

Article

Bird Exploitation and Chicken Size in the Late Medieval and Early Modern Periods in Continental Croatia

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Abstract: The significance of birds in the medieval human diet has been greatly explored in Europe. However, there is a lack of systematic analysis of data from Croatia. Avian remains dated to the Late Medieval and Early Modern Periods from five archaeological sites in continental Croatia underwent skeletal and taxonomic analysis. Age groups were determined and sex identification was conducted using visual and X-ray diagnostics. Chicken bone measurements were taken, and the logarithmic size index (LSI) technique was performed. Statistical analysis was applied to explore differences between sites. A total of 694 avian remains were studied, revealing 10 species/genera. Avian remains ranged from 8.88% to 20.32% across sites, with the highest percentage found at the urban site BAN. Hens outnumbered cockerels across all sites, with adult chickens prevailing over immature and subadult ones. Chicken sizes were generally consistent across sites, except for castle MIL, where a larger breed was identified. Cockerels tended to be larger than hens, except for one small-sized spurred specimen. To conclude, bird exploitation complemented the use of other animals in diets. Chickens were vital for eggs and meat, with monasteries excelling in bird husbandry over castles. Inhabitants of urban areas mainly consumed bird meat. Castles showed high status through game and imported birds. The aim of this article was to fill in the gap of information regarding the exploitation and consumption of birds at Croatian sites during the Late Medieval and Early Modern Periods.

Keywords: birds; medieval period; Early Modern Period; archaeozoology; size; Croatia

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1. Introduction

Throughout history, birds have always been part of human everyday life. Archaeological evidence has shown that they were considered symbolic and sacrifice animals in the past [1–6] as well as food sources [3,7]. From the Neolithic, wild birds were hunted for meat, mostly in small quantities, but from the 500 BC onward, when domestic chicken became more widespread, bird meat became more important in the human diet [7]. As well as for bird meat, which was used as a protein source, birds were exploited for egg production, feathers, fat, and liver, whereas bones were crafted into tools. Moreover, trained birds took part in hawking and cockfighting and were bred as companion animals [7]. Birds were very rarely the primary source of protein [8], which is nowadays true for most European countries. They served as an addition to the meat diet based mainly on domestic mammals such as pigs, cattle, sheep, and goat and were not classified in the same category as the meat of quadruped animals in medieval Europe [3,9].

Due to their structure, ancient avian bones represent very challenging study material. Avian bones are frequently smaller than the bones of domestic mammals and more delicate, especially those of small avian species. Moreover, they are often missed in the recovery process during archaeological excavations [7,10]. That is why analysing avian bones from archaeological sites has always been in the shadow of wild and domestic mammal bone remains. Sampling archaeozoological material by sieving deposits increases the amount of avian material that will be found [11]. Consequently, more avian bones are included in archaeozoological analyses.

Society in the Middle Ages was divided into different social statuses. People of low social status typically lived in rural areas, while individuals of various social ranks resided in towns. High-status inhabitants, i.e., nobility, lived in castles. The clergy had a more complex social structure: it included archbishops and bishops, often from noble families or noble lords themselves, as well as ordinary monks who were of low social status [12–14]. Various studies have shown that chicken, as the most common bird species in the archaeozoological material of medieval Europe, was present in the diet of all social ranks, i.e., townspeople, nobility, and inhabitants of rural and monastic areas [15–21]. Aside from chicken, wild bird consumption became more common in the Middle Ages [8]. Indicators of social status and certain food rules can be detected in archaeozoological bird material. Therefore, the diversity of bird species present at the archaeological site may indicate the social status of its inhabitants. More species are present on high status sites, especially wild ones. Even though they were not necessarily tastier than domestic ones, they were eaten as a display of wealth and hunting rights which were reserved only for the nobility [14,22]. Such a diet pattern was often observed in nobility in castles; however, it was also recorded in the diet of the urban and ecclesiastical elite [14,23,24]. Therefore, during the banquets organized by the nobility, many wild birds such as partridge, swan, pheasant, stork, and heron were on the menu [14,25]. At high-status sites, the consumption of young birds' meat, such as chicks and capons, was recorded [26]. The importance of a chicken meat, especially of young animals, during celebrations and guest dinners was also addressed in a document from the 15th century which states that Croatian bishop Osvald Thuz in Zagreb ordered young chicks for a meal with bishop Jan Filipac who was coming to visit [27]. The diet of the clergy was influenced by Christian church beliefs, especially the diet of the monks of the Benedictine order, who followed strict food rules that prohibited the consummation of quadruped meat [12]. Thus, one could expect fish and bird in surplus in the monks' diet, but some research showed that they did not strictly follow the rule [28,29], and the higher-ranked priests were excused from rules when having guests [14]. On the contrary, during the days of celebration, for example, Easter, capons, pigeons, and eggs prevailed in the diet, while at Christmas, the goose was often on the menu of secular and ecclesiastic nobility. Gentry, who presented middle social status, also consumed capons and pigeons during feast days [25,30]. On the contrary, inhabitants of rural sites consumed more chicken eggs and ate older animals because they could not afford to sacrifice animals before they stopped laying eggs [18]. Therefore, differences in diets were connected to social status, that is, what one could individually afford and had permission to eat [31].

Climatic and geographical differences, together with cultural traditions linked to food consumption and eating habits, had a profound impact on the diet of each European society, which varied both by region and by social group [9]. A large number of studies have shown the importance of birds in the medieval diet all over Europe [18,20,21,23,32], but there are very few studies from the Balkan Peninsula [16,19]. However, no systematic data from Croatia have been published yet. There is evidence of bird consumption in the Late Medieval and Early Modern Periods from castles and rural settlements in Continental Croatia, with chicken being the most common bird in the diet. However, it was eaten just as an addition to the main protein sources like pork and beef [33–39].

In this study, we analyse avian remains from five archaeological sites in Croatia. Morphological and biometrical analyses were performed in order to explore whether the

bird consumption and exploitation at archaeological sites from the Late Medieval and Early Modern Periods in continental Croatia was influenced by the differences in the social status of their inhabitants and the purpose of the site (monasteries, castles, and cities).

2. Material and Methods

2.1. Description of Archaeological Sites

Material for this research was excavated from 2010 until 2022 from five archaeological sites in continental Croatia (Figure 1). The archaeological site Plemički grad Vrbovec (abbrev. PGV), located in Zagreb County, was built in the 14th century and served as a defensive fortress of the high nobility families [40]. Stari grad Milengrad (MIL), located in Krapina-Zagorje County, was built in the 14th century on Ivanščica hill and served as a medieval high nobility manor [41]. The Pauline monastery of All Saints in Streza (STR) is in Bjelovar-Bilogora County and was built in the 14th century [42]. Over the years, Pauline monks in STR developed excellent management of their properties, which kept them in great social status [43]. The Benedictine monastery of St. Michael (RUD), located in the Požega-Slavonia County near Rudina, was built and established in the 12th century by a nobility family [44,45]. Urban site Banski dvori (BAN) is in Zagreb, today's capital city of Croatia. Historically, it was the prestigious block of the medieval town Gradec, an important trade and financial centre established in 1242 [46]. In total, the material originated from two castles (PGV and MIL), two monasteries (STR and RUD), and one urban site (BAN). Animal remains from those archaeological sites date back to the Late Medieval and Early Modern Periods (13th–16th century). The Croatian Conservation Institute and Institute of Archaeology, Zagreb, Croatia, carried out excavations of all archaeological sites.

