonomic remarks have been entered into a database in order to facilitate the comparisons and obtaining results. The sample amounts to 195 bird remains. Species were mostly identified on the basis of only one or several bones.

The anatomical nomenclature follows Baumel and Witmer (1993) and the osteological analysis of Fick (1974), Kessler (2015), Tomek and Bochenski (2000, 2009) and Wójcik (2002) were used to identify the remains. Example from Wójcik (2002) for taking measurements on the humerus of the bird shown in Figure 12.

Fig.11. Collection and extraction of the material. a) Sieving, b) picking-up, c) measuring, d) observing under a magnifying glass

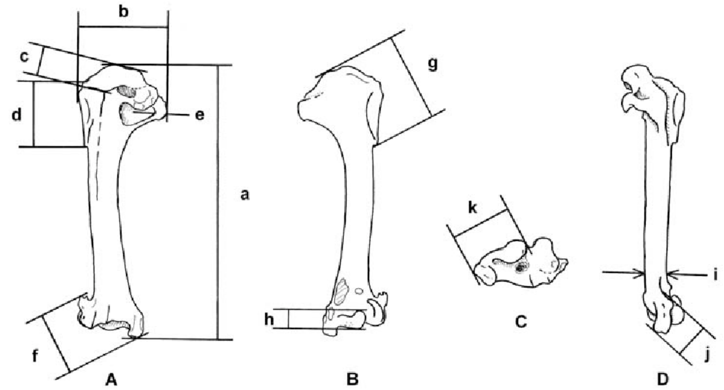

Fig.12. Example of taking measurements on the humerus of the bird.
A – caudal view, B – cranial view, C – distal part, distal view, D – ventral view.
from Wójcik (2002)

5.1 Anatomy

The majority of studied remains have been able to be anatomically identified. Even so, there are also bone fragments that cannot be classified as a specific element. Each bone has been included in one of the different sections of the skeleton: cranial skeleton (skull, quadrate, and mandible), axial (sternum, vertebra, rib, coracoid, furcula, scapula, and pelvis), anterior appendicular (humerus, ulna, radius, carpometacarpal, cuneiform, scapholunate and anterior phalanges) and posterior appendicular (femur, tibiotarsus, tarsometatarsus, fibula, calcaneus, posterior phalanges, and claws).

5.2. Taphonomy

Following the taphonomic analysis of the fossil assemblage we may draw some conclusions concerning the origin and the agents that lead to the accumulation of the animal remains. Caves and rock shelters are places often inhabited by small animals that died or naturally at the site or as prey of mammalian carnivores and/or birds of prey (Rufà et al., 2016). The superposition of different events can lead to a combination of elements that are difficult to distinguish when the bones are studied thousands of years later. Some earlier methods (e.g., Mourer-Chauviré, 1983; Ericson, 1987) based on the proportions of forelimb elements versus leg bones on the one hand, and butchering and burning traces on the other hand tried to assign bird remains to human hunting or predator activity. Nevertheless, bird taphonomy seems to be more complicated and many features of the deposit, the material and faunal composition have to be taken into account in addition.

Birds such as rock dove (*Columba livia*), common raven (*Corvus corax*), and kestrel (*Falco tinnunculus*) probably roosted or nested in the caves or crevices near the caves and might have died naturally there, although some of them were prey of animal predators.

Among the material from previously studied bones with anthropogenic marks were present, however among studied material for this work they have not been discovered yet. On the other hand, some scratch marks are present in a few bones of the anterior appendicular part. These marks indicate that some birds were hunted by carnivores and/or birds of prey.

5.3 Results

5.3.1 Preservation and representation of skeletal elements

The bones generally are not so well preserved. Most of the specimens were preserved in the range of 25 to 50%, where only the proximal and distal ends of the bones and the diaphysis of long elements would be preserved.

In the same way, bones that are among the most fragile parts of the skeleton (bones of the skull, clavicle, vertebrae, fibula, sternum and synsacrum) have not been preserved, which points to not so peaceful conditions of deposition that are a prerequisite for their preservation.

Serjeantson (2009) states that some authors use the ratio of skeletal elements to determine the dominant mode of accumulation. Thus, in the case of accumulation by natural death, all skeletal elements would be equally represented, and the bones in the sediment would mostly be together, sometimes in articulation (depending on post-mortem turbations in the sediment). However, in nature, it is a very rare case that remains are deposited completely undisturbed due to various biogenic and abiogenic factors, so numerous skeletal remains are crushed, transported, eaten, etc.

Although caves are generally a quiet type of terrestrial depositional environment, rock shelters like Crvena Stijena are often used by animals (including humans) who then turn over, disarticulate and chew (and digest) the bones. Humans can further disturb the already deposited bones by their specific behaviour, by digging holes, lighting fire, burying the deceased, etc.

5.3.2. Anatomical representation

Among the material that have been studied, individuals are mostly represented with one skeletal element (one bone) each. The highest density bones (e.g., wing bones) appear to be the most common in the samples together with the posterior appendicular bones, while more fragile elements (bones of the skull, scapula, sternum, ribs, vertebrae) are not preserved well or not preserved at all. This led to conclusion that the accumulation of bones itself was clearly active and dynamic. The best-preserved elements among the material from Crvena Stijena (three or more bones) are the coracoid, humerus, ulna, femur and the raptor claws.

