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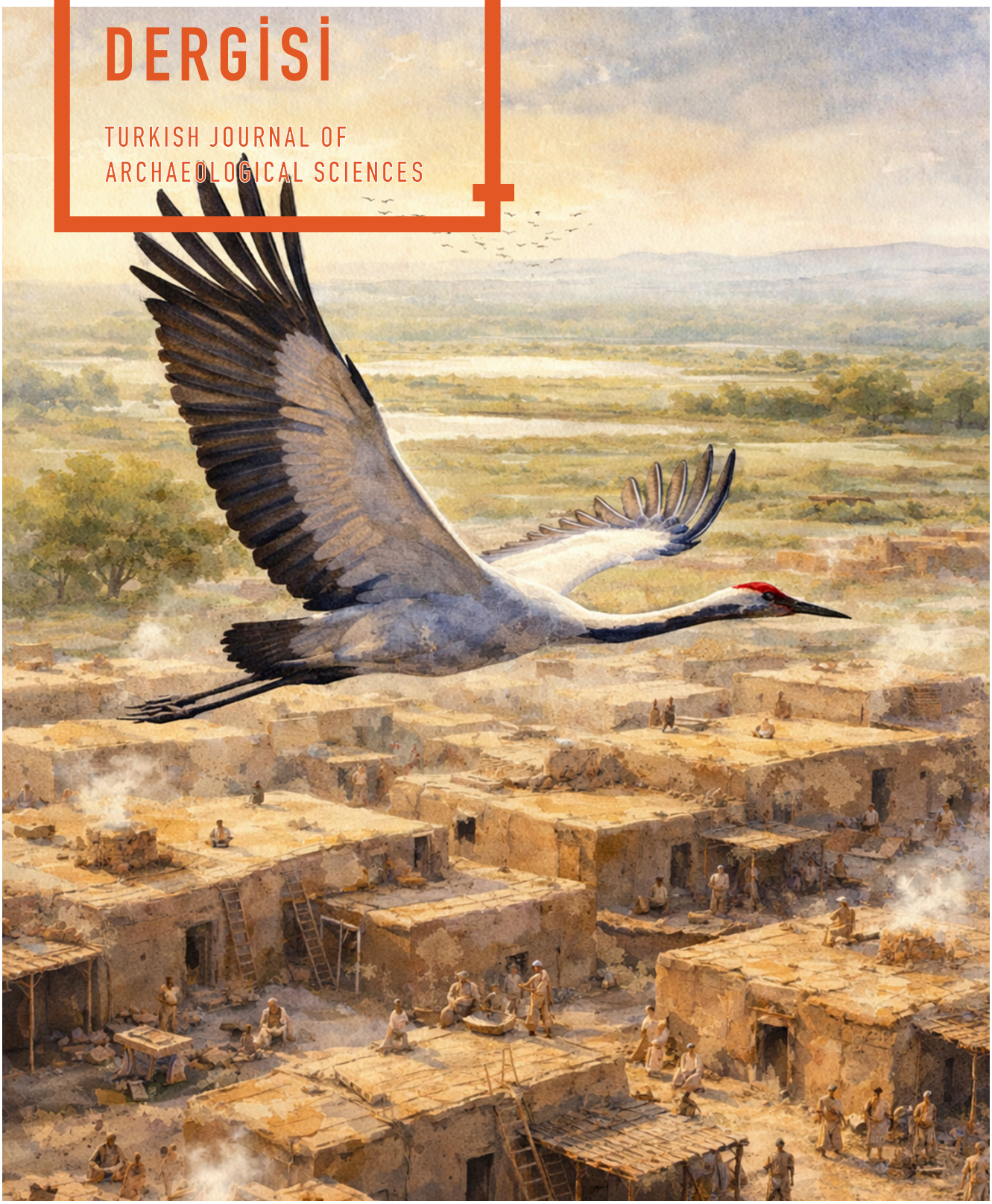

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Editörlerden

Elinizdeki altıncı sayımızla herkese yeniden merhaba. Arkeoloji Bilimleri Dergisi'nin TR Dizin kapsamına kabul edilmiş olması, altı yıldır süren emeklerimizin görünürlük kazanması açısından bizler için sevindirici bir gelişme. Bu süreci, başından beri sürdürmeye çalıştığımız ortak üretim anlayışının doğal bir sonucu olarak görüyoruz.