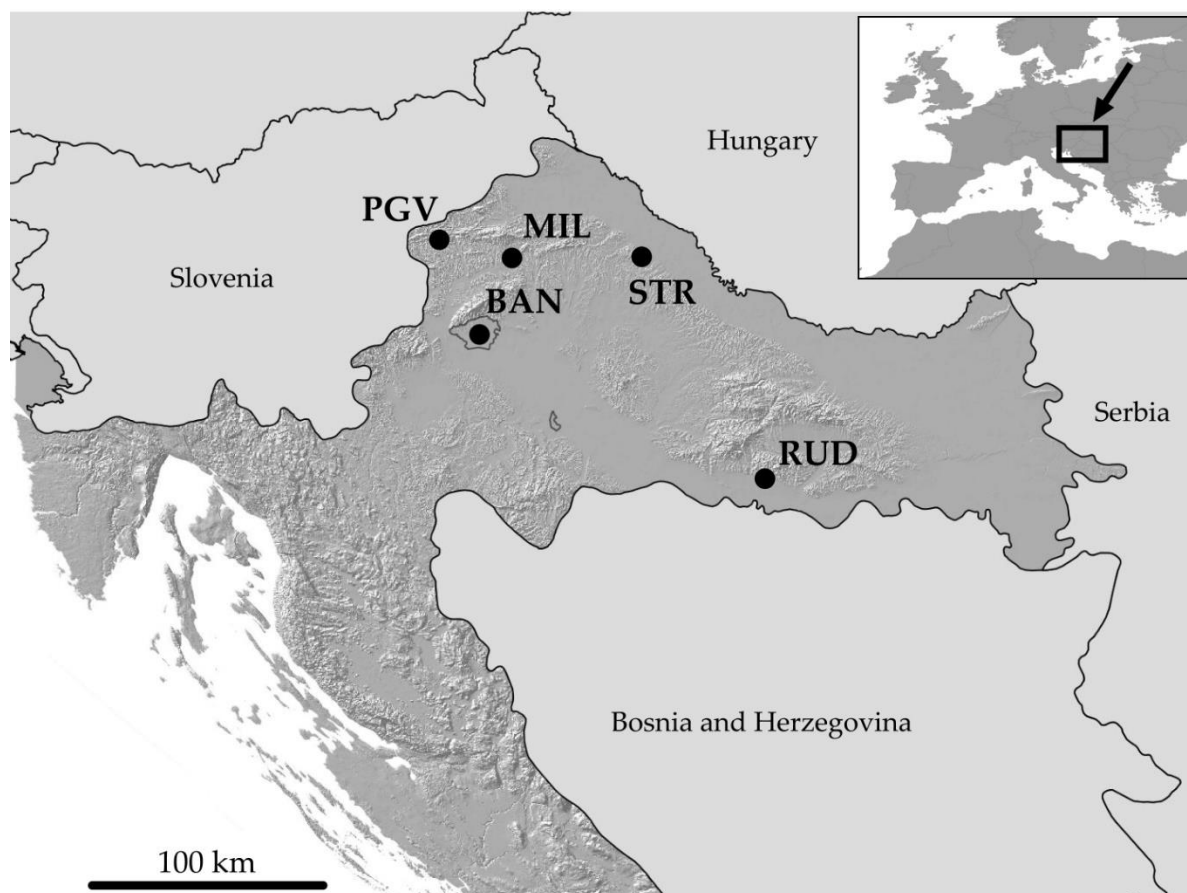


Figure 1. Map of Croatia with marked locations of analysed archaeological sites. PGV—Pleмиčki grad Vrbovec, MIL—Stari grad Milengrad, STR—Pauline monastery of All Saints, RUD—

Benedictine monastery of St. Michael, BAN—Banski dvori. In the top right corner, the arrow and rectangle indicate the position of Croatia on the European continent.

2.2. Material Recovery

The material was recovered without sieving according to standard archaeological excavation protocols. After the animal material was excavated, it was stored in plastic bags with accompanying information on site and transported to the Archaeozoological Laboratory of the Department of Anatomy, Histology and Embryology, Faculty of Veterinary Medicine, University of Zagreb, Croatia.

2.3. Identifications of Species and Skeletal Elements Frequency

In the laboratory, the material was washed and dried, and avian bones were isolated from other animal remains and analysed. Bones were skeletally and taxonomically determined. Taxonomic determination was carried out by comparison of the material with the reference collection of our laboratory and descriptions from books and papers [47–49]. Differences between species of orders Galliformes and Columbiformes were determined according to Tomek and Bocheński [50]. When the exact species could not be determined, the avian remains were assigned to a higher taxonomic or generic group, birds (Aves). For the skeletal determination, veterinary anatomy books were used [51,52]. All skeletal elements were recorded and used to calculate the number of identified specimens (NISP). To explore the abundance of certain body parts of chicken per archaeological sites, bone remains were selected and grouped as follows: wing bones (humerus, ulna and carpometacarpus) and leg bones (femur, tibiotarsus and tarsometatarsus). Based on NISP, an abundance of each bird species per archaeological site was calculated. Also, a minimum number of individuals (MNI) was calculated using the most numerous bone elements considering the body side.

2.4. Sex and Age Determination

In Galliforms, the sex was determined based on the presence of spur or spur scar on tarsometatarsi which is a reliable method of sexing Galliforms although some hens can develop spurs [7]. Females were determined by the absence of spurs and spur scars only on fully fused tarsometatarsi, while males were determined based on the presence of spurs or spur scars on both fused and unfused tarsometatarsi. The spur scar starts to develop at approximately four months of age when the fusion of the proximal epiphysis of tarsometatarsus with the shaft is usually finished, but in rare cases of delayed fusion, spur or spur scar can occur before fusion is finished [7]. Furthermore, sex was determined based on the presence of medullary bone in selected long bones (humerus, ulna, femur, and tibiotarsus), which is a characteristic structure found exclusively in female birds. Intact bones were radiologically examined with a Siemens Multix Compact K + LG flat panel digital detector (40 kV and 0.56/0.8 mAs) at the Department of Radiology, Ultrasound Diagnostics and Physical Therapy, Faculty of Veterinary Medicine, University of Zagreb, for the presence of the medullary bone, which is seen as increased radiopacity in medullary cavity of the long bones [53]. Broken bones were visually examined with the naked eye and magnifying lamp because the medullary bone can be seen on the inner surface of the cortical bone as a thin layer of a non-structural type of bone or it can fill up the whole medullary cavity [54]. The age of the studied specimens was estimated based on the fusion of epiphyses with the shaft and the bone porosity. Birds were categorized into three age groups: immature, subadult, and adult. All bones with epiphyses fully fused to the shaft were categorized as adult, bones with visible epiphyseal line as subadult, and unfused and porous bones as immature (adjusted according to Serjeantson, Table 3.6. [7]).