Table 3. shows anatomical representation of different species in the layer M4. While a total of remains (194), 20 bone elements of different individuals were found in this layer, however, a more preserved percentage of the bones appear to be in layer M5 (Table 4). In the M4 layer a very limited number of species were identified (maximum was two bones that were assigned for *Columba livia*). Total number of unidentified bones in this layer is 15, which is 90% of the bones that have been found in this layer. In the M5 layer number of bones count 171, among which 141 were unable to be identified (a high percentage of bones found in fragments). Similar to the layer M4, M5 layer have *Columba livia* as most likely identified species with 11 bones in total, and 5 bones that are assigned to the *Columba* sp. However, *Corvus corax* is absent from the layer M4, on the contrary *Corvus monedula* is equally presented in both layers. Taking into account results for microfaunal remains, layer M5 is very similar to today's fauna of the wider area.

	C. livia	*Columba sp.*	*C. monedula*	*F. tinnunculus*	Unidentified	Total
coracoid			1		0	1
humerus	1				1	2
ulna	1	1			1	3
radius				1		1
carpometacarpus					2	2
tibiotarsus					1	1
tarsometatarsus					1	1
raptor claw					1	1
unidentified					8	8
Total	2	1	1	1	15	20

Table 3. Anatomical representation of layer M4

	A.monachus	*Columba livia*	*Columba sp.*	*Corvus corax*	*C.monedula*	*F.tinnunculus*	*Perdix perdix*	unidentified	Total
coracoid		3		1	1	1		14	20
sternum								1	1
scapula		2						5	7
humerus		3	1	1				10	15
ulna			2					4	6
radius						1		1	2
carpometacarpus							2	4	6
femur		1	2					2	5
tibiotarsus	1					1		1	3
tarsometatarsus		2				2		3	7
phalanx								9	9
raptor claw								5	5
unidentified								85	85
Total	1	11	5	2	1	5	2	144	171

Table 4. Anatomical representation of layer M5

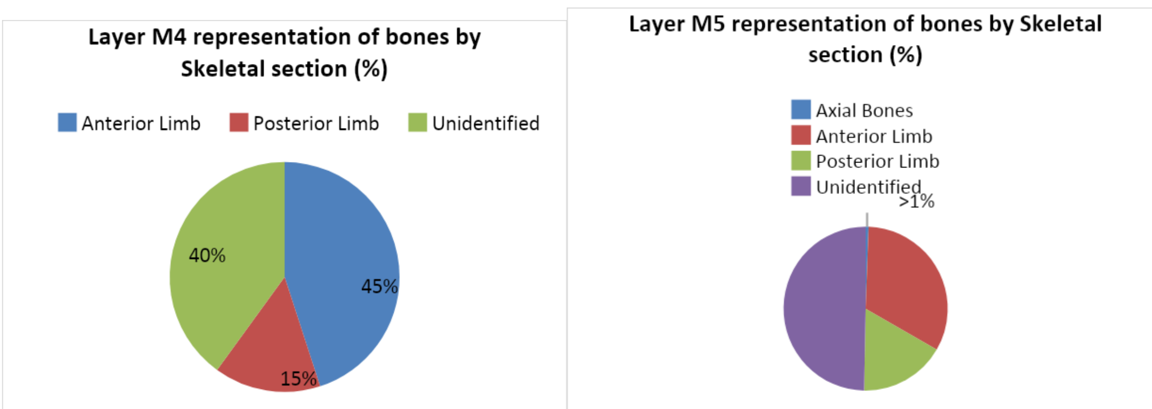

Fig.13. Representation of bones by skeletal section in layer M4 and M5

On Fig.13 the representation of bones by skeletal section are presented. Most of the skeletal section can't be determined in layer M4. The vast majority that can be identified in the layer M5 are limb bones with majority that belong to anterior limbs. There is really one specimen of axial bone which may bring the question of fragility of these bones on the site, but also whether deposition or transport may lead to different preservation. For level M4 there are only a few bones, only 20. In this case 60% of representational bones in this layer belong to limb bones - 45% anterior and 15% posterior limb bones. Similar to level M5, in layer M4 there is a 40% of unidentified bones that came poorly preserved and impossible to determine.

Six raptor claws were found, one in layer M4 and five were extracted from the layer M5 (Table 5.). All claws are different in size and shape, that leads to the conclusion that most probably are from different species. These findings should have more attention in the future taphonomical studies.

5.3.3. NISP

The two accumulations considered in this research show marked differences. Layer M5 sample is the most diverse in terms of biodiversity, with seven bird taxa identified. Layer M4 is less diverse with only four taxa. In terms of the NISP, layer M4 has a value of 5 (Fig.14.) while layer M5 (Fig.15) has 27. If we consider the individual taxon, *Columba livia* is the most abundant bird taxon in layer M4 with 2 total remains, representing 40% of the assemblage. The three other bird taxa present are *Columba sp.*, *C. monedula* and *F. tinnunculus* which make up each 20% of the sample with one remain each.

