의학석사 학위논문

Anatomical Study on Phasianidae Bone Remains from Neukdo and Bukjeong Shell Midden Sites of Proto-Three Kingdoms and Three Kingdoms Period in Korea

늑도 및 북정패총 유적에서 출토된 원삼국시대 및 삼국시대 꿩 科 유존체에 대한 해부학적 연구

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Anatomical Study on Phasianidae Bone Remains from Neukdo and Bukjeong Shell Midden Sites of Proto–Three Kingdoms and Three Kingdoms Period in Korea

by
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Abstract

Anatomical Study on Phasianidae Bone Remains from Neukdo and Bukjeong Shell Midden Sites of Proto-Three Kingdoms and Three Kingdoms Period in Korea

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Objectives: The Chicken (*Gallus gallus domesticus*) has been regarded as a significant domestic animal in ancient Korea as well as in many other regions, as they contributed much economically and socially to agrarian societies. However, in spite of their significance, little has been known about the origin and history of chicken domestication in Korea. The presence of archaeological discovery of chicken remains also has been controversial hitherto. Thus, in this study, morphological re-examination of Phasianidae bone remains was conducted to confirm discovery of archaeological chicken remains and establish the early history of chicken exploitation in Korea.

Materials and methods: In the present study, Phasianidae bone remains from two archaeological sites of the Early Iron Age ~ Proto-Three Kingdoms period (Neukdo shell midden site) and Three Kingdoms period (Bukjeong shell midden site) were re-examined. Bone remains were re-analyzed according to the recently improved morphological identification criteria for species identification.

Results: The morphological analysis of 307 Phasianidae bones from Neukdo shell midden site (勒島貝塚) identified 6 chicken candidate remains, providing convincing evidence for spread of domestic chicken into Japan through the Korean Peninsula in the Early Iron Age ~ Proto-Three Kingdoms period. Investigation of 5

Phasianidae bones from Bukjeong shell midden site (北亭貝塚) re-confirmed the chicken remains from the late 4th – early 5th century archaeological site and its pathology.

Conclusion: The present study suggests the earliest evidences of chicken domestication in Korea by morphological re-examination of archaeological chicken remains.

Keywords : *Gallus gallus domesticus*, Zooarchaeology, Proto-Three Kingdoms Period, Three Kingdoms Period, Korea

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Introduction

Chickens (*Gallus gallus domesticus*) are the most common and ubiquitous domestic birds. They contributed economically and socially to agrarian societies through food production, aesthetic values, livestock manure production and as source of income. It has been assumed that chickens were initially bred for ritual purposes, then raised for the sport of cock−fighting and as pets (Hata et al. 2021). However, despite of their historical and archaeological significance, the origin and expansion of chicken domestication have remained rather controversial. Several publications regarding the earliest history of domestic chickens had been significantly addressed (Peters et al. 2022). Zeuner (1963) proposed that chickens originated from Southeast Asia and possibly from South India. West and Zhou (1988) argued that domestic chickens appeared in northern China before they were introduced to Europe, and that they were originated from Southeast Asia before the 6000 BCE. These publications were highly cited, however, did not include directly assessed osteological data (Peters et al. 2022).

Recognizing limitations, past publications and archaeological reports of domestic chicken remains have been critically reviewed and reevaluated using advanced analytical techniques in recent years. For instance, ancient DNA researches revealed that chickens were domesticated from the red junglefowl subspecies (Gallus gallus spadiceus). Domesticated chickens then interbred locally with other jungle fowl species and Red junglefowl subspecies, spreading across South and Southeast Asia (Wang et al. 2020). Also, it has been argued that chicken domestication occurred independently in multiple places across Southeast Asia (Hata et al. 2021). Peters et al. (2022) recently suggested correlation between cereal cultivation and the initiation of chicken domestication, and discovery of first reliable domestic chicken bones at Neolithic site in central Thailand by reassessment of textual, archaeological and iconographic evidences. Morphological studies also have enabled re-estimation of archaeological chicken candidate remains. Deng et al. (2014) identified chicken bones retrieved from Early Western Han Dynasty (206 BCE – 8 CE) cemetery site based upon morphological species identification criteria and questioned the accuracy of past recognitions of domestic chicken remains from archaeological sites in China. Eda and Inoué (2011) reevaluated chicken candidate remains from the Yayoi period by observation of nonmetric osteological characteristics, and reconfirmed the authenticity of discoveries from 5 archaeological sites. Eda et al. (2016) identified avian bones from Neolithic and Early Bronze Age sites in China previously determined to be domestic chicken remains as non-chicken bones.

In Korea, investigation of chicken candidate remains using the latest analytical techniques has been very scarce thus far. The origin and history of chicken domestication has not yet been fully revealed despite of few archaeological reports. As there are difficulties in examination with a mere literature review, anatomical analysis of avian bones found at archaeological sites has become significant in that it enables the scientific reconstruction of the history. Since there has been absence of discoveries of chicken bones in archaeofaunal assemblages from Neolithic site, it is regarded that chicken domestication did not precede the Neolithic period in the southern half of the Korean peninsula. It is presumed that chickens migrated from China to Korean Peninsula, in the same period of diffusion of agrarian culture. A later arrival was in the Japanese archipelago, subsequently in Middle Yayoi period (~100 BCE – 100 CE). As this eastwards expansion of chicken domestication to Japan is regarded to have been through Korea, it carries significant meaning to reveal the origin and history of domestic chickens in Korea, in that this also enables broader elucidation of diffusion and development of chicken domestication in East Asia.

In recent years, there have been advances in morphological studies that enabled reevaluations of archaeological bird remains formally identified as domestic chicken bones. Even though ancient DNA analysis is a very efficacious tool for species identification, it is clear that there are cases where the method is inapplicable due to its technical invasiveness to remains or is unavailable depending on the preservation status. Reliable morphological analyses can be especially useful on such occasions, as well as can be effectively used with aDNA analysis method where possible. In recent years, ancient avian bones originally known as those of chickens in China and Japan have been often re−estimated as pheasants, as suggested above. Criticism has been also raised in Korea, that previous archaeological reports on chicken remains seem contentious (Ko 2021). For this reason, it is inevitable to re−verify previous cases identified as ancient chicken bones with the latest techniques.