2.5. Butchery Marks

All bones analysed in this study were visually examined under the magnifying lamp for cut and chop marks. When present, marks were recorded with data on their position on the bone, the direction of chop according to standard animal body planes (sagittal, transversal, horizontal), and their number.

2.6. Biometry

Only fully fused chicken and Columbidae bones were measured with a measuring scale in millimetres, according to Von den Driesch [55]. Differences in chicken size between archaeological sites were determined according to the logarithmic size index (LSI). Bone measurements were converted in log10 base and deduced from the same base of standard measurements [56]. The standard chicken measurements for this technique were from a work published by Welker et al. [57], since there are no biometrical data for chicken of the local breed. Measurements taken for this analysis, together with the standard chicken measurements, are listed in Table 1. Length and breadth measurements were separately analysed because they are not equally variable [58]. Also, to find size differences between cockerels and hens, a scatter plot diagram with the greatest length (GL) and breadth of the proximal end (Bp) of metatarsi was made [59]. Columbidae bone measurements were used for the identification of species following Tomek and Bocheński [50].

Table 1. Bone measurements used in the analysis and the standard chicken measurements used for log ratio diagrams in millimetres published by Welker et al. [57].

Bone	Greatest Length (GL)	Breadth of Distal End (Bd)	Breadth of Basal Articular Surface (BF)	Diagonal of Distal End (Did)
femur	82.91	16.64		
tibiotarsus	118.39	12.31		
tarsometatarsus	81.07	14.66		
humerus	75.52	16.21		
os coracoideum	57.29		13.21	
ulna	74.29			10.17
carpometacarpus	40.49			

2.7. Statistics

The Pearson's chi-square test was performed to assess whether significant differences exist between the total number of animals and the number of birds (NISP), the sex and age groups of chickens, and the number of wing and leg bones of chicken across the analysed sites. Since the chi-square tests are statistically powerful, we have calculated effect size measures, specifically phi (ϕ) coefficient, to complement our chi-square test results. To determine the variations in chicken size between the sites, the Mann–Whitney U test was used. The level of statistical significance was set at $p < 0.05$, and statistical analyses were performed using the program STATISTICA version 14.0.25 [60].

3. Results

3.1. Frequency of Bird Remains and Skeletal Element Frequency

In our study, a total of 694 avian remains were documented across all five archaeological sites. The distribution of avian remains per site, compared to the total number of animals remains (Total NISP), is presented in Table 2. The average percentage of avian remains per site is 11.40%. Urban site BAN exhibited the highest percentage of avian remains (20.32%), while castle site MIL had the lowest (8.88%). When compared to all other archaeological sites, BAN had a significantly higher ($p < 0.05$) number of avian

remains. However, the relationship between the variables is not strong enough to be considered highly influential because the phi (ϕ) coefficient was approximately 0.1.

Table 2. The total number of animals remains (Total NISP), the number of avian remains (Avian NISP), and the percentage of identified specimens (% NISP birds) of all avian remains per archaeological site.

Archaeological Site	Total NISP	Avian NISP	% NISP Birds
BAN	443	90	20.32%
STR	596	84	14.09%
PGV	2146	251	11.70%
RUD	1302	127	9.75%
MIL	1600	142	8.88%

In total, 10 bird taxa were determined at the studied archaeological sites (Table 3, Figure 2). Chicken (*Gallus domesticus*) and duck (*Anas* sp.) were the only bird taxa found at all sites. Chicken was the most common avian species (75.00–93.33%) at all sites, while the duck was represented in very small numbers (1.11–2.79%). Geese (*Anser* sp.) were found at PGV, MIL, STR, and BAN, while turkey was found (*Meleagris gallopavo*) at MIL, STR, and BAN. Columbidae were represented by three remains which are determined as follows: one humerus of European turtle dove (*Streptopelia turtur*) at MIL, one radius of either rock dove (*Columba livia*) or a stock dove (*Columba oenas*), and another Columbidae sternum that could not be determined to the species level, both at RUD. Pheasant (*Phasianus colchicus*) and swan (*Cygnus* sp.) were found at PGV. Corvid (Corvidae) remains was recovered from STR and peafowl (*Pavo* sp.) from MIL. A small percentage (6.92%) of the avian remains could not be attributed to a certain bird species or family, and hence they were sorted in the group of birds (Aves). The minimum number of individuals (MNI) follows the avian NISP calculations and confirms that chicken is the most abundant species on all sites (Table 3).

Table 3. Representation of skeletal elements, number of identified specimens (NISP), and minimum number of individuals (MNI) of all avian remains per archaeological site.

Archaeological Sites	PGV						MIL						STR						RUD				BAN					
Skeletal Element	Chicken	Goose	Duck	Swan	Pheasant	Birds	Chicken	Goose	Duck	Turkey	Peafowl	European Turtle Dove	Birds	Chicken	Goose	Duck	Turkey	Corvid	Birds	Chicken	Duck	Columbidae	Birds	Chicken	Goose	Duck	Turkey	Birds
Cranium	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Vertebrae	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synsacrum	-	-	-	-	-	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternum	7	-	-	-	-	-	2	-	1	-	-	-	-	3	-	-	-	-	-	7	-	1	-	1	-	-	-	1
Furcula	1	-	-	-	-	-	3	-	-	-	-	-	-	1	-	1	-	-	-	1	-	-	-	3	-	-	-	-
Os coracoideum	13	1	2	-	1	-	13	1	1	-	-	-	1	5	1	-	-	-	-	6	-	-	-	4	-	-	-	-
Scapula	8	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	2	6	-	-	-	-
Humerus	41	4	-	1	-	-	17	3 *	-	3 *	-	1	3 *	11	1	-	-	-	2	19 *	-	-	4	9	-	1	-	-
Radius	6	-	1	-	-	-	13	1	-	-	-	-	-	6	1	-	-	-	-	7	-	1	1	4	1	-	-	-
Ulna	29	6	1	-	-	-	8	1	-	1	1	-	-	3	2	1	-	-	-	16	-	-	1	10	-	-	-	-
Carpometacarpus	1	2	-	-	-	-	5	2	-	1	-	-	-	1	2	-	-	-	-	2	1	-	-	-	-	-	-	-
Pelvis	1	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	3	-	-	-	-
Femur	22	-	1	-	-	-	15	-	-	1	-	-	-	9	-	-	1	-	-	10	-	-	4	16	1	-	1	-
Tibiotarsus	46 *	7 *	1	-	-	8 *	22 *	2	-	-	-	-	3	10 *	3 *	-	-	-	2 *	16	1	-	10 *	19 *	-	-	-	-
Fibula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Tarsometatarsus	29	5	1	-	1	2	9	1	-	-	-	-	2	8	2	-	-	1	1	9	-	-	1	9	-	-	-	-
Phalanx	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NISP	205	26	7	1	2	10	110	12	3	6	1	1	9	63	12	2	1	1	5	100	2	2	23	84	3	1	1	1
MNI	24	4	1	1	1	5	12	3	1	3	1	1	3	9	2	1	1	1	2	13	1	1	4	11	1	1	1	1

* Bones used for the calculation of MNI (when the MNI value is 1, the bone used for calculation is not marked).