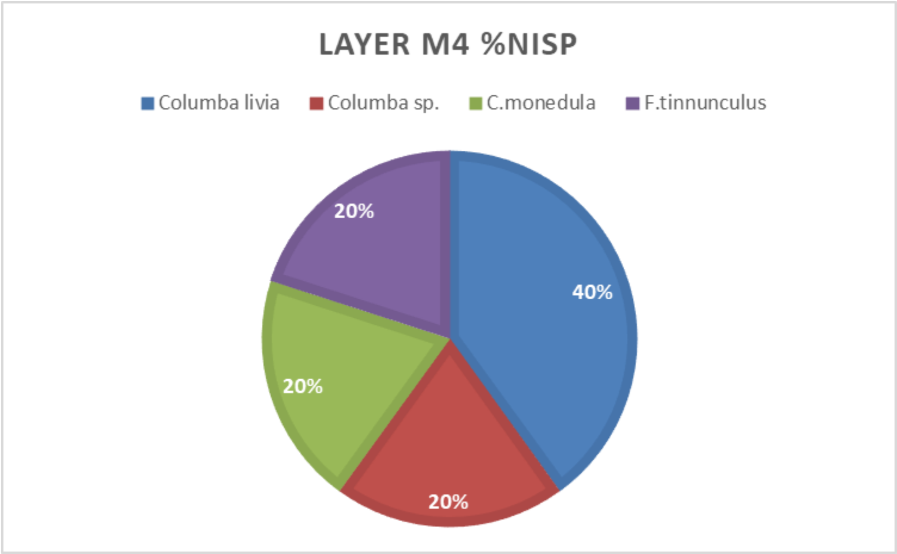

Fig.14. Number of Identified Specimens (NISP) from the layer M4

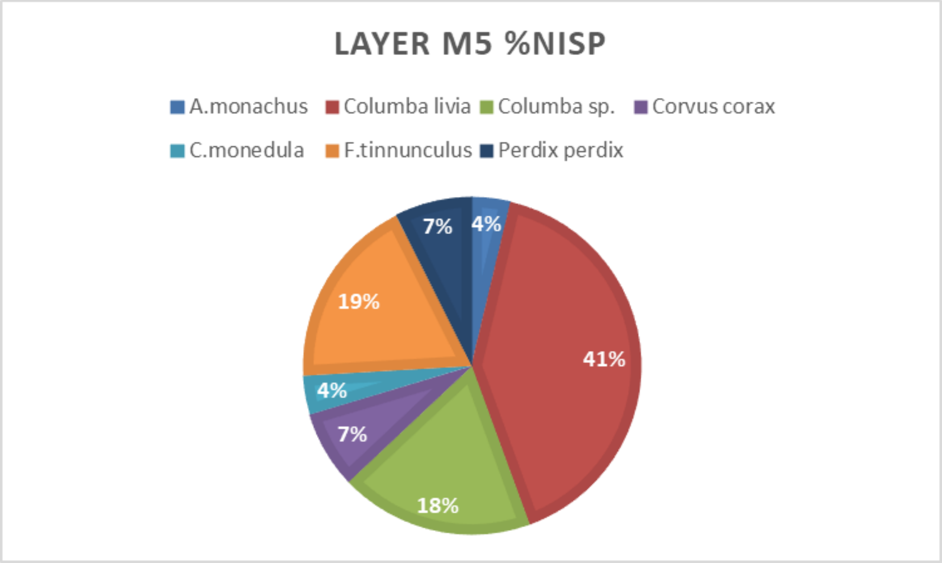

Fig.15. Number of Identified Specimens (NISP) from the layer M5

Layer M5 shows the most abundant values when compared to layer M4. That being said, *Columba livia* is still the most represented taxon in layer M5, with 41% of NISP (Fig. 15). On the other hand, *F. tinnunculus* constitutes the second most abundant with 10 remains representing 19% of the NISP. *Columba sp*. is the third most abundant with a NISP of 6, making up 18% of the total NISP. Other taxon identified including *A. monachus*, *C. corax*, *P. perdix* and *C. monedula*. All of them make up residual values, with *A. monachus* and *C. corax* having 7% representation each, and *P. perdix* and *C. monedula* representing only 4% of the total NISP of layer M5.

5.3.4. Minimal Number of Individuals in the layers M4 and M5

A huge difference is observed between the NISP and MNI of Layer M4. While *Columba sp, C. monedula* and *F. tinnunculus* represent the same percentage in NISP where they make up 20% each, a major drop is observed with *Columba livia*. It shows the same percentage as with other taxa (25%) (Fig. 16), while its NISP was twice the percentage of other taxa (40%).

A similar situation is observed in layer M5 where *Columba livia* which represents the most abundant in NISP but plunges in MNI making it roughly 19% of the total individuals in M5. This reduction puts *Columba livia* MNI at the same value as *Perdix perdix, F. tinnunculus* and *Columba sp*. *Perdix perdix* has 2 distinct individuals out of 2 identifiable remains, which explains the increase in percentage.