In Korea, thus far, most archaeological reports on chicken bone candidates have been made from sites later than Proto−Three Kingdoms period of Korea (1^{st} – 3^{rd} century CE) (Lim and Hwang 2004). Remains were primarily retrieved from ancient tombs of the Proto−Three Kingdoms ~ Three Kingdoms period (Ancient Tombs in Daeseong−dong, Gimhae, and in Jisan−dong, Goryeong) and shell midden sites located in the southern coast of the peninsula. Neukdo and Bukjeong shell midden sites in this report belong to the latter.

Materials and Methods

Neukdo shell midden site is located in Neukdo island and dates to the Neolithic period ~ Proto−Three Kingdoms period of Korea (Figure 1A, B). The site was firstly excavated in 1985~1986 by Pusan National University Museum. Faunal remains in this study were retrieved later in 1998~2001, during the following excavation of District C (Early Iron Age ~ Proto−Three Kingdoms period) conducted by Dong−A University Museum (Dong−A University Museum 2008). More animal bone assemblages are expected to be retrieved from Neukdo archaeological site further, as the site has been only partially excavated. Species diversity was high in District C, as remains of various species as deer, monkey, boar, wild birds and shellfishes were identified. Also, numerous oracle bones for ritual practices and a number of finished and unfinished bone tools were recovered. Deer was the dominant species with the highest Minimum number of individuals (MNI), and Phasianidae bone remains represented the second highest MNI (41). Phasianidae bone remains were found across the entire district and recovered skeletal elements were primarily long bones in limbs (Dong−A University Museum 2008). Unearthed Phasianidae bones were initially estimated and reported as pheasant bone remains or Phasianidae remains without assertive species identification, with only one exception of the spurred tarsometatarsus (0180−01). 0180−01 was identified as a chicken bone candidate based upon the shape and large size of the spur (Dong−A University Museum 2008).

Bukjeong shell midden site is located in Busan city, and was partially excavated in 1992 by Busan Fisheries University Museum (Figure 1A, C). The site is divided into District 1 (Neolithic period) and 2 (Three Kingdoms period), and the avian bone remains were obtained from District 2. Among the avian assemblage, five Phasianidae bones were initially identified and reported as chicken candidate bones (Busan Fisheries University Museum 1993).

In this research, morphological study was conducted on faunal collections housed in the Seokdang Museum of Dong−A University (Neukdo shell midden site) and Pukyong National University Museum (Bukjeong shell midden site). Personal collection and archaeological reports on avian remains were consulted for family-level identification (Busan Fisheries University Museum 1993; Dong-A University Museum 2008). It has been known that modern domestic chickens and their bones tend to be bigger than their ancient equivalents, whilst overall morphological characteristics are not dissimilar (Eda et al. 2014). As wild red junglefowls are not native to the Korean peninsula, possibility of their discovery has not been taken into account. The faunal assemblage from the Neukdo shell midden site yielded approximately 330 Phasianidae bones, and a total of 307 bones (Femur: 64, Tibiotarsus: 66, Tarsometatarsus: 69, Coracoid: 18, Humerus: 59, Ulna: 23, Radius: 3, Carpometatarsus: 5) was examined in this study. Among the assemblage, six chicken bone candidates were identified (Table 1). In the case of the assemblage from Bukjeong shell midden site, a total of five Phasianidae bones was investigated and one chicken bone candidate was found (Table 2). Phasianidae bones were re-analyzed according to the morphological identification criteria (Cohen and Serjeantson 1986; Serjeantson 2009; Eda and Inoué 2011; Deng et al. 2014; Eda et al. 2016; Deng and Li 2020; Hsu and

Eda 2022) (Table 3). Discriminating features were examined for species identification in hindlimb and forelimb bones. In general, distinguishable characteristics are known to be more definite in hindlimb bones and less indisputable in forelimb bones. Age estimation could be conducted by assessing the degree of ossification, fusion of long bones and porosity of outer cortical bone. In the case of chicken, cartilaginous growth plates are existed at both proximal and distal ends of long bone until growth is finished approximately 30 weeks later (Church and Johnson 1964; Serjeantson 2009; Sasson and Arter 2020). As there are several elements in bird skeleton which fuse by growth, it is possible to evaluate fusion in bones for age estimation (as in spur core in Galliformes) (Stamenković 2005; Serjeantson 2009). Porosity of outer cortical bone can be also referred to, since the bone of hatchlings and fledglings often retains porous outer surface (Serjeantson 2009; Sasson and Arter 2020). Length of long bones was limitedly and referentially used to establish age, as limb bones grow by apposition in birds. Measurements were obtained by using a Vernier Caliper (Mitutoyo, Japan) (Matsui 2007; Serjeantson

2009). Sex estimation was conducted by unaided gross observation of the presence or absence of medullary bone where possible. The spur was also examined as its presence or absence on the tarsometatarsus and stages in the development are worthy of being referred to the age and sex estimation (Serjeantson 2009).

Results

In total, among the avian bone assemblage from Neukdo shell midden site, 301 bones were recognized as pheasant or non-identifiable Phasianidae bones according to the morphological characteristics and the state of preservation. On the other hand, six chicken bone candidates (Femur: 2, Tarsometatarsus: 1, Coracoid: 1, Ulna: 2) were identified through morphological analysis (Figure 2). Two femora (1 right (2072-08), 1 left (0325-03) sided) were estimated as chicken bone candidates based upon those absences of pneumatic foramina on the greater trochanter and anatomical characteristics of Phasianidae bones (Figures 3 and 4). As seen in figures 3 and 4, the sizes of bones were both smaller than that of the pheasant femur in this study. Measurements of 2072-08 were able to record whereas that of 0325-03 was partially possible due to its preservation status (Table 4). Meanwhile, considering the degree of ossification that diminishes the thickness of cartilage covering condyles and the femoral head, 2072-08 and 0325-03 were estimated to be adult bones. It seems that relatively small sizes could be attributable to their sex, individual differences or other causes. For example, with regard to sex, as hens of Korean native chicken breed are known to show significantly smaller femur size than their male equivalents, there is also a possibility that the two femora belong to a hen (Tae 2015).