Bu sayı, dördüncü sayıda aldığımız bazı editoryal kararların devamı niteliğinde, kapsamı görece daha geniş bir içerikle hazırlandı. Teknolojik yenilikler, kuramsal ve metodolojik tartışmalar ile arkeolojinin farklı disiplinlerle kurduğu temaslar; günümüz arkeoloji çalışmalarının çeşitliliğini yansıtan örnekler olarak dergide bir araya geliyor. Dergimiz, belirli bir kuruma, yaklaşıma ya da düşünce hattına bağlı kalmaksızın; farklı ölçeklerde ve farklı bakış açılarıyla üretilmiş çalışmaları bir arada sunmayı amaçlıyor. Bu çeşitliliğin, arkeoloji bilimleri için besleyici ve geliştirici olduğuna inanıyoruz.

Altıncı sayımızın da bu açık ve paylaşımcı çerçeveye katkı sunmasını diliyor; emeği geçen tüm yazarlarımıza, hakemlerimize ve okurlarımıza teşekkür ediyoruz.

Herkese iyi okumalar.

ARKEOLOJİ BİLİMLERİ DERGİSİ
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Note from the editors

We are pleased to once again address our readers with the publication of our sixth issue. The inclusion of the Turkish Journal of Archaeological Sciences in the TR Index constitutes a significant and gratifying development, rendering visible the sustained efforts of the past six years. We regard this achievement as a natural outcome of the collective and collaborative scholarly ethos that has guided the journal since its inception.

This issue has been prepared with a comparatively broader scope, in continuity with certain editorial decisions adopted in the fourth issue. Contributions addressing technological innovations, theoretical and methodological debates, and the intersections established between archaeology and other disciplines are brought together here as reflections of the diversity and dynamism characterizing contemporary archaeological research. Without aligning itself with any particular institution, theoretical framework, or intellectual orientation, the journal seeks to provide a platform from diverse perspectives. We maintain that such plurality constitutes a productive and generative ground for the advancement of archaeological sciences.

We hope that this sixth issue will further contribute to this open and dialogical framework. We extend our sincere thanks to all contributing authors, reviewers, and readers for their valuable support and engagement.

Enjoy your reading!

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ARKEOLOJİ BİLİMLERİ DERGİSİ / TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES – 2026: 42-68

Birds Through Time in Türkiye: Morphological and Proteomic Approaches to Archaeological Avifauna

Ramazan Parmaksız[a], Beatrice Demarchi[b], Lisa Yeomans[c]

Abstract

Türkiye has sustained a dynamic ecosystem from prehistory to the present, characterized by its rich biogeography and natural resources. Birds are essential components of this ecosystem and have maintained components of this ecosystem, have always maintained a close relationship with human communities the area covered by modern day and are currently represented by more than 500 species in Türkiye. When examined in an archaeological context, birds play a significant role in understanding past environments and climates; the cultural and symbolic life of prehistoric humans and human-environment entanglement. In this study, 97 zooarchaeological studies conducted at 94 archaeological sites across Türkiye were compiled and subjected to meta-data analysis to assess the extent to which birds have been studied in archaeological contexts.

Our study shows that, despite the recent increase in zooarchaeological research in Türkiye, there are still significant gaps in the study of birds. After identifying the possible reasons for these gaps, we offer several research suggestions. These would enable high-quality analyses of bird eggs and bones —which are crucial for understanding past environmental conditions, seasonality, and early bird management— include: establishing a comprehensive ornithoarchaeological reference collection in Türkiye, training specialists interested in archaeological bird remains, and employing ancient protein analyses (paleoproteomics), which allow the identification of highly fragmented remains with high success rates. Additionally, within the scope of this study, recent rapid developments in paleoproteomics are briefly reviewed, and the methods are introduced.

Keywords: avifauna, zooarchaeology, paleoproteomics, ZooMS, meta-data analysis

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Özet

Türkiye, tarihöncesinden günümüze kadar zengin biyocoğrafyası ve doğal kaynaklarıyla dinamik bir ekosisteme ev sahipliği yapmaktadır. Bu ekosistemin en hareketli unsurlarından biri olan kuşlar, insan topluluklarıyla her zaman yakın ilişki içinde olmuştur ve günümüz Türkiye'sinde de 500'den fazla türüyle temsil edilmektedir. Kuşlar, arkeolojik bağlamda incelendiğinde geçmiş çevrenin ve iklimin; tarihöncesi insanının kültürel ve sembolik yaşantısının; insan-çevre dolanıklığının anlaşılmasında büyük rol oynamaktadırlar. Bu çalışmada, Türkiye'deki 94 arkeolojik alanda yapılmış 97 zooarkeolojik çalışma derlenerek meta-veri analizi yapılmış ve kuşların arkeolojik bağlamda ne kadar çalışıldığı anlaşılmaya çalışılmıştır.