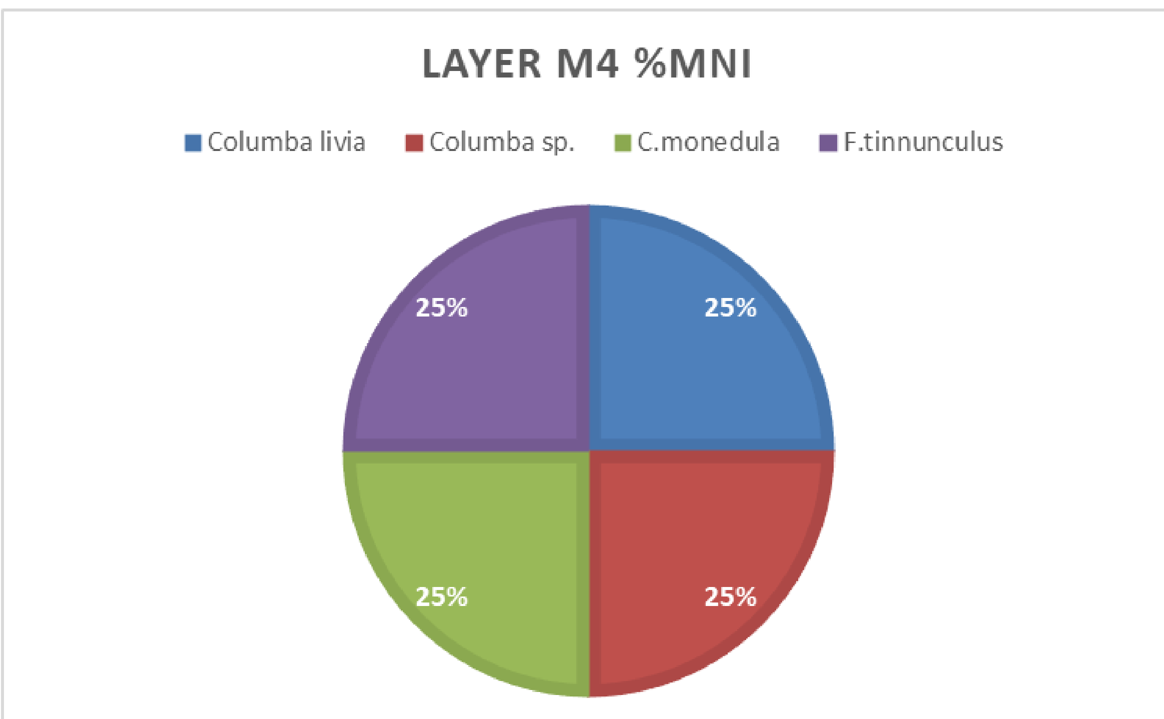

Fig.16. Minimal Number of individuals (MNI) for layer M4

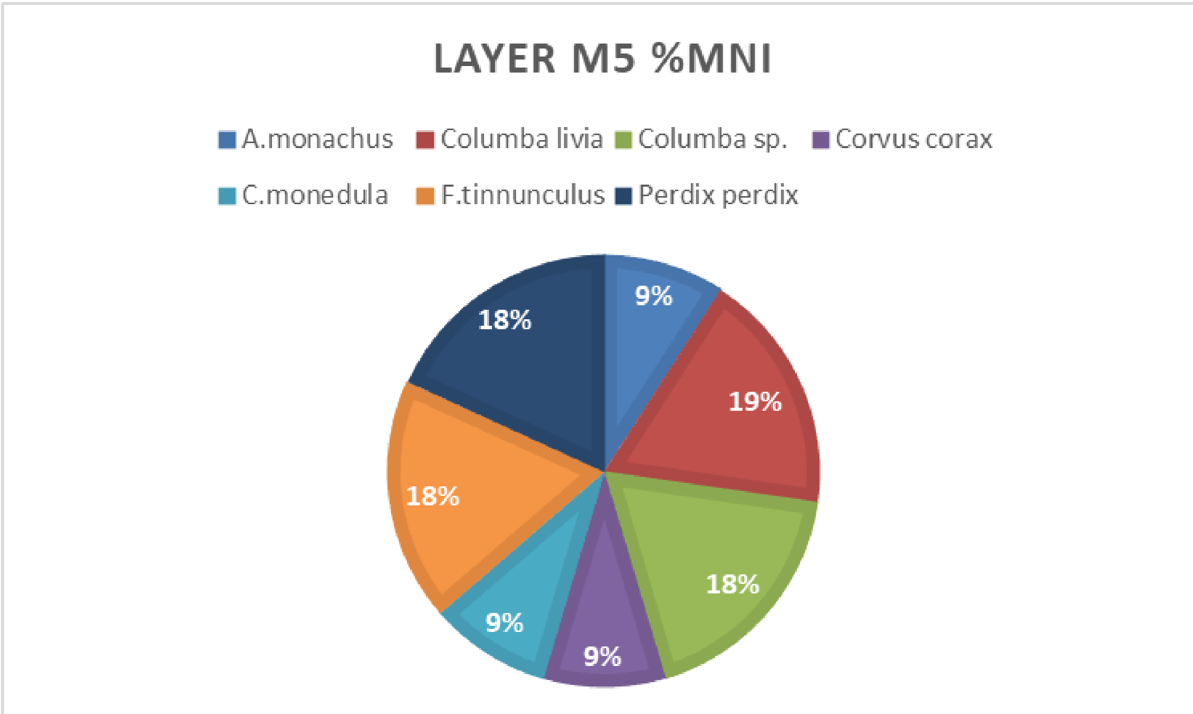

Fig.17. Minimal Number of individuals (MNI) for layer M5

5.4. Systematic paleontology

Unidentified bones are part of every zooarcheological analysis, bone fragments that are either too small or too worn for identification by an archaeologist. From both layers (M4 and M5) 194 bones were collected however, most of which were found fragmented so they were not sufficient for determination.

The anatomical nomenclature follows Baumel and Witmer (1993) and the osteological analysis of Fick (1974), Kessler (2015), Tomek and Bochenski (2000, 2009) and Wójcik (2002) were used to identify the remains. The assemblage is dominated by Columbiformes remains, followed by Corvidae and diurnal birds of prey (Falconiformes and Accipitriformes).

Order Columbiformes Latham, 1790

Material (all partial remains) M4c2-M5

Family Columbidae Illiger, 1811

Genus *Columba* Linnaeus, 1758

Columba livia Gmelin, 1789

Material is from layers M4 and M5. Three coracoid, two scapulae, four humeri, one ulna, one femur, and two tarsometatarsi.