In the case of tarsometatarsus, 0180-01 was identified as a chicken bone candidate for its absence of calcaneal ridge on the ventral side of the proximal tarsometatarsus. The bone was fused and a spur was present, suggesting that the bone might belong to an adult cock or a hen in certain conditions (Serjeantson 2009) (Figure 5). The presence of spur is a useful, but not an entirely reliable guide to the sex estimation in galliformes since hens (especially modern) have spurs on occasions. Nevertheless, considering the very low percentage of spurred hens, the presence or absence of a spur can be a meaningful evidence for the sex estimation on an archaeological Phasianidae bone assemblage. In this case, the spur was particularly well developed compared to those of pheasant bones. Since spurs on hens are relatively less well developed, it was speculated that the bone may belong to a cock. The size of the bone is summarized in Table 4. Estimated age calculated by the formula suggested by Doherty et al. (2021) was at least approximately 2-year-old (calculations=26.92). As the relative size of the spur grows significantly over the first 12-18 months and the subsequent rate of growth is more restricted, there is a possibility that the bird was much older. In any case, it appeared that the chicken candidate lived much longer time than the modern equivalents surviving only for a few weeks. One coracoid (0187-01) was also identified as a chicken bone candidate, based upon its overall morphological characteristics of Phasianidae bones, size and discriminating morphological features of chicken bones. Absence of the fossa on the dorsal side of distal coracoid, clearly sharp lateral angle and shape of distal coracoid in ventral view were in distinction from pheasant bones, and could be observed in 0187-01 (Eda and Inoué 2011; Hsu and Eda 2022) (Figures 6 and 7). The size of the bone was in a range of a female chicken (Matsui 2007; Hsu and Eda 2022) (Table 4). 0187-01 was estimated to be an adult bone considering its size and degree of skeletal development in articular surface. In addition, one right and left ulnae (0132-02, 0070-01) were appeared to be possible chicken bone candidates with less certain evidences. The sizes of the bones are summarized in Table 4. In two ulnae, distal ends of bicipital tubercle were observed to be continuous with the intermuscular line, and were more distally extended than that of cotyla dorsalis (Figure 8). Recently, these morphological characteristics have been known to be seen in chicken ulnae (Hsu and Eda 2022). However, it seems that further investigation and more evidences are required to confirm the identification. Overall, with exception of one tarsometatarsus, sex identification of the avian remains was difficult to perform due to the unavailability of invasive methods for observation on medullary bone. In the case of broken bones, medullary bone was not observed.

In the case of Bukjeong shell midden site assemblage, one femur (BJSD-EVI-10) was recognized as a chicken bone candidate by the discriminating characteristic. Also, pathological evidence of femoral head necrosis and joint disease were found from the same specimen, suggesting the possibility of survival extended by the benefit of poultry husbandry. Overall, of the five specimens, accurate species identification of BJSD−EVI−9 (femur) and BJSD−EVI−12 (tibiotarsus) was impossible due to the loss of identifying characteristics. On the other hand, one humerus (BJSD−EVI−8) and two femora were identifiable and revealed as chicken (BJSD−EVI−10) and pheasant (BJSD−EVI−8, BJSD−EVI−11) remains, respectively. Firstly, BJSD−EVI−8 was identified as a probable pheasant remain considering the shape of epicondyle−condyle junction of the distal humerus (Figure 9). Species identification using femur bone was done by observing the presence of pneumatic foramina. BJSD−EVI−10 was identified as the chicken bone candidate for its absence of the foramen, whereas BJSD−EVI−11 was identified as a pheasant bone remain based on its measurement and the presence of pneumatic foramen of the greater trochanter (Figure 10). Both were regarded as mature bones based upon their measurements, the degree of ossification and porosity (Brothwell 1997; Breugelmans 2007; Serjeantson 2009). Measurements in BJSD−EVI−10 and BJSD−EVI−11 are summarized in Table 5 for comparison. With regard to the pathological evidence, flattening of femoral head (Coxa Plana) could be seen in the case of BJSD−EVI−

10, and abnormal shape of femoral head also allowed of Subluxation. In addition to this, irregularity of the femoral head surface could be observed (Figure 10). It has been known that deformity of femoral head caused by a compromise of the blood supply could induce Secondary Coxarthrosis (Rowe 2012). That is, the above observations indicated evidence of femoral head necrosis and joint disease. Deformity of femoral head due to osteonecrosis can be assessed by analyzing diverse deformity patterns (Rowe et al. 2006; Rowe 2012). Nonetheless, diagnosis of disease was difficult to confirm due to a lack of research on poultry pathology of femoral head. However, Observations implied potential gait disturbance. It has been accepted that femoral head necrosis is the most common cause of lameness in chickens (Xu 2010). This pathological evidence could attest to domestication, as poultry often survive various diseases, thus leaving pathological findings in their bones, whereas wild species have less chances to show evidences in their remains due to lower survivability (Serjeantson 2009). Considering that the bird had survived for a long period of time enough to be fully grown despite of the possible disability, it is highly likely that the bird was a domesticated chicken. Ultimately, among the five specimens obtained from Bukjeong shell midden site, only BJSD−E Ⅵ−10 was recognized as a chicken bone candidate by anatomical and pathological evidences. Similar to Neukdo remains, sex identification was difficult to perform due to the unavailability of invasive methods.

Table 1. Information on chicken candidate remains from Neukdo shell midden site in this study

ID	Bones	Archaeological period	Excavation at	Estimation of Dong−A University Museum (2008)	Estimation of this study
2072−08	Femur	Proto−Three Kingdoms period	District C, Pit C−3	Phasianidae	Chicken
0325−03	Femur	Proto−Three Kingdoms period	District C, Pit B−3	Phasianidae	Chicken
0180−01	Tarsometatarsus	Proto−Three Kingdoms period	District C, Pit E−6	Chicken	Chicken
0187−01	Coracoid	Proto−Three Kingdoms period	District C, Pit F−2	Phasianidae	Chicken
0132−02	Ulna	Proto−Three Kingdoms period	District C, Burnt layer 14	Phasianidae	Chicken
0070−01	Ulna	Proto−Three Kingdoms period	District C, Pit F−2	Phasianidae	Chicken

Table 2. Information on chicken candidate remains from Bukjeong shell midden site in this study

ID	Bones	Archaeological period	Excavation at	Estimation of Busan Fisheries University Museum (1993)	Estimation of this study
BJSD-EVI-8	Humerus	Three Kingdoms Period	District 2, Pit VI	Chicken	Pheasant
BJSD-EVI-9	Femur	Three Kingdoms Period	District 2, Pit VI	Chicken	Not available*
BJSD-EVI-10	Femur	Three Kingdoms Period	District 2, Pit VI	Chicken	Chicken
BJSD-EVI-11	Femur	Three Kingdoms Period	District 2, Pit VI	Chicken	Pheasant
BJSD-EVI-12	Tibiotarsus	Three Kingdoms Period	District 2, Pit VI	Chicken	Not available*

*Due to bone loss

Table 3. Morphological identification criteria for species identification of pheasants and domestic chickens used in the present study