Figure 2. Selected avian remains from analysed archaeological sites. (a): Pheasant (*Phasianus colchicus*) tarsometatarsus from site PGV; (b): corvid (*Corvidae*) tarsometatarsus from site STR; (c): European turtle dove (*Streptopelia turtur*) humerus from site MIL; (d): peafowl (*Pavo* sp.) ulna from site MIL; (e): swan (*Cygnus* sp.) humerus with chop marks (marked with arrows) from site PGV; (f): duck (*Anas* sp.) ulna from site PGV; (g): duck (*Anas* sp.) tibiotarsus from site RUD; (h): goose (*Anser* sp.) carpometacarpus from site STR; (i): goose (*Anser* sp.) femur from site BAN; (j): goose (*Anser* sp.) carpometacarpus with cut and chop marks (marked with arrows) from site PGV; (k): turkey (*Meleagris gallopavo*) carpometacarpus from site MIL; (l): turkey (*Meleagris gallopavo*) femur from site BAN.

The skeletal elements that were most abundant in all avian taxa primarily belonged to the limbs (wing and leg), whereas components of the axial skeleton (cranium, vertebrae and sternum) are less common, as indicated in Table 3. Analysis of chicken skeletal remains reveals a consistent pattern across archaeological sites, with leg bones outnumbering wing bones, except for at the RUD site (Figure 3). There were statistically significant more wing bones at the RUD site compared to the BAN, but the phi (ϕ) coefficient values did not confirm that.

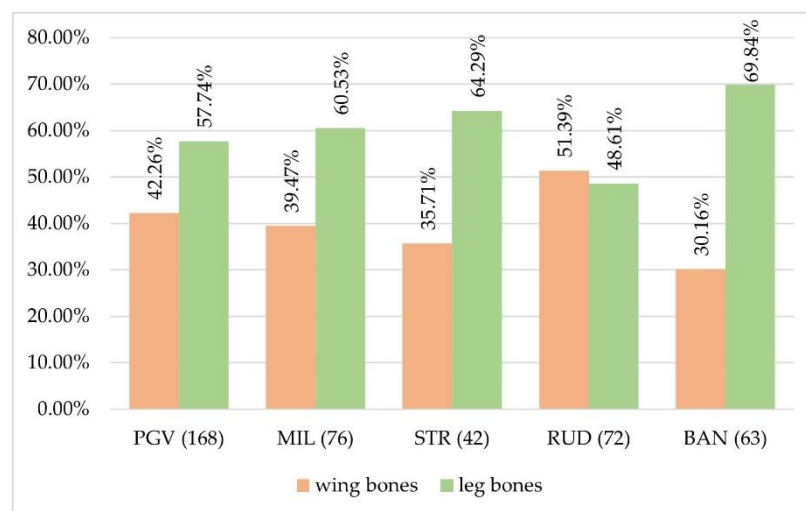


Figure 3. Distribution of wing and leg bones of chicken per archaeological site. Numbers in brackets represent the total number of chicken wing and leg bones per site.

3.2. Sex Ratio

Sex was determinable in only 28.07% ($N = 121$) out of the total number of selected bones for analysis of sex ($N = 431$). Out of 121 bones with the determined sex, 93.39% belonged to chickens. Based on the presence or absence of spur or spur scar, 20 cockerels and 27 hens were determined. Medullary bone was identified in 66 chicken remains using both macroscopic and radiological examinations, and they were classified as hens. At archaeological sites RUD and BAN, only hens were identified, while at PGV, MIL and STR, hens outnumbered cockerels when considering the presence of medullary bone and spur/spur scar data combined (Figure 4). Although the number of hens was significantly higher ($p < 0.05$) relative to chicken NISP per site at BAN compared to PGV, MIL, and RUD, the results of the effect size (phi (ϕ) coefficient of approximately 0.1), showed that the difference between the sites has a negligible effect and thus showed a weak relationship. Additionally, one female pheasant remain was identified at PGV based on the absence of spur/spur scar on the tarsometatarsus. Furthermore, based on the presence of medullary bone, female geese, ducks, and peafowl were recorded. The two remains of female geese were found at MIL and one at STR, one set of female duck remains at BAN, and one set of female peafowl remains at MIL. Two female remains from the bird group were found, one each at STR and RUD.

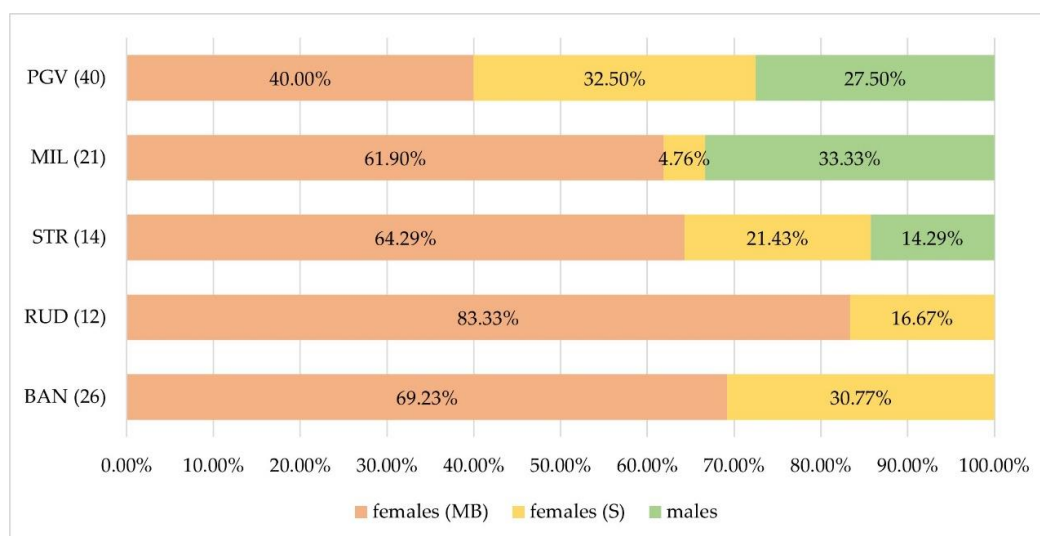


Figure 4. Sex ratio of chickens per archaeological site. Numbers in brackets are total numbers of chicken remains per site where sex could be determined. (Females (MB)—determined by presence of medullary bone; females (S)—determined by absence of spur/spur scar).