Description. The coracoid has the hook-like morphology of the *facies articularis humeralis* in ventral view, and the edge of *processus supracoracoideus* does not protrude in medial view. From layer M5 there are one left and two right humeri. The one humerus (P88-402) is complete and shows a broader proximal epiphysis and a triangular *crista deltopectoralis* (total length 48.7 mm). The right humerus O88-311 shows broken *crista pectoralis* and *crista bicipitalis*. Distal part of the bone is also broken. In the distal part of tarsometatarsus (total length 28.8 mm) projection of *trochlea metatarsi II* stretches medially (distal view) (Tomek and Bochenski 2009).

Remarks. *Columba livia* inhabits rocky areas and caves near open scrub vegetation (Lowther et al. 2020). It is most common species that have been found in both layers of the site, as well as during the previous studies. Recent studies have shown that Neanderthals exploited *Columba livia* for food on a regular basis (Blasco et al., 2014).

Columba sp.

Material from layer M4 one ulna, layer M5 one humerus, two ulna and 2 femur

Description.

The right humerus O88-366, has a total length of the bone is not possible to measure since the bone is broken. *Processus supracondylaris* is clearly separated from the distal part and forms a knob which is located high. Distal width is 8.1 mm. Based on distal width bone could belong to *C. livia*. However, the size of recovered bones does not allow the distinction between *Columba livia* and *C. oenas*, thus the remains have been assigned to the *Columba* sp. (Fick 1974; Tomek and Bochenski 2009).

Remarks. Three species of the genus *Columba* are present in Europe today, of which *Columba palumbus* can be clearly distinguished anatomically from the other two. *C. livia* and *C.oenas* are very similar in size range and anatomy and can be distinguished only on the basis of small anatomical details on the sternum, ulna and tarsometatarsus (Tomek and Bochenski, 2009; Serjeantson 2009). In cases where these elements were not involved and/or if parts of those elements with distinctive anatomical characteristics were not preserved, it is impossible to attribute the specimen to a specific species.

Order Accipitriformes Vieillot, 1816

Family Accipitiridae Vieillot, 1816

Genus *Aegypius* Savigny, 1809

Aegypius monachus Linnaeus, 1766

Material from layer M5

Description. Determined based only on one bone - epiphysis of right tibiotarsus. Proximal width (i.e., width of articular surface) is 22.2 mm. On the anterior side bone is broken. Bone is compared to online reference (Fig.18).

Remarks. The Cinereous Vulture (*Aegypius monachus*) is a large scavenger, the largest vulture species in Europe today, with a wide distribution spanning from Portugal to China (Ferguson-Lees and Christie, 2001). However, since the birds are sensitive to changes in temperature - this may have been an important factor why this species is not present nowadays in this part of Europe.

Fig.18. Proximal part of tibiotarsus and bone drawing from reference collection

Order Falconiformes Sharpe, 1874

Family Falconidae Vigors, 1824

Genus *Falco* Linnaeus, 1758

Falco tinnunculus Linnaeus, 1758

Material belongs to both layers. Layer M4 one radius. and coracoid, radius, tibiotarsus and tarsometatarsus from the layer M5.

Description.

In total represented in five remains. Distal parts of right radiuses are preserved in both layers (one at each) and in both cases the cranial edge of distal part is curving cranially. From the M5, right tibiotarsus (O88-VQAFT) with the anatomical-morphological structure and proportions of the bone belongs to this *Falco tinnunculus*. There are two tarsometatarsus, both bones belong to the right side of the bird skeleton. Both are from the layer M5. Tarsometatarsus finding marked as N88-149 was compared to the same bone from the Crvena Stijena's reference collection (Fig.19).

Remarks.
This bird of prey has been found in the Pleistocene layers across former Yugoslavia. Mostly inhabiting open or sparsely wooded regions. As previously mentioned *Falco tinnunculus* has been found in previous excavations at Crvena Stijena as well as in Šandalja (Croatia).

Fig.19. Comparison between tarsometatarsus that have been found at the site and the one from the reference collection

Order Passeriformes Linnaeus, 1758

Family Corvidae Leach, 1820

Genus *Corvus* Linnaeus, 1758

Corvus corax Linnaeus, 1758

Material is from layer M5

Description: Species is determined on the right humerus (P88-550, Fig.20) from the layer M5 with total length 44.1 mm and proximal width of 13.7 mm. On the proximal part of the bone, sharp and pointed *tuberculum ventral* and *processus supracondylaris* are visible. In the ventral view, *epycondylus ventralis* form a flat surface. On the distal part of the bone *processus supracondylaris dorsalis* is within the distal articular part. *Sulcus musculi scapulotricipitis* is deep. These characteristics, based on the size and proportions tables provided by Tomek and Bochenski (2009), allows the assignment of the bones to the *Corvus corax*.

Remarks: The largest species of the songbird clade Passeriformes include family Corvidae (crows, ravens, jays and allies). They easily are one of the most recognizable groups of birds given their long and culturally varied association with humans (del Hoyo et al., 2009; Winkler et al., 2020). This species is found throughout its global distribution in all types of habitats, from coastal areas, forest areas, steppe areas, mountainous regions, desert areas and tundras. It is found in more open areas at the northern and southern ends of its range (Boarman and Heinrich, 2020). *Corvus corax* have been discovered in a lot of sites in Croatia, Serbia and Montenegro (Malez, 1973).