Discriminating features	Descriptions	References
Pneumatic foramina at the greater trochanter in femur	The presence of pneumatic foramina in femur can be observed in pheasant bones, whereas absence of this feature is identified in chicken bones.	Serjeantson (2009); Eda and Inoué (2011); Deng et al. (2014); Eda et al. (2016); Deng and Li (2020)
Ridge on the ventral side of the proximal tarsometatarsus	The presence of ridge in the proximal tarsometatarsus can be observed in pheasant bones, whereas the absence of the ridge is identified in chicken remains.	Eda and Inoué (2011); Eda et al. (2016); Deng and Li (2020)
Shape of posterior ligament of tibiofibular joint in tibiotarsus	Shape of posterior ligament in tibiotarsus is more rounded in pheasant bones, whereas line-shaped in chicken and red junglefowls bones.	Eda and Inoué (2011)
Shape of bicipital crest in humerus	Bicipital crest represents sharper angle in pheasant bones and is blunter in chicken humerus.	Cohen and Serjeantson (1986)
Shape of epicondyle - condyle junction	Border of epicondyle and condyle is clearer and the lower perimeter slopes slightly downwards in pheasant bone,	Deng and Li (2020)

	whereas an epicondyle–condyle transition is flat, and the lower perimeter runs upward or remains flat in chicken humerus.	
Small fossa in the distal humerus	The presence of small fossa in the distal humerus can be often observed in pheasant bones, but rarely in chicken or red junglefowl bones.	Eda and Inoué (2011); Deng et al. (2014)
Fossa and its direction on the dorsal side of distal coracoid	The oval fossa in a vertical direction on the dorsal side of distal coracoid can be identified in pheasant bones, whereas absence or the fossa at a slant can be observed in chicken coracoids.	Eda and Inoué (2011); Deng and Li (2020);
Shape and lateral angle of distal coracoid in ventral view	Lateral angle of chicken coracoid in ventral view clearly shows sharp angle whereas pheasant bones represent a blunt angle.	Hsu and Eda (2022)
Differences between the shapes of bicipital tubercle in ulna (Tuberc. bicipitale ulnae)	In chicken ulnae, distal end of bicipital tubercle is continuous with the intermuscular line (Linea intermuscularis ulnaris), and is more distally extended than that of cotyla dorsalis. Relatively more various shapes can be observed in pheasant bones and distinguished with that of chickens. In many instances, distal end of bicipital tubercle is parallel with that of cotyla dorsalis and located more ventrally from the continuance of intermuscular line in pheasant ulnae.	Hsu and Eda (2022)

Table 4. Measurements of chicken candidate bones from Neukdo site in this study (mm)

ID	Bones	Greatest length (GL)	Proximal breadth (Bp)	Distal width (Bd)	Breadth of the facies (Bf)	Spur length
2072−08	Femur	66.3	12.45	12.7	ND*	ND
0325−03	Femur	ND	ND	12.35	ND	ND
0180−01	Tarsometatarsus	73.59	12.49	12.51	ND	19.81
0187−01	Coracoid	50.8	ND	ND	8.0	ND
0070−01	Ulna	59.41	10.26	8.49	ND	ND
0132−02	Ulna	70.66	12.83	9.9	ND	ND

*ND: Not Determined

Table 5. Measurements of Phasianidae femora from Bukjeong site for comparison in this study (mm)

ID	Bones	Greatest length (GL)	Proximal breadth (Bp)	Distal width (Bd)
BJSD-EVI-10	Femur	86.1	16.2	16.57
BJSD-EVI-11	Femur	85.12	16.3	ND*

*ND: Not Determined

Figure 1. Locations of Neukdo and Bukjeong shell midden sites. **(A)** a map showing the locations of the sites. **(B)** a topographic map of the Neukdo shell midden site. **(C)** a satellite image of the Bukjeong shell midden site.

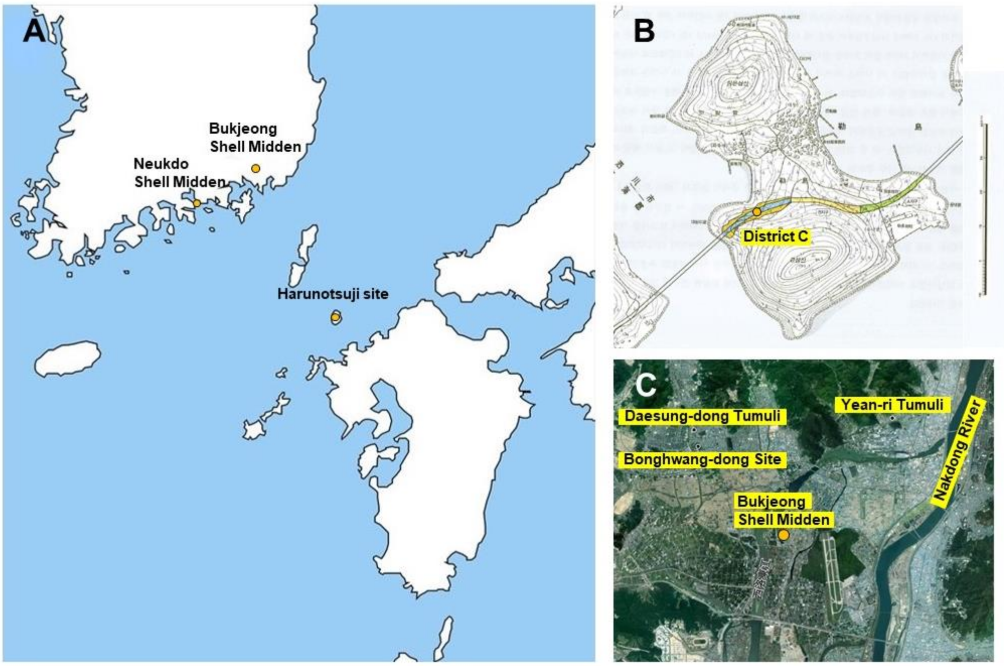


Figure 2. Six chicken candidate bones retrieved from Neukdo shell midden site. From left to right, 2072−08, 0325−03, 0180−01, 0187−01, 0070−01 and 0132−02.

Figure 3. Chicken (2072-08) and pheasant femora from Neukdo shell midden site. **(A)** chicken and **(B)** pheasant bones reconfirmed in the present study. The arrows indicate the absence or presence of pneumatic foramina. In chicken femur, the absence of pneumatic foramen is identified, whereas the presence of pneumatic foramen is recognizable in pheasant femur.