3.3. Age Groups

Age was determined in 88.33% (N = 613) of the avian remains. Out of all determinable remains, most of them belonged to adult birds (77.49%), followed by immature specimens (20.23%). The lowest number of remains belonged to subadult birds (2.28%). The age was determined most frequently in chicken remains (N = 512), where the adult group was the most numerous on all studied archaeological sites (Figure 5). Our study revealed statistically significantly higher number of immature chicken remains at STR and RUD than at BAN ($p < 0.05$), but effect size analysis did not show any significant connection between variables.



Figure 5. Percentages of age groups of chicken per archaeological site. Numbers in brackets represent the total number of chicken remains per site where age group could be determined.

Similar to the chicken, most of the geese, duck, and turkey remains belonged to the adult group (Table 4). Two adult remains of pheasant at PGV, one of swan at PGV, and one of peafowl at MIL were found. One set of corvid remains found at STR was subadult.

Table 4. Distribution of age groups of turkey, goose, duck, Columbidae, and bird group per archaeological site expressed in number of identified specimens. A—adult; Sa—subadult; Im—immature.

Bird Taxa	PGV			MIL			STR		RUD		BAN
	A	Sa	Im	A	Sa	Im	A	Im	A	Im	A
goose	14	1	8	10	-	-	8	2	-	-	3
duck	5	-	1	3	-	-	2	-	1	1	1
turkey	-	-	-	4	-	1	1	-	-	-	1
Columbidae	-	-	-	1	-	-	-	-	2	-	-
birds	-	-	5	-	1	6	-	1	-	12	1

3.4. Butchery Marks

Butchery marks were recorded on 16 (2.31%) avian remains. Most of the butchery marks were found on chicken bones (N = 12, 75.00%). A sternum of a chicken from STR was chopped in the paramedian plane. Two chicken humeri from RUD had longitudinal chops laterally on the distal epiphysis. One humerus from PGV was chopped in the transverse plane on the top of the proximal epiphysis, while another chicken humerus from PGV showed a cut mark in the longitudinal plane cranially on the proximal epiphysis. A chicken femur found at PGV had a longitudinal chop mark cranially on the proximal epiphysis and proximally on the diaphysis. Chicken tibiotarsi (N = 5) from BAN, STR, RUD, and PGV had either transverse cut or chop marks on the distal epiphysis. A tarsometatarsus from PGV had cuts and chop marks on the spur (Figure 6). At PGV, three goose bones had butchery marks: a humerus showed a paramedian chop; a carpometacarpus showed a transverse chop on the proximal and distal epiphysis with additional cut marks on the proximal epiphysis (Figure 2); a tibiotarsus showed a transverse chop on the distal epiphysis. One swan's humerus from PGV was chopped in the transverse plane on the top of the proximal epiphysis and in the longitudinal plane cranially on same epiphysis (Figure 2).



Figure 6. Tarsometatarsi of chicken from the site PGV. (a): specimen with cut and chop mark on spur (marked with arrows), (b): specimen with unfused proximal epiphysis and spur scar (marked with

arrow), potentially indicating the capon, (c): specimen with spur scar (marked with arrow) and small GL, potentially indicating spurred hen.

3.5. Chicken Size

Log ratio values of Bd of humerus, femur, tibiotarsus, and tarsometatarsus, Did of ulna, and BF of coracoid bone, as well as log ratio values of GL humerus, femur, tibiotarsus and tarsometatarsus, coracoid bone, ulna, and carpometacarpus compared to log ratio of standard chicken, revealed that at all archaeological sites, most of the values belong to the individuals that were smaller than the standard chicken (Figures 7 and 8). Chickens at MIL were significantly bigger, both in length and breadth measurements, than those at all other analysed sites ($p < 0.05$).

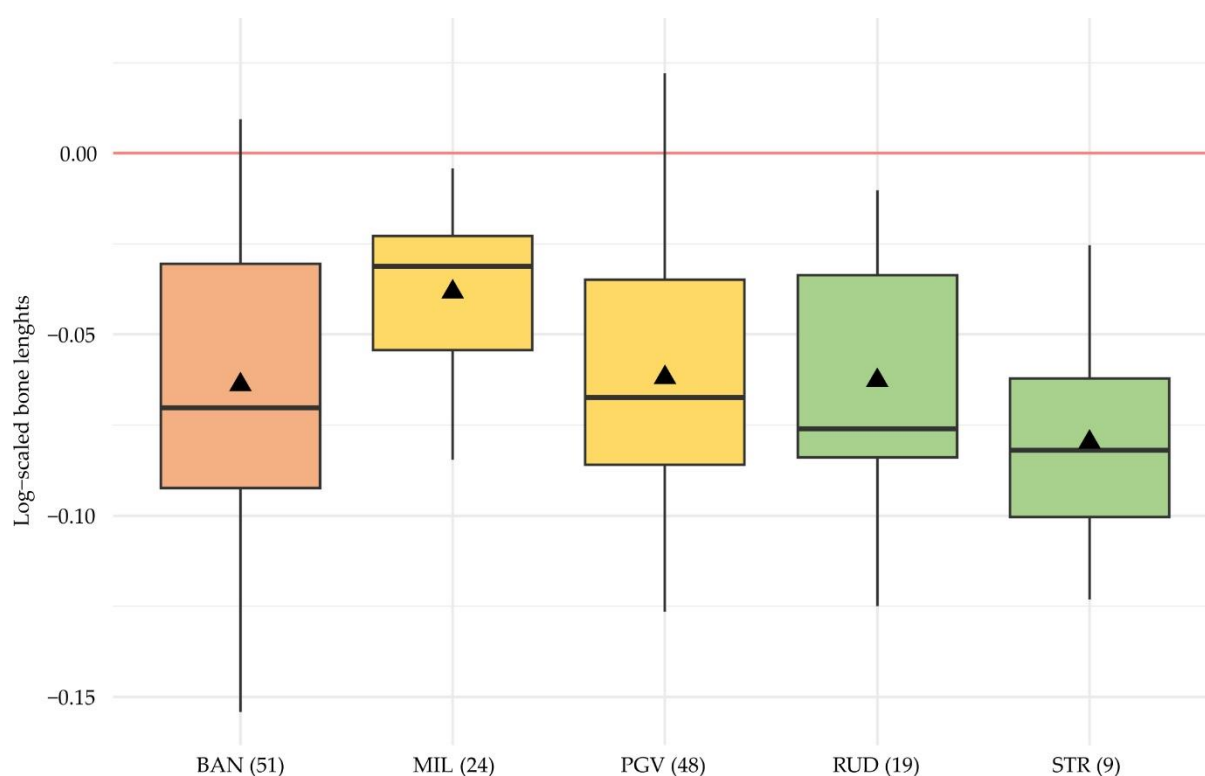


Figure 7. Log values of GL of humerus, femur, tibiotarsus and tarsometatarsus, coracoid bone, ulna, and carpometacarpus. Value zero is standard chicken values (red line). Each box plot graph represents one archaeological site. Triangles represent mean values. Numbers in brackets represent the total number of log values per site used for box plot. Orange colour marks the urban site, yellow marks castle sites, and green marks monastery sites.