Çalışmamız son yıllarda Türkiye'de artan zooarkeolojik çalışmalara rağmen arkeolojik kuş kalıntılarının çalışılmasında hâlen önemli boşluklar olduğunu göstermekte ve bu boşlukların olası sebeplerini tespit ettikten sonra çeşitli çözüm önerileri sunmaktadır. Geçmiş çevre şartlarının, mevsimselliğin ve kuş evcilleştiriciliğinin anlaşılmasında büyük önem taşıyan kuş yumurtalarının ve kemiklerinin nitelikli çalışılabilmesi için önerilerimizin başlıcaları; Türkiye'de kapsamlı bir ornitoarkeolojik koleksiyonunun oluşturulması, arkeolojik kuş kalıntıları ile ilgilenen uzmanların yetiştirilmesi ve tanımlanamaz koşullardaki faunal kalıntıları yüksek başarı oranıyla tanımlamamıza olanak tanıyan antik protein analizlerinin (paleoproteomik) alternatif bir araştırma yöntemi olarak uygulanmasıdır. Çalışmamızda son yıllarda dünyada hızla gelişmekte olan paleoproteomik çalışmalarda kısaca derlenmiş ve yöntemler tanıtılmıştır.

Anahtar kelimeler: kuş, zooarkeoloji, antik protein, ZooMS, meta-veri analizi

Introduction

Türkiye, located between approximately 36°–42° N latitude and 26°–45° E longitude, encompasses a wide range of climatic and ecological conditions with an average annual precipitation of around 600 mm and a mean annual temperature of about 13°C; however, substantial differences occur among regions owing to its large geographic size and varied topography. Due to these variable conditions and the country's extensive land area, ranging from coastal plains to high mountain systems between the European-Siberian, Mediterranean, and Irano-Turanian biogeographic zones (Birben & Gençay, 2019), the country provides habitats for a remarkably diverse biota, comprising over 12,000 known species. Among them, birds represent one of the most prominent groups, with nearly 500 species recorded, with at least 486 of them migratory and 376 of them observed regularly during the entire year (Elvan et al., 2022). Because birds select geographic corridors to avoid long-distance sea crossings during migration, several key regions in Türkiye serve as critical passageways as shown in Figure 1. The Bosphorus in the Marmara Region channels large numbers of eagles, hawks, storks, and waterfowl; the Borçka–Artvin corridor in northeastern Anatolia is an important route for storks, raptors, and vultures; and the Belen–Hatay corridor in southern Türkiye is another major flyway, especially for soaring birds. Together, these pathways constitute some of the most significant migration routes within the African–Eurasian and African–Asian flyways, as well as between Eastern Europe and

the Kazakhstan steppes (Arslangündoğdu, 2005; Elvan et al., 2022; Kirwan et al., 2008; Üner et al., 2010).

Birds are known to be highly adaptable to climatic and environmental changes due to their evolutionary history, which has shaped their breeding and migratory behaviors to be closely synchronized with climatic conditions, as well as with food and nesting availability (Carey, 2009). Some bird species are tightly bound to specific environments; for instance, cormorants are closely associated with large bodies of water, while chukar partridges typically inhabit dry and rocky hillsides covered with grass. Other species, however, exhibit migratory behavior during particular periods of the year to meet their ecological requirements by moving between colder and warmer (e.g., white storks), or drier and wetter (e.g., white pelicans) environments (Boyla et al., 2025). Although the evolutionary origins of bird migration are difficult to trace due to their complex nature, migratory behavior has persisted for thousands of years, shaped by both genetic factors and external environmental influences (Gu et al., 2024).