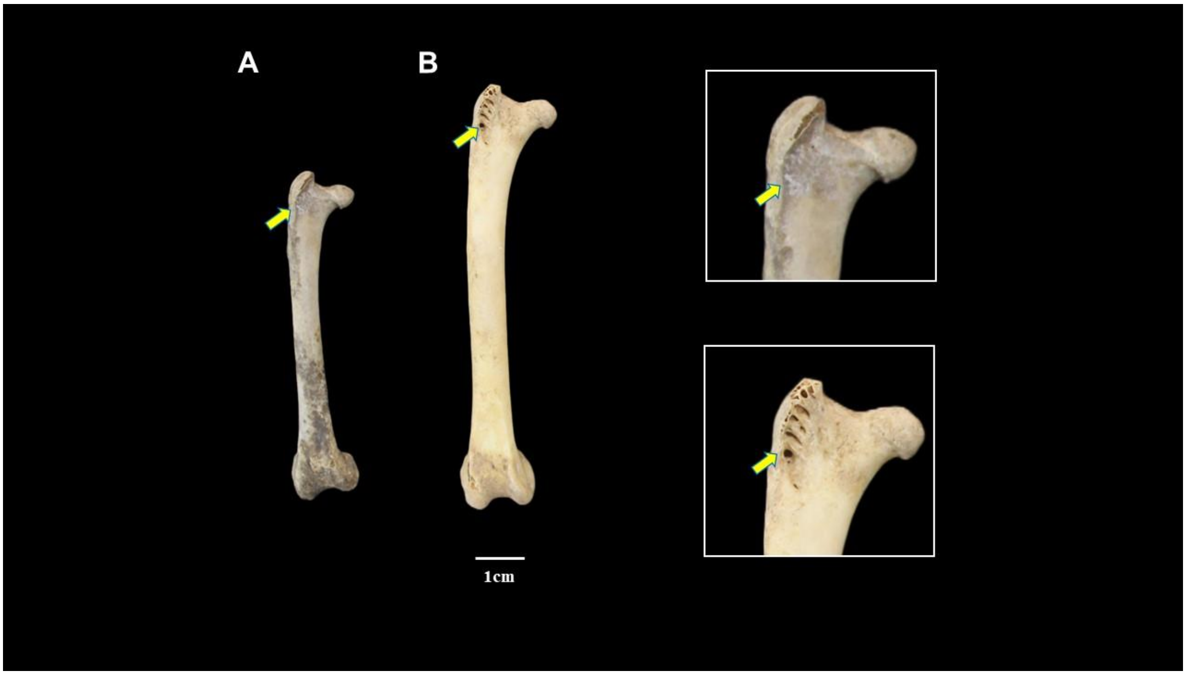


Figure 4. Chicken (0325-03) and pheasant femora from Neukdo shell midden site. **(A)** chicken and **(B)** pheasant bones reconfirmed in the present study. The arrows indicate the absence or presence of pneumatic foramina. The absence of pneumatic foramen is recognizable in 0325-03, whereas the presence of pneumatic foramen is identified in the pheasant femur.

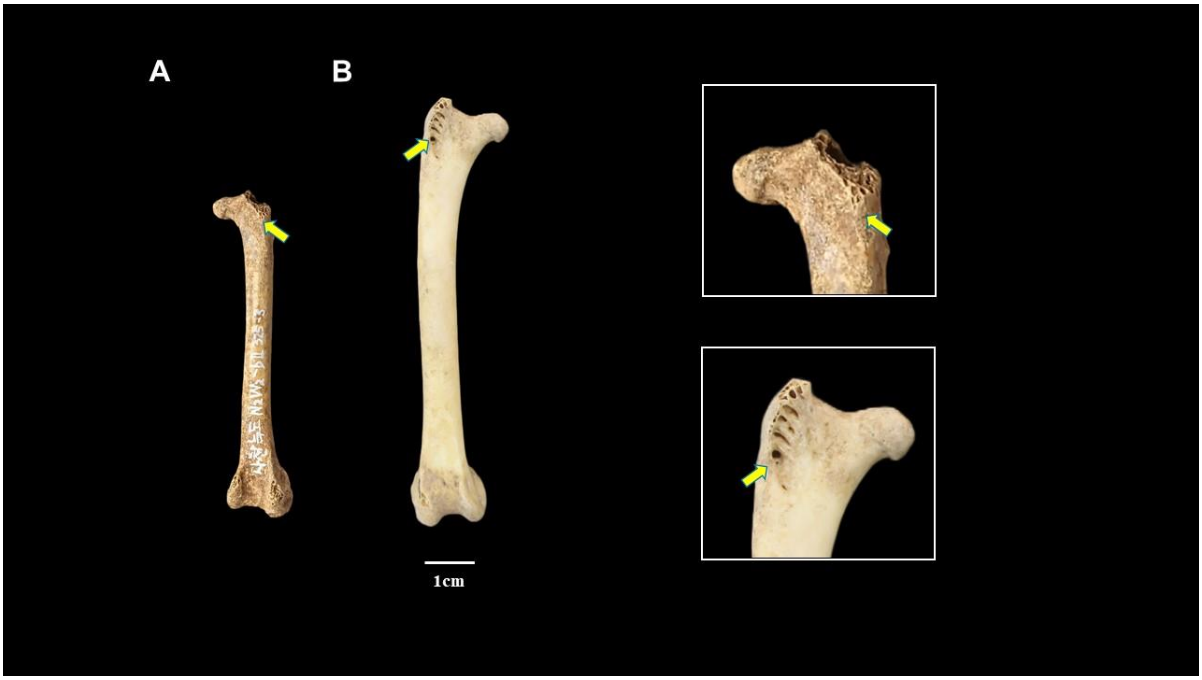


Figure 5. Chicken (0180−01) and four non−chicken Phasianidae tarsometatarsi from Neukdo shell midden site. **(A)** chicken and **(B)** pheasant bones. The arrows indicate the absence or presence of ridge on the ventral side of the proximal tarsometatarsus. The ridge is not identified in chicken tarsometatarsus, whereas the presence of the ridge is clearly recognized in pheasant bone.

Figure 6. Chicken (0187−01) from Neukdo site and modern pheasant coracoids. **(A)** chicken and **(B)** modern pheasant bones. The oval fossa in a vertical direction on the dorsal side of distal coracoid can be identified in the pheasant bone (indicated by yellow arrow in B), whereas absence of the fossa can be observed in the chicken coracoid (indicated by yellow arrow in A). In ventral view, lateral angle of distal coracoid of chicken shows sharp angle (indicated by orange arrow in A), whereas that of pheasant bone represents a blunt angle (indicated by orange arrow in B).