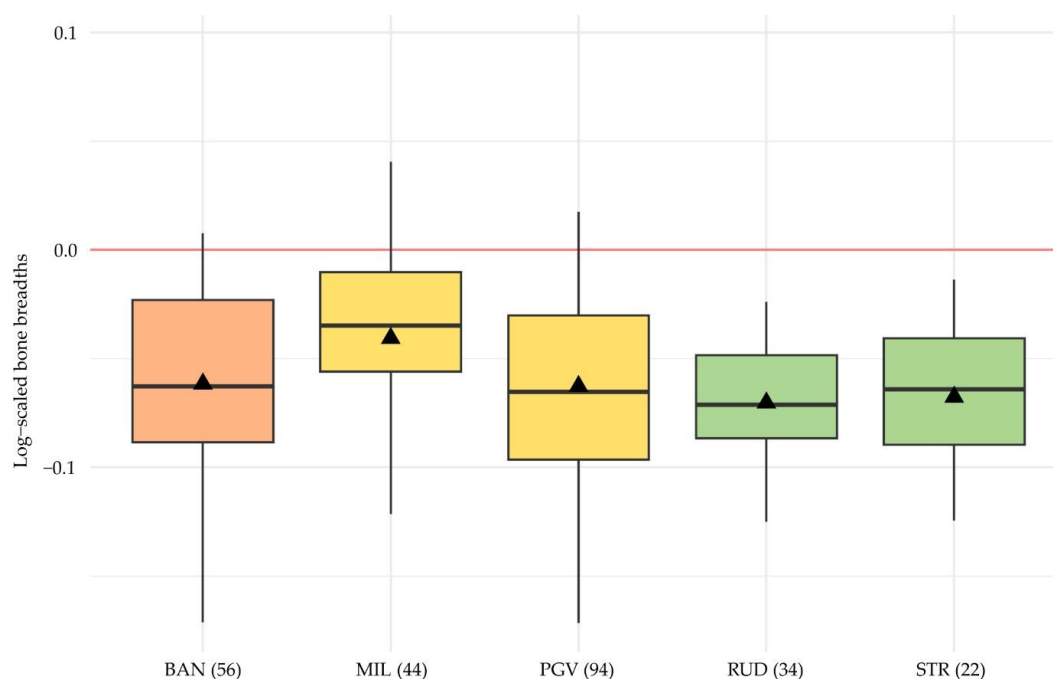


Figure 8. Log values of Bd of humerus, femur, tibiotarsus and tarsometatarsus, BF of coracoid bone, and Did of ulna. Value zero is standard chicken values (red line). Each box plot graph represents one archaeological site. Triangles represent mean values. Numbers in brackets represent the total number of log values per site used for box plot. Orange colour marks the urban site, yellow marks castle sites, and green marks monastery sites.

Values of Bp are plotted against GL of spurred and unspurred tarsometatarsi expressed in millimetres from all archaeological sites. Most of the values are separated into two groups, females without spurs and with smaller values of Bp and GL and males with spurs and larger values (Figure 9). However, one spurred tarsometatarsus is an exception, falling within female values, and could be evidence of spurred hen (Figure 6).

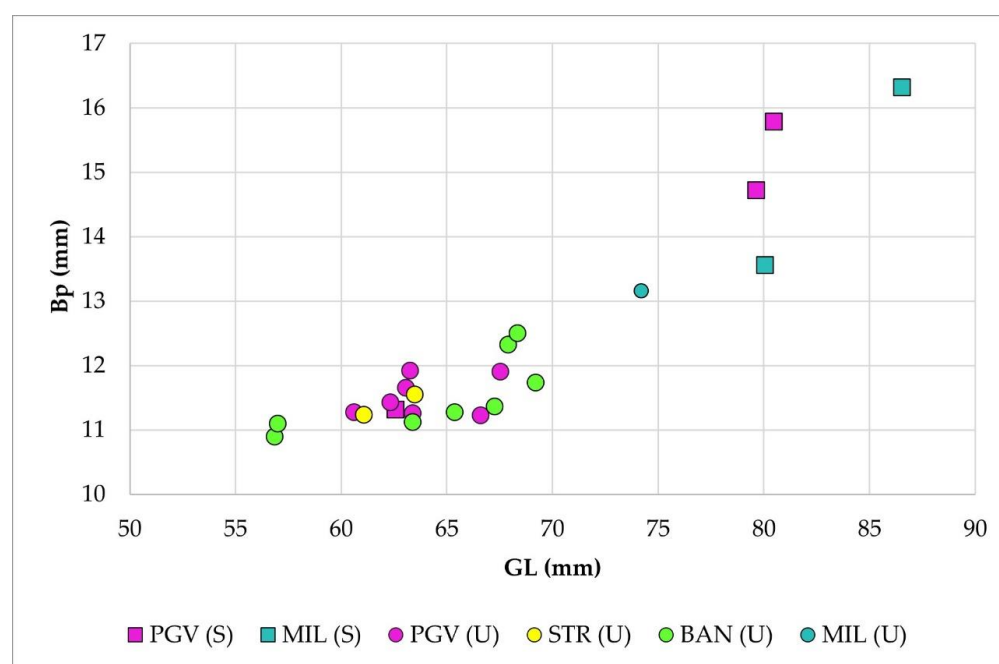


Figure 9. Distribution of tarsometatarsi values of spurred and unspurred chicken tarsometatarsi per archaeological site. S = spurred; U = unspurred. Spurred and unspurred tarsometatarsi from the same archaeological site are marked with same colour but different shape.

4. Discussion

4.1. Frequency of Birds in Diet in Late Medieval and Early Modern Period

Birds composed a smaller but still important part of the diet throughout history, which is also confirmed by this study on the Late Medieval and Early Modern Periods in continental Croatia. The average percentage of bird remains per site was 11.40%. A similar finding in Southern England showed that birds composed 18% of the diet in the Late Medieval Period and 12% in the Postmedieval Period [32]. Other research, regardless of the site function, in Croatia and neighbouring countries also display frequencies of birds remains lower than 20% [19,21,36–39,61–65]. The urban site (BAN) in our research had the highest percentage (20.32%) of birds compared to the other site types. Conversely, in Medieval Norway, Romania, and Slovenia, birds compose only up to 3% of the remains at urban sites [16,20,61]. Other studies showed that higher percentages of bird remains are expected in high-status sites, followed by ecclesiastical sites, and the lowest percentages are present in urban areas [32]. However, in Brussels, in the Early Modern Period, nobility from urban sites had a higher percentage of birds in their diet than monastic sites inside cities, which is more similar to our research [17]. Therefore, since site BAN was part of the city Gradec, where high-status inhabitants lived [66], the higher bird remains percentage is somewhat expected.