Order Passeriformes Linnaeus, 1758

Family Corvidae Leach, 1820

Genus *Corvus* Linnaeus, 1758

Corvus monedula Linnaeus, 1758

Material is from the layers M4 and M5, two right coracoids (N88-LFSBI from M4;P88-556 fromM5)

Description. Based on bone measurements that have been taken with the following measurement table from Tomek and Bochenski (2009) for comparison, bones can be assigned to the *Corvus monedula.*

Remarks. Among sites in Montenegro and Croatia, according to Malez (1973), fossil remains of this species were also familiar from Crvena Stijena. This species has been extracted from the stratum XI and XIII that have been excavated during the 70s. Generally, *Corvus monedula* is typical of forests, whether leafy or coniferous, that border open spaces.

Fig.20. Humerus from the site (left) and from the reference collection (right)

6. CONCLUSION

Previous research exposed many birds that indicate a varied, mosaic-like habitat. In comparation with the small mammal taxonomic identification, the paleoenvironmental condition surrounding Crvena Stijena indicates the predominance of rocky habitat. With the material that has been analyzed for this work, it can be concluded that the studied avifauna in both strata lived on rocky ground and a smaller number of forest inhabitants were also present. The families Falconidae and Corvidae, as well as *Columba* sp. are nesting sites in a wider area even today.

With bird remains from this site is important to consider whether they were associated with people or whether they accumulated naturally. If anthropogenic, were they killed for reasons other than for food? Were the birds killed for feathers or for tools?

As final remarks for this work, the studies of reconstruction of the environment and climate will be carried out in future works in order to be published, following the taphonomic analysis of the avifaunal fossil assemblage. In the future we may draw some conclusions concerning the origin and the agents that lead to the accummulation of the animal remains. With a similar goal, more studies on other environmental proxies will be helpful for better understanding this site and this part of Balkan Peninsula.

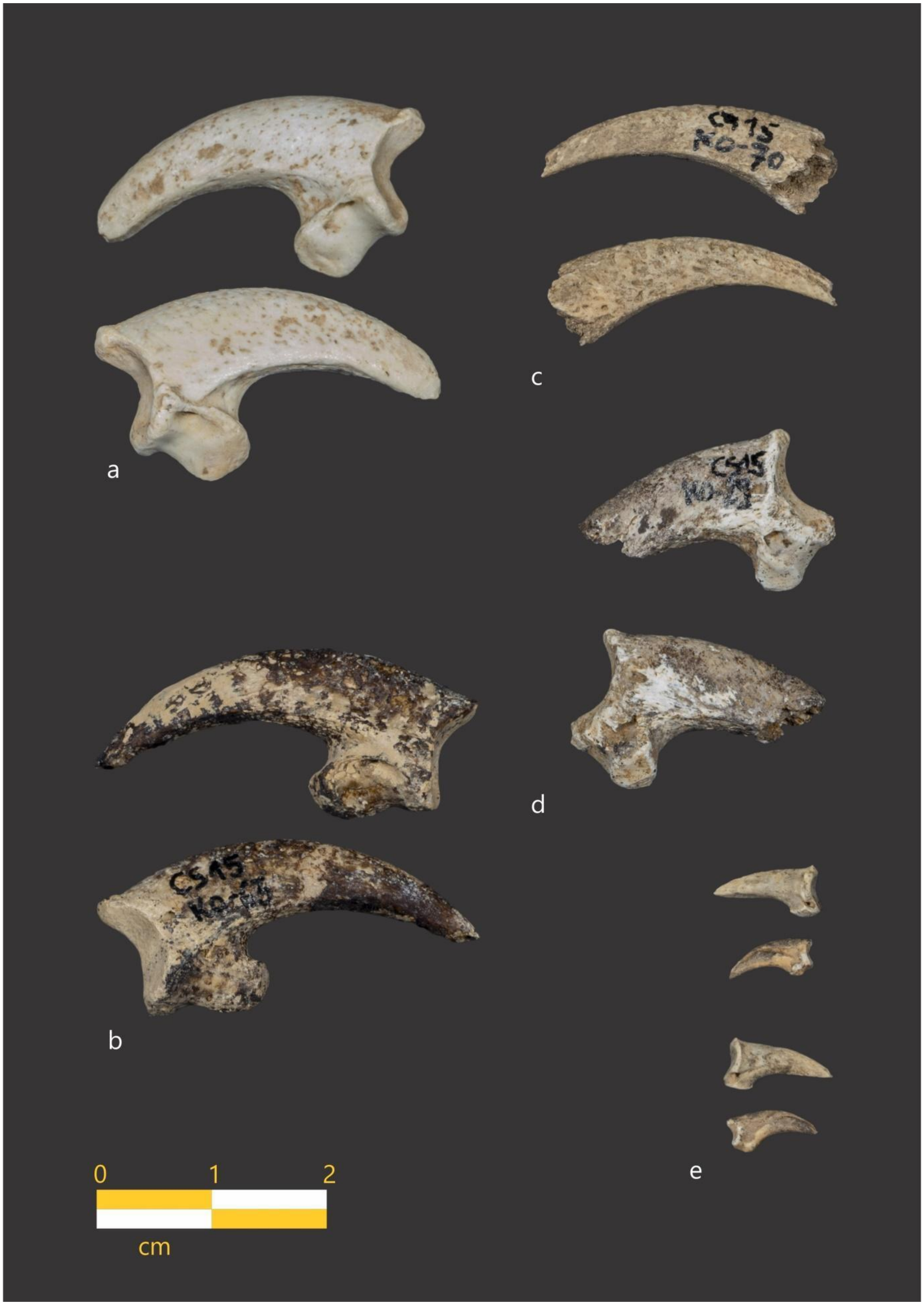

Table 5. Raptor claws from layer M4 and M5

References

Ahern, J.C., Karavanić, I., Paunović, M., Janković, I., and Smith, F.H. 2004. New discoveries and interpretations of hominid fossils and artifacts from Vindija Cave, Croatia. *Journal of human evolution*, 46(1), 27–67. https://doi.org/10.1016/j.jhevol.2003.09.010

Anđelković, M., 1982. *Geologija Jugoslavije - Tektonika*. Beograd: Rudarsko-geološki fakultet.