Figure 7. Chicken candidate (0070-01) from Neukdo site and modern pheasant ulnae. **(A)** chicken and **(B)** modern pheasant bones. In chicken ulna, distal end of bicipital tubercle is continuous with the intermuscular line (Linea intermuscularis ulnaris), and is more distally extended than that of cotyla dorsalis. In pheasant bone, distal end of bicipital tubercle is located more ventrally from the continuance of intermuscular line.

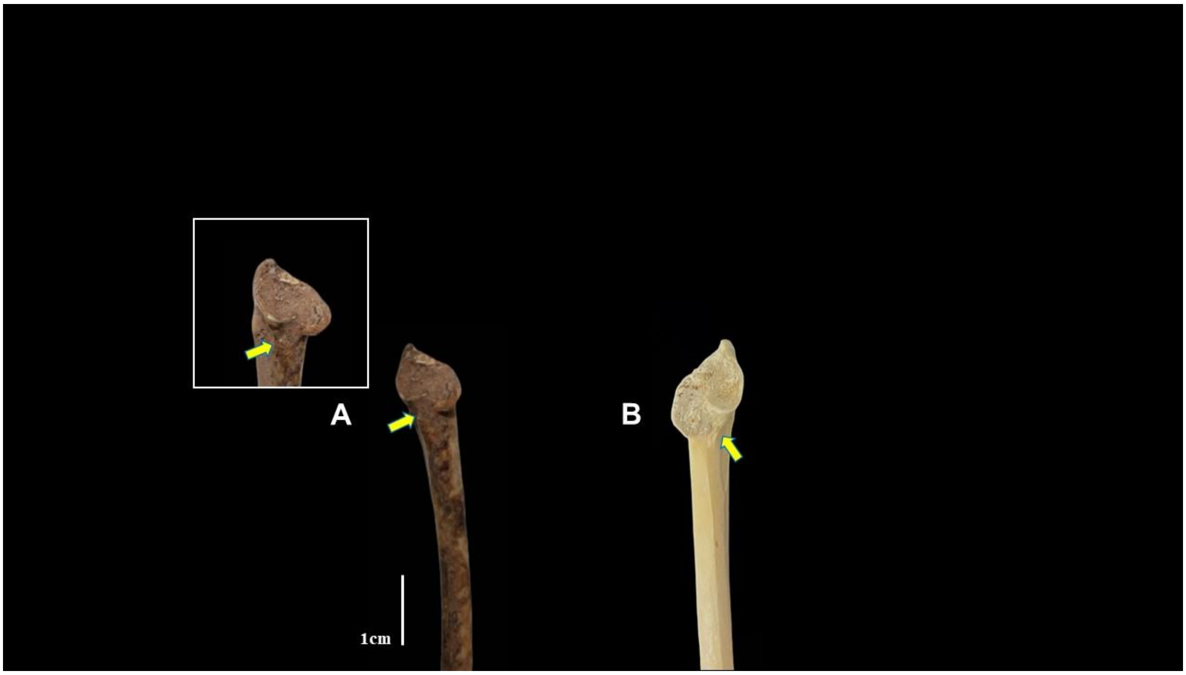


Figure 8. Chicken candidate (0132-02) from Neukdo site and modern pheasant ulnae. **(A)** chicken and **(B)** modern pheasant bones. In chicken ulna, distal end of bicipital tubercle is continuous with the intermuscular line, and is more distally extended than that of cotyla dorsalis. In pheasant ulna, distal end of bicipital tubercle is located more ventrally from the continuance of intermuscular line.

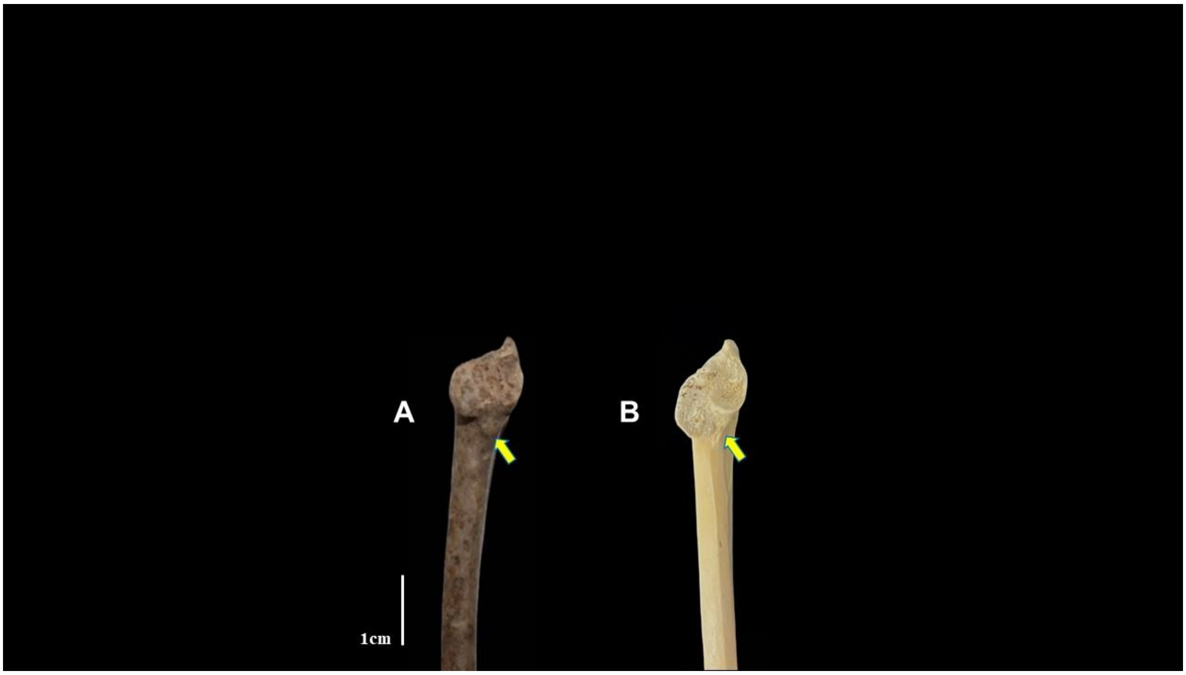
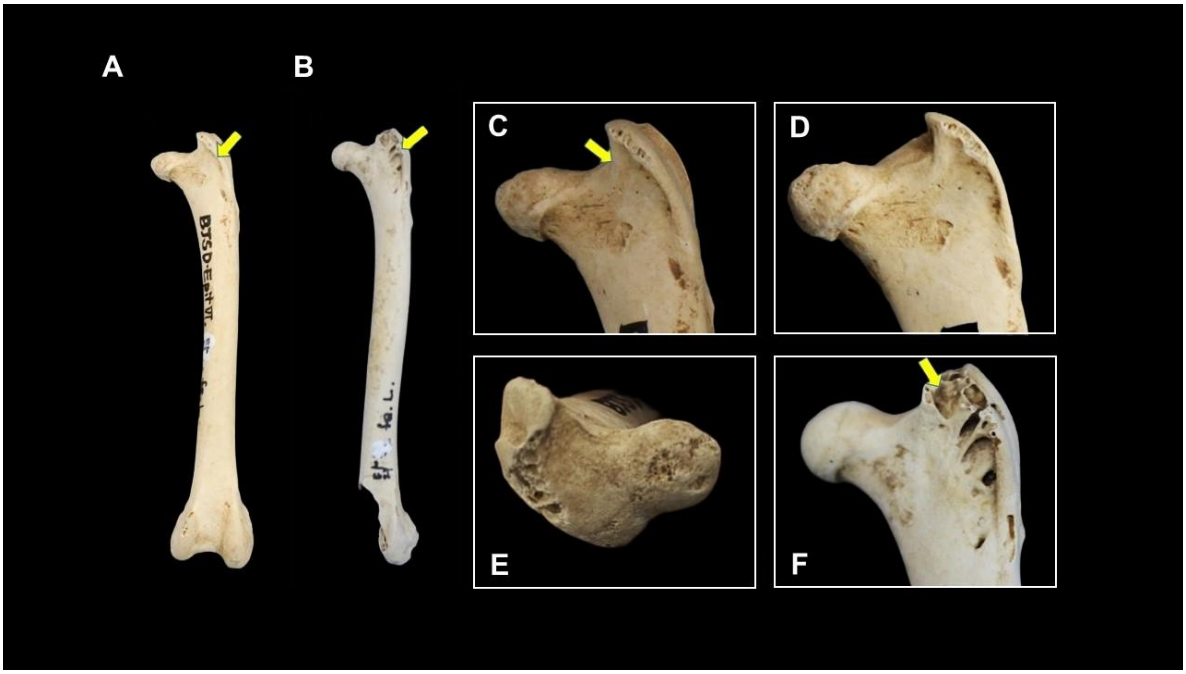