Results for the castles (PGV and MIL) in this research showed that birds made up a smaller percentage (11.70% and 8.88%) of all remains than at urban site BAN. Some research on castles in continental Croatia showed lower percentages of bird remains than in our research, such as at the nobility castle Barilović where birds composed only 1.58% of all remains [37], followed by 2.57% found at the important trade centre and fortress Virovitica [34] and 3.24% at castle Kloštar Podravski—Gorbonok [62]. Additionally, the military crew in the defence fortress Paka, northwestern Croatia, had 2.92% of birds in their diet [38]. Authors reported a somewhat higher percentage of bird remains for the eastern Croatian high-status fortress Veliki Zdenci-Crni Lug (15%) and the northern Croatian castle Cesargrad (16.61%) [39,63]. The highest reported percentage of bird remains in castles was 35.5% for the Sveta Ana-Gradina in eastern Croatia [39]. However, what singles out this site is not just the abundance of avian remains but also the exclusive use of young pig and piglet meat. Considering these factors alongside the consumption of wild birds, it is evident that the inhabitants of Sveta Ana-Gradina enjoyed a distinguished noble and elite status. Similar to our research, 10.22% of bird remains were found at the medieval castle Čanjevo in northern Croatia [35], which is geographically the closest site to our castles. There are reports from castles in the neighbouring countries, for example, in castle Smlednik in Slovenia, that birds were present more (17.17%) in the diet than in our analysed castles [64]; at the castle of Grafendorf in Austria, a somewhat lower percentage (7.2%) was found [65]. Additionally, research from castle Ojców in Poland showed that birds made up 18.44% of the diet [67].

In the two ecclesiastical sites (STR and RUD) from our research, the percentage of birds in the diet was the most similar to a study of a monastery in Serbia, where birds composed 14.8% [19]. There are reports from other ecclesiastical sites in Europe. For example, in Norway, where the overall consumption of birds in the Medieval Period was very low, it is not surprising that birds composed only 3% of identified specimens (NISP) at ecclesiastical sites as well [20]. A review paper on ecclesiastical sites in Hungary reported lower percentages of avian remains in two cloisters, the Buda-Dominican cloister (2.92%) and the Pauline cloister of Márianosztra-Toronyalja (5.3%), than in our research [21]. On the contrary, in the material from the archbishop's kitchen from Hungary, birds composed 35.65%, which is due to the high social status of the archbishop. Moreover, the material from this site was sieved, and such a high percentage could be due to the recovery method [24].

Domestic taxa, primarily chicken, prevailed in our study over wild ones at all analysed sites, regardless of their function and social status. Similarly, in medieval sites in

Britain, chicken was the most represented bird species in the diet of inhabitants of all social statuses, followed by waterfowl, ducks, and geese [22]. Also, chicken was the most common poultry species in Namur, Belgium, in castle and urban areas [15], as well as in all cloisters in Hungary, Romania, and Slovakia [21] and castle Smlednik in Slovenia, castle of Grafendorf in Austria, and castle Ojców in Poland [64,65,67]. The difference in the share of domestic bird remains is noted in Medieval Romania, where domestic birds remains were most numerous at elite sites, followed by rural and military settlements, while remains in urban sites were the least numerous [16]. It is expected that some monks, due to their religious laws, included more birds, i.e., chicken, in their diet [12]. On contrary, in Late Medieval England, religious and nonreligious sites had approximately equal percentages of chicken in inhabitants' diets [32]. Previous analyses of Late Medieval sites in continental Croatia showed that chicken was always the most frequently represented bird in the excavated archaeozoological material. At nobility fortresses Sveta Ana-Gradina, Veliki Zdenci-Crni Lug, and castle Čanjevo, the material originating from chicken represented 96.34%, 73.33%, and 59.60% of the total bird remains, respectively [35,39]. A high abundance of chicken remains was also determined at the defence fortress Paka—88.4% [38]. It is interesting to mention a rural settlement, Mekiš—Zgruti, where wild birds (pheasant and grey partridge) outnumbered domestic chicken, but the primary focus of animal husbandry for the inhabitants was still on domestic animals (pigs and cattle), while hunting was occasional activity practised to acquire additional food resources [62]. Our research showed that religious sites and castles have similar shares of domestic birds remains, primarily the chicken, whereas the highest share was found at an urban site. The only urban site in our research had the highest percentage of chicken remains and a few wild birds, probably because the site was inside the city, so hunting was not an activity that inhabitants engaged in.

4.2. Chicken

Based on the analysis of chicken skeletal remains, a consistently higher incidence of leg bones than wing bones was observed across all sites except RUD, with the most pronounced at BAN. Similar higher numbers of leg bones vs. wing bones are noted in the Studenica monastery in Serbia and sites in Romania [16,19]. This preference may signify the high status of these sites, as the legs contain more meat than the wings. At the urban site BAN, it is possible that particular chicken body parts were acquired elsewhere and consumed on-site since the site is in the strict city centre and animal husbandry was very unlikely, similar to medieval sites in Central Italy [18]. However, in galliform birds, wing bones are generally less robust than leg bones, resulting in a higher expectation of finding leg bones in the archaeological assemblages [7]. Both rural and urban sites in Italy showed similarity to the site RUD, where the consumption of both body parts occurred at a similar level, indicating a trend towards a production site [15].

Our analysis reveals a predominance of hens over cockerels across the surveyed sites, suggesting a focus on chicken exploitation for egg production. Notably, the urban site BAN exhibited a higher proportion of females compared to both castle sites (PGV and MIL) and one monastery (RUD), which could lead to conclusion that egg production was the most developed at the urban site BAN. There is scarce evidence of raising chickens in towns [17,18]; it is more likely that chickens were bought from somewhere else and just consumed at the urban site BAN. Also, at the BAN site, the overall number of chickens was high, and no male remains were recovered, which could be an explanation for a higher share of females than at other sites. At monastery RUD, a smaller number of female chickens was determined compared to the urban site BAN when compared to the NISP of all chickens at sites. This could be due to a small number of remains with medullary bones, which means that the inhabitants of RUD exploited chickens for eggs for an extended period and killed them when they stopped producing eggs. In the castles (PGV and MIL), cockerels were determined in approximately 30% of chicken remains, which is higher than in all other sites. This may suggest that cockfighting was used as entertainment for

medieval nobility in Croatia, similar to other parts of Europe [68]. Additionally, although chickens were exploited for eggs at the castles, there was more focus on the chicken meat consumption than at other sites since cockerels were more common and they have more meat than hens.

The predominance of immature chickens on both monasteries (STR and RUD) examined in this study, compared to other sites, particularly to urban site BAN, indicate that chicken husbandry within monastic settings was developed, unlike in urban areas, since monasteries were geographically isolated and had a lot of land to use. Additionally, the higher share of immature chicken at castles than at urban sites suggests the preference for the meat of young chickens, which was tastier and potentially reflective of higher social status [8,26].

A small percentage of butchery signs were identified on the chicken bones across all analysed sites, which is unsurprising given the animals' small size, suggesting they were likely prepared and consumed whole [18]. Despite their low frequency, cut marks and chop marks indicate disarticulation at the tarsal, elbow, and shoulder joints to discard non-meaty portions of the limbs [69]. Additionally, chop marks and cut marks were identified on the spur of one tarsometatarsus from PGV, similar to those found in Norway [68]. This suggests that spurs may have been removed to attach artificial spurs, likely made of metal, to enhance them for cockfighting purposes.