Bird niche specialization and mobility are useful concepts in ecology, as they allow researchers to monitor and model the biological impacts of climate change and ecosystem health (Chen et al., 2011; Devictor et al., 2008). However, the same avian traits also provide complementary data for historical studies and paleoenvironmental reconstruction in archaeology. Traditionally, paleoenvironmental and paleoclimatic research in archaeology has relied heavily on the analysis of macro and microbotanical remains, geomorphological approaches, and isotopic geochemistry (Biltekin et al., 2025; Kabukcu & Asouti, 2022; Kolbüken et al., 2025; Kuzucuoglu, 2013; Machado et al., 2025; Marston et al., 2022; Roberts et al., 2011). However, due to their strong niche preferences and their seasonally synchronized mobility, bird remains from archaeological contexts can serve as highly effective indicators of past climatic and environmental conditions, thereby complementing traditional datasets (see Russell, 2025). While birds are undoubtedly useful environmental proxies, it is also important to highlight that avian remains on archaeological sites are usually the result of human activities and human-avifauna interactions, therefore representing a biased assemblage. For example, birds have been used extensively as a food source, for tool making (e.g., bone awls, feather ornaments), and valued for their symbolic significance, often appearing in ritual, art, and burial contexts. Many bird species are often highly abundant in human-modified environments due to the attractiveness of human settlements (e.g., waste, nesting structures) or agricultural lands, leading to a possibility of high frequencies of their remains in the archaeological record. Therefore, the detailed analysis of avifaunal assemblages offers dual utility: providing both proxies for paleoenvironmental reconstruction and direct evidence for past human subsistence strategies, resource selection, and cultural practices.

Despite the clear potential of avian remains as paleoenvironmental proxies and as tools for understanding past societies —particularly within the deep prehistory and diverse environments of Türkiye— avian research in the archaeology of the region remains limited. Considering

Anatolia's rich biogeography, cultural diversity, and long archaeological record, it is important to understand the reasons underlying the relative scarcity of avifaunal studies. Therefore, this research first evaluates the current state of avifaunal research in archaeology of Türkiye through a review of previous zooarchaeological studies. By compiling and reassessing existing zooarchaeological data, the study aims to identify possible factors contributing to the underrepresentation of avifaunal research in the region. In the following sections, ancient protein analysis (paleoproteomics) as an alternative or complementary approach for identifying bird bones and eggshells from archaeological contexts when osteomorphological identification is limited or inconclusive and morphological analysis of eggshells will be introduced. Together with selected case studies from Türkiye and beyond, this research aims to foster a more robust and integrated ornithoarchaeological framework within Anatolian archaeology.

A Historical Overview of Avifaunal Research in Anatolian Zooarchaeology

Anatolia stands out as a region of remarkable geographical and cultural significance, with continuous human occupation from the Late Pleistocene to the present day (Akgül & Dinçer, 2021; Altınbilek-Algül et al., 2022; Arbuckle & Erek, 2012; Atıcı, 2010, 2011; Baird, 2012; Çelik, 2011; Çilingiroğlu et al., 2020; Karul, 2020; Kodaş, 2023; Kodaş et al., 2020; Kökten, 1959; Ökse, 2021; Özbaşaran & Duru, 2011, 2015; Özdoğan, E., 2024; Özdoğan, M., 2014; Özkaya, 2011; Starkovich & Stiner, 2009). Within this long and complex socioecological history, tracing the dynamic relationships between avian species and humans across extended periods presents both a challenge and an opportunity for advancing archaeological and paleoenvironmental understanding. An early appreciation of Anatolia's long-term human–avian interactions fueled studies of animals in archaeological contexts, which were initially focused on iconographic and epigraphic descriptions (Akurgal, 1961; Mellink, 1964). Over time, however, this research has become more insightful with the realization that animals, once regarded merely as "other creatures" play a central role in addressing archaeology's social, economic, symbolic, and environmental questions (Clutton-Brock, 1992; Russell, 2011; Sherratt, 1983). This shift, largely driven by the emergence and development of zooarchaeology as a discipline, has significantly advanced research on avifaunal assemblages, providing new perspectives on human–bird interactions across millennia.

The study of avifaunal assemblages within archaeological contexts, commonly referred to as *ornithoarchaeology*[1], a subdiscipline of zooarchaeology, primarily relies on taxonomic identification

1 The term was first used by Morales-Muñiz (1993) and has been used interchangeably as *archaeo-ornithology* and *avian zooarchaeology* in several other academic studies (Boev, 1993; Gal, 2006; Higgins, 1999; Kost & Hussain, 2019; Serjeantson, 2009).

through the osteomorphological analysis of bird skeletal remains, micromorphological analysis of eggshells and bird feathers, and analysis of ancient biomolecules. In the archaeology of Türkiye, avifaunal research has primarily relied on the osteomorphological analysis of bird skeletal remains as part of broader zooarchaeological investigations of archaeological sites. Although there is still a challenge in the recovery of bird bones from archaeological sites because of their small size and fragility, increasing interest in zooarchaeological research along with more careful recovery techniques, is helping to improve the recovery of bird bones and other small faunal fragments. Using a meta-data analysis approach, this paper evaluates the current state of avifaunal research in Anatolian zooarchaeology and provides a series of observations and possible resolutions to ongoing challenges.