Figure 9. Five Phasianidae bones excavated from Bukjeong shell midden site. From left to right, BJSD−EVI−8, BJSD−EVI−9, BJSD−EVI−10, BJSD−EVI−11, and BJSD−EVI−12.

Figure 10. Chicken (BJSD−EVI−10) and pheasant (BJSD−EVI−11) femora from Bukjeong shell midden site. (A) chicken and (B) pheasant bones. A sign of femoral head necrosis and joint disease is observed in the former. (A) Chicken femur, the absence of pneumatic foramen and flattening of femoral head (Coxa Plana) are recognized. (B) Pheasant femur, the presence of pneumatic foramen is observed. (C) Magnified image of (A). The absence of pneumatic foramen of the greater trochanter is obvious. (D) Magnified image of (A). The irregularity of the femoral head surface and flattening of femoral head is seen. (E) Magnified image of (A). The irregularity of femoral head surface can be clearly observed. (F) Magnified image of (B). the presence of pneumatic foramen is observed.



Discussion

In regard to anatomical study, morphological characteristics for species identification of domestic chickens and pheasants are required to be newly discovered and should be confirmed by further studies where possible. Also, development of distinguishing criteria for other Phasianidae species bones would be useful in terms of accuracy of species identification in this subject. Meanwhile, measurements of ancient chicken bones are required to be obtained, as scarcity of those information has been obstructive of understanding in development of chicken domestication in Korea. It has been inevitable to consult measurements of Japanese remains due to lack of measurements obtained from ancient chicken remains in Korea (Ko 2021). Osteological measurements enable estimation of body size and its diachronic changes, as well as its differences depending on sex and age.

Archaeological Site on Neukdo Island primarily consists of shell midden, dwelling and burial sites. Neukdo Island was a major port in 2^{nd} BCE to 1^{st} CE, and there were vigorous interchanges between the two islands, Neukdo and Iki (壱岐島) in Japan. In Iki Island, Harunotsuji site (原の辻遺跡) was a key port of trade in the same period (Yayoi period). As in Neukdo shell midden site in this study, the presence of chicken remains has been reported and reconfirmed by Eda and Inoué (2011) in the Harunotsuji site (Kuroda 1959; Eda and Inoué 2011). It has been known that rice cultivation, iron and divination were spread into Iki Island through the Korean peninsula (Jinju National Museum 2016). It is presumed that Neukdo Island had a crucial role in exchanges between geographically close Iki Island and Japan, as the important port at the time. Results of this study raise the possibility that domestic chickens were introduced to the island and Japan through such exchange. It is also noteworthy that discoveries of early chicken remains from Yayoi period in Japan have been confined to the Western Japan, mainly around Northern Kyushu (北九州).

In number, chicken bone candidates were rarely retrieved from the Neukdo shell midden site, whereas a majority of pheasant bones were found in the same site. This scarcity may reflect small-scale poultry production in the site. In japan, Nishimoto et al. (1992)

suggested the possibility of small-scale chicken farming in Yayoi period based upon the similar scarcity of excavated remains. Otherwise, there is also a possibility that chickens were not locally bred and taken from the mainland as deer and boars in this site (Jinju National Museum 2016). Likewise, discovery of chicken bone remains was relatively scarce in Bukjeong shell midden site. However, the details remain yet unknown in both sites. Also, as there is little evidence for the full scale of chicken farming in the Korean peninsula, further research is required to determine how often or seldom poultry production occurred at the time.

With respect to age, it seems that chickens in the Proto-Three Kingdoms ~ Three Kindoms Period survived longer than their modern equivalents, as they lived to reach adulthood. In Korea, modern chickens are bred mostly for their meats and eggs, only surviving for a few weeks or months, with exception of laying hens survives for a longer period of time. Cockerels are slaughtered in especially early stages, since they are unable to produce eggs and provide better meat than roosters. By contrast, it could be assumed that male chickens survived longer in ancient times, as they were kept for ritual sacrifices and other purposes such as cockfighting and plumage. However, more research in multiple sites is necessary to confirm the assumption pertaining to age.