Bakovic, M., Mihailovic, B., Mihailovic, D., Morley, M., Vusovic-Lucic, Z., Whallon, R., Woodward, J., 2009. Crvena Stijena excavations 2004-2006, preliminary report. *Eurasian Prehistory* 6(1-2), 3-31.

Basler, Dj. 1975. "Старији литички периоди у Црвеној Стијени". In: Ђ. Базлер (ed.) *Црвена Стијена – Зборник радова*. Никшић: Заједница културних установа, 11–120.

Baumel, J.J., Witmer, L.M. 1993. 'Osteologia'. In: J.J. Baumel (ed.) *Handbook of Avian Anatomy: Nomina Anatomica Avium*. Publications of the Nuttal Ornithological Club, 23, Cambridge.

Boarman, W. I., Heinrich, B. (2020). Common Raven (*Corvus corax*), version 1.0. En: Billerman, S. M. (Ed.). *Birds of the World*. Cornell Lab of Ornithology, Ithaca, NY, USA.

Boev, Z., Milošević, S. 2020. Late Pleistocene avifauna of the Pešturina Cave (Nišava District, SE Serbia) and its implications for Late Pleistocene refugia on the Central Balkans. *Bull. Nat. Hist. Mus. Plovdiv*, vol. 5, 1-14.

Carrera, L., Pavia, M., and Varela, S. 2022. Birds adapted to cold conditions show greater changes in range size related to past climatic oscillations than temperate birds. *Sci. Rep.* 12, 10813.

Casinos, A., Cubo, J. 2001. Avian long bones, flight and bipedalism. *Comparative biochemistry and physiology. Part A, Molecular & integrative physiology*, 131(1), 159–167. https://doi.org/10.1016/s1095-6433(01)00463-9

Derevianko, A.P., Shunkov, M.V., Bulatovic, L., Anoykin, A.A., Ulianov, V.A., Kozlikin, M., and Medenica, I. 2019. New Results of Research at the Mališina Stijena Rock Shelter in Montenegro. *Problems of Archaeology, Ethnography, Anthropology of Siberia and Neighboring Territories*, 25, 95-102. 10.17746/2658-6193.2019.25.095-102.

Feduccia, A., 1999. *The Origin and Evolution of Birds, second edition*. Yale University Press, New Haven, CT, USA.

Fergusson-Lees, J., Christie, D. 2001. *Raptors of the world*. London, United Kingdom: Christopher Helm.

Fick, O.K.W. 1974. *Vergleichend morphologische Untersuchungen an Einzelknochen europäischer Taubenarten*. Diss. med. vet., LMU-München.

Frayer, D.W. 2006. *The Krapina Neandertals: A Comprehensive, Centennial, Illustrated Bibliography*. Zagreb: Croatian Natural History Museum.

Fromm, A., Meiri, S., McGuire, J. 2021. Big, flightless, insular and dead: Characterizing the extinct birds of the Quaternary. *Journal of Biogeography*, 48, 2350–2359.

Gorjanović-Kramberger, D. 1906. *Der Diluvijale Mensch von Krapina in Kroatien. Ein Bertrag zur Paläoanthropologie*. Kreidel: Wiesbaden.

Harrison, C.J.O. 1982. *An Atlas of the Birds of the Western Palearctic*. Princeton University Press, Princeton.

Harvati, K., Roksandic, M. (Eds.). 2016. *Paleoanthropology of the Balkans and Anatolia. Vertebrate Paleobiology and Paleoanthropology*. Springer.

Hoyo J. del, Elliott, A., and Christie, D.A. 2009. *Handbook of the birds of the world*. Barcelona: Lynx Edicions.

Jovanović, M. 2021. *Pleistocene small-vertebrates (amphibians, reptiles, and small mammals) studies in Serbia (Balkan Peninsula, SE Europe): history of research, methodological state of the art, and paleoclimatic and paleoenvironmental reconstructions*, Doctoral dissertation.

Karavanić, I., Miracle, P.T., Culiberg, M., Kurtanjek, D., Zupanič, J., Golubić, V., Paunović, M., Lenardić, J.M., Malez, V., Šošić, R., Janković, I., and Smith, F.H. 2008. The Middle Paleolithic from Mujina Pećina, Dalmatia, Croatia. *Journal of Field Archaeology*, 33(3), 259–277. http://www.jstor.org/stable/25608514

Kessler, J.(E.). 2015. Osteological guide of songbirds from Central Europe. *Ornis Hungarica*, 23(2), 62–155. doi:10.1515/orhu-2()015-0016

Lang, N., Wolff, E.W. 2011. Interglacial and glacial variability from the last 800 ka in marine, ice and terrestrial archives, *Clim. Past*, 7, 361–380. https://doi.org/10.5194/cp-7-361-2011

Lowther, P.E., Johnston, R.F. 2020. 'Rock Pigeon (Columba livia), version 1.0.' In: Billerman, S.M. (ed.), *Birds of the World*. Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.rocpig.01

Majkić, A., d'Errico, F., Milošević, S., Mihailović, D., and Dimitrijević, V. 2017. Sequential incisions on a cave bear bone from the Middle Paleolithic of Pešturina Cave, Serbia. *Journal of Archaeological Method and Theory*, 25(1), 69-116.