Meta-data Analysis of Avifaunal Zooarchaeology in Türkiye

To assess the scope and impact of avifaunal zooarchaeology in Türkiye, we employed a meta-data approach, compiling data from 85 published zooarchaeological studies, including 13 open-access primary sources, representing a total of 91 archaeological sites. Where open-access primary data were available, these sources were preferentially used; otherwise, the dataset was compiled from published studies that reported the Number of Identified Specimens (NISP) or from faunal reports in which specimen counts could be converted to NISP. When multiple publications presented updated analyses of the same assemblages, only the most recent version was included. In addition, only publications that clearly specified archaeological periods associated with the NISP data were selected. Finally, the complete dataset, comprising a total of 179 cultural phases from 91 archaeological sites, was classified into eight distinct cultural periods, as shown in Figure 2. The figure illustrates the Number of Identified Specimens (NISP) for all faunal species, including all identified Amphibia, Arthropoda, Mammalia, Mollusca, Pisces, Reptilia, and Aves, and excluding any unspecified taxa (e.g., "small mammal" or "medium artiodactyl"); the number of identified bird bones (Identified Aves) at least to the family level (e.g., *Anatidae*); the number of unidentified bird bones (e.g., Aves) and the relative proportions among these categories. By integrating these three categories (total faunal NISP, Identified Aves, and Unidentified Aves), we aimed to examine general patterns in the abundance of avian remains, particularly identified bird bones, relative to overall faunal assemblages across human occupational periods from the Epipaleolithic to the Medieval period.

As indicated by the colored sections in Figure 2, bird remains account for approximately 0.5-2% of the total faunal assemblage across most of the archaeological periods, with few exceptions including the Early Byzantine assemblage from Sagalassos (represented in the Medieval category) studied by Van Neer et al. (2024), where a substantial number of chicken remains were identified. Furthermore, no clear correlation is observed between the total Number of

Identified Specimens (NISP) and the number of identified bird bones. This lack of a trend is expected, as multiple factors must be taken into consideration, including the differences in excavations and bone recovery methods, the chronological period and environmental context of the archaeological sites, and the cultural preferences of past communities. Nevertheless, it is evident that unidentified bird remains far exceed those identified remains (to family level and below). This is largely due to the high taxonomic diversity of birds and the morphological similarities among many species (Serjeantson, 1996). Their skeletal anatomy is often highly uniform, and accurate identification typically requires a comprehensive reference collection with multiple comparative specimens from the same species (Bochenski & Tomek, 1995; Morales-Muñiz, 1993).

During the early prehistoric periods, including the Epipaleolithic and Neolithic, the proportion of unidentified bird remains is relatively higher in comparison to later periods, likely because the exploitation of a broader range of wild taxa makes species identification more challenging in the absence of comprehensive reference collections. In the subsequent cultural periods, the number of bird remains decreases sharply, possibly for two main reasons. First, there were changes in subsistence economies and cultural preferences between pre-farming and farming societies. Second, almost all available avian-focused zooarchaeological studies in Anatolia are concentrated on the Neolithic, and this creates a bias towards earlier periods (Emra et al., 2022; Peters et al., 2005; Pöllath & Peters, 2023, 2024; Russell, 2019a, 2019b, 2022; Russell & McGowan, 2003; Zeder & Spitzer, 2016).

Furthermore, zooarchaeological reports selected only from those providing NISP data were grouped into five time blocks (by decade) according to their year of publication in order to assess long-term trends in zooarchaeological and ornithoarchaeological research in Türkiye. Based on the 97 publications from 94 archaeological sites, Figure 3 shows the distribution of studies across these time blocks, indicated by gray bars. Some studies were excluded from the NISP meta-data analysis presented in Figure 2 because they encompassed mixed chronological periods or contained data unsuitable for inclusion, were considered in Figure 3. The results indicate a steady increase in zooarchaeological research activity since 1974, as reflected by the rising number of studies represented by the gray bars. It is important to note that the first time block (1974–1985) is based on only three publications, and the final block (2016–2025) includes the current year. However, this does not alter the overall pattern. Then, we focused specifically on bird identifications from these sites. Nineteen of the 97 studies reported no avian data at all, and 48 sites contained no identified avian species, meaning that the bird remains were only classified to the order or class taxonomic levels (e.g., Aves or Anseriformes). Finally, we created an Avian Identification Index (AII) based on the number of archaeological sites in which at least one bird specimen was identified to the family level or below (i.e., family, genus, or species). This value was then divided by the total number of archaeological sites to examine

whether there is a positive correlation between the number of zooarchaeological studies and the ratio of identified avian species through time, as expressed in the formula below.