As faunal remains excavated in association with chicken bones from Neukdo shell midden site varies from food scraps and bone tools to oracle bones, it seems difficult to conclude use of chickens in the site (Table 1). On the other hand, as the male/female ratio in the Phasianidae assemblage assessed by the presence or absence of spur was 2:1, their use for beautiful plumage has been cautiously suggested in the previous report (Dong-A University Museum 2008). In Bukjeong shell midden, chicken candidate bone has been found in association with shellfish remains (District 2, Pit VI). There has been difficulty in understanding use of the domestic chicken, likewise due to a paucity of archaeological information and the scarcity of discovery. In Korean peninsula, chickens were less consumed as food than pheasants and other wild birds even until late Joseon Dynasty period and were seen as sacred according to historical records (Shin et al. 2022). In neighboring Japan, it has been assumed that chickens in the early stage of domestication were primarily treated as prestige goods (威信材). Use for meat consumption appears to have been less significant, while other roles as producing eggs and crowing to proclaim the hour of dawn seem to have been more important (Nishimoto et al. 1992; Nishimoto 1997). Still, there is a lack of research on utilization of chickens in their early stage of domestication, both in Korea and Japan. However, at present, it can be speculated that even though they were kept for food in the early stages, such cases had been fairly rare. It seems that chickens from both sites survived longer than their modern equivalents, and their discoveries are much rarer than that of pheasants. In this regard, it is possible that chickens were valuable food, exceptional and less affordable, if they were kept for food at the time. There are several possible explanations for this speculation. Breeding chickens may have been not universal at the early stage of domestication, or hunting may have been a better way to acquire meat. It is also possible and more likely that chickens played other more important roles than providing meat. Since studies on archaeological remains of domestic chickens and their use in Korean history have been very scarce hitherto, more research is needed to elucidate utilization of chickens. Especially, future efforts to investigate newly excavated avian remains in two Koreas and integrate further archaeological and historical reports are required.

Lastly, in Korea, it is argued that the previous archaeological reports on chicken bones may have been mistaken, and it is necessary to re-verify whether the cases are authentic (Ko 2021). Due to historical records affirming the utilization of chicken (Chen 2022) and a high degree of development in agricultural society in the three kingdoms period, it has been assumed that chicken domestication was well established in the same period, at the latest. Nonetheless, the case of chicken breeding evidenced by ancient bones is still very rare. Therefore, these reports are good examples of the clear recognition of the existence of chicken remains in the Proto-Three Kingdoms ~ Three Kingdoms period ruins, reconfirming that chicken was already raised in the southern part of the Korean Peninsula at this stage. Certainly, more investigations on the avian bones preceding Proto-Three Kingdoms period are necessary in order to clarify the earliest history of chicken domestication in ancient Korea.

Conclusion

In spite of their significance as a domestic animal in Korean history, archaeological discovery of chicken remains has been very scarce and controversial hitherto (Ko 2021). Thus, in an effort to establish the origin and history of chicken domestication in Korea, re-examinations on Phasianidae remains from two archaeological sites were conducted in the present study. By morphological analysis of Phasianidae bone remains from Neukdo and Bukjeong shell midden sites, discoveries of chicken bone candidates from Proto-Three kingdoms ~ Three Kingdoms period of Korea have been reconfirmed or newly confirmed. Chicken bone candidates from Neukdo island are especially noteworthy in that their discovery could attest to spread of domestic chicken from the Korean Peninsula to the Japanese archipelago through trade. The chicken remains from Bukjeong shell midden site and its pathology could be evidences of chicken domestication in the late 4th - early 5th century, being consistent with historical records affirming the presence of domestic chicken in the Korean Peninsula at the time.

Further scientific studies using stable isotope analysis, aDNA and mass spectrometry will be conducted where possible, to reconfirm the species identification results as well as to elucidate breeding methods. For instance, it is expected that results from stable isotope analysis could explain breeding method, by revealing regional origin and feed for the birds. Archaeological information and historical records are also useful in that these could provide more detailed explanation for utilization of domestic chickens. In general, morphological analysis can be used only indirectly to address such subjects. More comprehensive research is needed to confirm conjectures concerning the origin and early history of chicken exploitation in Korea thus.

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임학종, 황철주（2004）신석기시대 새의 위치 -남해안 지역 패총 출토 새뼈를 중심으로-영혼의 전달자. 국립김해박물관, 김해.

국 문 초 록

닭 (*Gallus gallus domesticus*)은 농경사회에서 사회경제적으로 중요한 기여를 함으로써 한국사의 주요한 가축으로 자리매김하였다. 그러나 닭이 가지는 역사'고고학적 중요성에도 불구하고, 한반도에서의 닭 사육의 기원과 역사에 대해서는 알려진 바가 드물다. 더욱이 고고학 발굴현장에서 출토되어 사육 닭의 유존체로서 규명된 사례가 희소하고, 이제까지의 발견에 대해서는 그 진위에 관한 논쟁이 존재하는 상황이다. 이에 본 연구에서는 초기철기시대 ~ 원삼국시대 (늑도패총 유적) 및 삼국시대 (북정패총 유적)로 편년되는 유적 2곳에서 출토된 꿩科 (Phasianidae) 유존체를 재검토하여 한반도에서의 초기 닭 사육의 역사를 규명하고자 하였다. 이를 위하여 늑도패총 (勒島貝塚) 유적에서 출토된 307 점의 꿩科 유존체에 대해 형태학적 분석을 실시하였으며, 6점의 사육 닭 추정 유존체를 확인하였다. 해당 자료들은 초기철기시대~원삼국시대로 추정되는 한반도로부터 일본으로의 닭 사육 전파 과정을 반영하는 근거로서 주목할 만하다. 아울러, 북정패총 (北亭貝塚) 유적에서 수습된 5점의 꿩科 유존체를 조사하여 4세기 후반 ~ 5세기 전반의 사육 닭 유존체 및 그 병리를 확인하였다. 고고학 발굴현장 출토의 닭 유존체에 대한 이 같은 형태학적 재검토를 통하여, 본 연구에서는 한반도에서의 닭 사육에 관한 가장 이른 고고학적 근거를 제시하고자 한다.

Keywords: 닭 (*Gallus gallus domesticus*), 동물고고학, 원삼국시대, 삼국시대, 한국

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