Analysis of chicken sizes across Medieval and Early Modern sites in continental Croatia indicates a general uniformity in size and likely breed, except at castle MIL, where chickens were notably larger. This suggests the husbandry of a larger breed of chicken at MIL, possibly driven by a greater focus on meat production rather than egg laying. Furthermore, the recovery technique should be considered for the interpretation of biometrical analysis. Since the material was hand-collected, it could be that at the castle MIL, only more robust chicken remains were collected and that is reflected in the overall bigger size of the chickens from this site. The overall small size of chickens at all analysed sites corresponds to the finding of small breeds in extensive research in Romania [16] and the uniformity of chicken breeds as reported for the ecclesiastical sites in Hungary and Romania [21]. Reported values of the greatest length and breadth of the proximal end of tarsometatarsus for female and male chickens in the monastery Studenica in Serbia fall in the range of these values in our research [19]. Furthermore, the greatest length of tarsometatarsi for both sexes reported in our research are similar to those from the ecclesiastical sites in Hungary and Romania.

A small percentage of hens may exhibit spurs [7,70,71]. For instance, a spurred tarsometatarsus from PGV, comparable in size to female tarsometatarsi in our study, could represent a spurred hen. Castrated male chickens, known as capons, are challenging to identify in archaeozoological material because they are consumed young, with still immature bones that hinder biometric analysis for distinguishing them from cockerels [72]. However, a tarsometatarsus from PGV remained unfused proximally but had a spur scar (Figure 6). This specimen could belong to a capon, which exhibits delayed bone fusion, or to a cockerel of a slow-maturing breed [7].

4.3. Other Bird Taxa

Ducks and geese were probably wild, suggesting they were hunted rather than raised, as evidenced by the scarcity of immature bones, which does not support the notion of husbandry of these taxa. However, at PGV, immature goose bones suggest small-scale husbandry. Chopped goose bones were discovered only at PGV, indicating the separation of the distal parts of the wings and legs. The highest proportion of goose remains compared to other bird remains at STR can be explained by its location, given that the monastery is situated in a valley bordered by two streams [42]. Previous research from Late Medieval Croatia also report remains of ducks at fortress Sveta Ana-Gradina (3.66%), castles Čanjevo (19.86%) and Cesargrad, and rural settlement Stari Perkovi-Sela

[35,39,63,73], whereas goose remains were previously found at castle Čanjevo (3.31%), defence fortress Paka (5.8%), and rural settlement Stari Perkovci-Sela [35,38,73].

The only other waterfowl species in the material was a swan with cut marks, which was found at castle PGV. Previous studies also note the consumption of swans as part of the diet, indicating the high social status of the site's inhabitants [14,15]. In addition to waterfowl hunting, the presence of pheasants at PGV suggests that game hunting was a leisure activity for the nobility at this area.

The introduction of turkeys to Europe occurred in the early 16th century, supported by numerous studies [23,74,75]. In Croatia, turkeys were previously reported at the castle Čanjevo, comprising 3.32% of bird remains [35]. We identified this species at castle MIL, monastery STR, and urban site BAN, suggesting a potentially higher status of the residents compared to other sites examined [76]. At MIL, a relatively higher number of turkey remains were found, including one immature specimen, implying possible connections via medieval roads for acquiring turkeys from elsewhere, as well as the potential for on-site breeding of this species. The presence of turkeys in northern Croatian territory during the Early Modern Period is consistent with written sources documenting their consumption by Pauline monks in 1561 [77].

Peafowl was often recorded on medieval sites in Europe [23,32,74]. The discovery of the remains of a peafowl at castle MIL suggests potential use of this species in the diet. Also, the remains belonged to a female bird with the medullary bone present, which could mean that on-site breeding efforts of this species was present, either to exploit it further in diet or to produce male offspring which were prized for their magnificent plumage [7]. Peafowl keeping and eating was a sign of the high social status [7,23] that the inhabitants of castle MIL certainly enjoyed.

Species that belong to the Columbidae family are commensal animals, so they are frequently encountered in areas of human activity [8]. Remains of adult and immature pigeons were common from the 11th century onward in food waste pits, and they were bred for meat and kept inside the dovecots [7]. However, we found only three adult Columbidae remains without butchery marks at MIL and RUD, and there were no findings of dovecotes, suggesting these remains were from a commensal bird who fed on human waste rather than forming part of a diet.

The discovery of corvid remains was incidental, as consumption of corvids was traditionally avoided due to their association with death and evil [78]. Furthermore, corvids are typical scavengers that coexist closely with humans [7].

Overall, our analysis showed that geese and ducks, as possible game birds, were more numerous at castles than on the other sites. A further indicator of castles' high social status is the presence of pheasant, swan, and peafowl. Similarly, other authors reported that wild and game bird species are usually more numerous at high-status sites than on ones of lower social status [14,22].

Regarding the diversity of wild birds on our sites, geographical position and environment should also be taken in consideration. BAN is located inside a strict city centre and the absence of any game birds does not surprise since it was a consumption site, in which inhabitants bought food instead of raising their own animals or hunting them. Monastery RUD is the most isolated site on eastern Croatia, which could be an explanation for the lack of imported wild species such as peafowl and turkey. Also, the monks that lived there were probably of a lower status and did not have a right to hunt. Castle PGV was on the slope above the river Sutla in the woods, so the presence of waterfowl and pheasant is expected. Castle MIL is on the slopes of Ivanščica hill in the woods, but no game birds were found; however, it probably had great treadway since both peafowl and turkey are present.

In conclusion, during the Late Medieval and Early Modern Periods in continental Croatia, bird exploitation was just an addition to the exploitation of other animal species, primarily domestic mammals. The social status of the inhabitants and the purpose of the archaeological site influenced the diversity of bird species in the diet and types of their

exploitation. Chicken was the most important species at all sites, valued for both eggs and meat. Bird husbandry was more developed within monasteries than castles, while urban areas primarily served as consumption sites. Chickens were generally uniform in size, except at castle MIL, where a larger breed was likely raised for meat consumption. In addition to hunting, nobility at the castles engaged in cockfighting during leisure time. Castle MIL stands out with a higher status than the others do, featuring two imported bird species, turkey and peafowl. The differences between the two monasteries could be attributed to a combination of social status and geographic location. The RUD monastery, isolated with poor trade routes, relied mostly on raising chickens and egg production. In contrast, the STR monastery, located near the main socio-political centre of that period, reflects higher social rank and better access to trade, indicated by the presence of imported species (turkey) and a higher percentage of goose and duck remains due to its proximity to water areas. However, it is important to acknowledge that hand recovery of the material likely influenced the distribution of bird species at the sites. Small differences between sites might have been more pronounced if the material had been sieved, allowing the discovery of smaller bird species. Although sieving is not yet standard practice in Croatian archaeozoology, we hope this study will encourage scientists to use it more frequently. Overall, the results of this study open the new door in the archaeozoology of the medieval period in southeast Europe, where the research focus is still on mammal remains.

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