Malez, M. 1963. 'Aves'. In: Malez, M., Salopek, M. (Eds.), *Kvartarna fauna pecine Veternice u Medvednici*, RAD Jugoslovenske Akademije Znatnosti i Umetnosti, 5, 136-140.

Malez, V. 1983: Birds in the food and art of Paleolithic hunter in the region of southeastern Yugoslavia. *Naš krš*, 9(14-15), 95-109.

Mayr, G. 2016. *Avian Evolution: The Fossil Record of Birds and its Paleobiological Significance*. Chichester: John Wiley & Sons, Ltd.

Monnier, G.F. 2006. The Lower/Middle Paleolithic Periodization in Western Europe: An Evaluation, *Current Anthropology* 47(5), 709–744.

Monnier, G., Tostevin, G., Pajović, G., Borovinić, N., and Baković, M. 2020. Nova istraživanja paleolitskog nalazišta Crvena Stijena, istorijski kontekst. *Istorijski Zapisi*, godina XCIII, 1-2.

Ненадић, Д., Богићевић, К. 2010. *Геологија квартара*. Београд: Рударско-геолошки факултет Универзитета у Београду.

Patou-Mathis, M. 1997. Analyses Taphonomique et Palethnographique Du Matériel Osseux de Krapina (Croatie): Nouvelles Données Sur La Faune et Les Restes Humains. *Préhistoire Européenne,* 10, 63–90.

Radovanović, I. 1986. Novija Istraživanja Paleolita i Mezolita u Crnoj Gori. *Glasnik Srpskog Arheološkog Društva,* 3, 63–76.

Radovčić, D., Sršen, A. O., Radovčić, J., & Frayer, D. W. 2015. Evidence for Neandertal jewelry: modified white-tailed eagle claws at Krapina. *PloS one, 10*(3), e0119802.

Rakić, M., Rakovec, I., 1961. *Mladopleistocenska favna iz Parske golobine v Pivški kotlini*. Slovenska Akademija znanosti in umetnosti.

Rakić, M., Dimitrijević, M.D., (Eds.) 1973. *Basic Geological Map SFRJ 1:100,000. Textual Explanation for the sheet Niš.* Belgrade: Federal Geological Survey. (In Serbian).

Rink, W.J., Schwarcz, H.P., Smith, F.H., and Radovčić. 1995. ESR ages for Krapina hominids. *Nature*, 378(6552), 24.

Ruiz-Redondo, A., Garate, D., González-Morales, M. R., Jankovíc, I., Jaubert, J., Karavanić, I., Komšo, D., Kuhn, S. L., Mihailovíc, D., Moro Abadía, Ó., Vander Linden, M. and Vukosavljević, N., 2020. Beyond the bounds of western Europe: Paleolithic art in the Balkan peninsula. *Journal of World Prehistory*, 33, 425-455.

Rufà, A., Blasco, R., Rivals, F., Rosell, J., 2016. Who eats whom? Taphonomic analysis of the avian record from the Middle Paleolithic site of Teixoneres Cave (Moià, Barcelona, Spain). *Quaternary International,* 421, 103-115.

Serjeantson, D. 2009. *Birds (Cambridge Manuals in Archaeology)*. Cambridge: Cambridge University Press.

Smith, F. H. 1976. The Neandertal remains from Krapina, northern Yugoslavia: An inventory of the upper limb remains. *Zeitschrift Für Morphologie Und Anthropologie*, 67(3), 275–290. http://www.jstor.org/stable/25756274

Šarić, J. 2013. Smolućka cave: Unpublished chipped stone artifacts from excavations in 1987. *Starinar*, 63, 9-21.

Tomek, T., Bochenski, Z.M. 2000. *The Comparative Osteology of European Corvids (Aves: Corvidae), with a Key to the I*dentification of their *Skeletal Elements*. Krakow: Polish Academy of Sciences, Institute of Systemics and Evolution of Animals.

Tomek, T., Bochenski, Z.M. 2009. *Key to the Identification of Domestic Bird Bones in Europe: Galliformes and Columbiformes.* Krakow: Institute of Systematics and Evolution of Animals, Polish Academy of Sciences.

Vujisić, T.J., Navala, M. (eds.). 1980. *Osnovna geološka karta SFRJ 1:100 000. Tumač za list Bela Palanka*. Beograd: Savezni geološki zavod / SGZ.

Whallon, R. (ed.), 2017. *Crvena Stijena in Cultural and Ecological Context: Multidisciplinary Archaeological Research in Montenegro*. Podgorica: Montenegrin Academy of Sciences and Arts and National Museum of Montenegro.

White, T.D. 2001. Once Were Cannibals. *Scientific American*, 265, 47–55.

Winkler, D.W., Billerman, S.M., and Lovette, I.J., 2020. 'Crows, jays, and magpies (Corvidae), version 1.0.' In: Billerman, S.M., Keeney, B.K., Rodewald, P.G., and Schulenberg, T.S. (Eds.), *Birds of the World*. Cornell Lab of Ornithology, Ithaca, NY, USA.

Wójcik, J.D., 2002. The comparative osteology of the humerus in European thrushes (Aves: Turdus) including a comparison with other similarly sized genera of passerine birds – preliminary results. *Acta Zoologica Cracoviensia*, 45, 369-381.

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