$$AII = \frac{N\ achaeological\ sites\ (at\ least\ one\ family\ or\ below\ level\ bir)}{N\ all\ archaeological\ sites}$$

As represented in the red line in Figure 3, identified bird specimens do not show a significance increase across time. This finding is contrary to our expectations, as the growth in zooarchaeological research in Anatolia (represented by the gray bars) has not been accompanied by a corresponding improvement in the identification of bird remains through time.

Identification of Bird Bones: Problems and Suggestions

Zooarchaeological research in Türkiye has increased in recent decades, as reflected in the number of published studies reporting NISP data (Figure 2 and 3). When we consider the zooarchaeological research that has not focused on general zooarchaeological reports with NISP data, but rather on species-specific (e.g., cattle management, dog sacrifice, pathology of horses) or methodological issues, zooarchaeological research in the past decades is even greater than the data presented (Crabbé et al., 2025; Çakırlar et al., 2021; De Cupere et al., 2009; Gündem, 2024; Onar et al., 2012; Siddiq et al., 2021; Slim & Çakırlar, 2023; Stiner et al., 2014; van Tuinen et al., 2025). However, the increase in zooarchaeological research does not correspond to a higher ratio of avian identification in contrary to our expectations. We propose several main reasons for this issue:

- Limited recognition of the value of bird remains for paleoenvironmental reconstruction and social/cultural studies impacting on overall methodological choices.
- The complete absence of bird bones at some sites.
- Excavation and sampling biases, as sieving is not routinely conducted, especially in later periods focused on architecture and material culture, limit the recovery of small or fragmentary bones and eggshells.
- Poor preservation and adverse taphonomic factors result in fragmented bones and eggshells that cannot be reliably identified morphologically.
- Lack of specialization in avian skeletal anatomy, osteological similarities between bird species, and the absence of comprehensive ornithological reference collections hindering accurate identification.

We argue that the low frequency of avian bone identification in zooarchaeology of Türkiye represents a critical gap that limits the full interpretive potential of archaeological assemblages. Several of the issues outlined above could be mitigated by increasing the number of researchers

specializing in archaeological avifauna and by establishing comprehensive reference collections, although the latter presents challenges regarding time and cost. Nevertheless, reference collections alone cannot solve problems related to poor taphonomic conditions or high rates of bone fragmentation.

Other research areas within ornithoarchaeology, such as the study of bird feathers, may not be highly productive due to the low likelihood of preservation and recovery in archaeological contexts (Urquiza & Echevarria, 2018). In contrast, the study of bird eggshells has become essential for understanding avian domestication (see Yeomans, 2025). For example, analysis of incubation stages in turkey eggshells from the American Southwest has demonstrated an intensification of management practices after around AD 1100 (Beacham & Durand, 2007). Early goose domestication at Neolithic Çatalhöyük was also proposed by Sidell (1993b) based on morphological analysis of eggshells. To further evaluate or refine such hypotheses, investing more research effort in eggshell analysis is valuable, but it is equally important to move beyond traditional approaches. In this context, paleoproteomics, a rapidly advancing field, offers substantial potential for the taxonomic identification of both unidentified bird bones and eggshell fragments.

Decoding Ancient Birds through Paleoproteomics: Eggshells and Bones

Paleoproteomics is a rapidly growing research area that studies ancient proteins preserved in the remains of organisms, with applications in many fields, including paleontology and zooarchaeology. Ancient proteins are exceptionally long-lived biomolecules that can survive for millions of years (Cappellini et al., 2012; Demarchi et al., 2016), and they are abundant in biomineralised tissues of organisms, i.e., bones, teeth, shells, and eggshells (Demarchi, 2020; Hendy et al., 2021; Warinner et al., 2022). Within avian zooarchaeology, unidentified bird bones are very common due to the high degradation and fragmentation of bones. Besides bird bones, eggshell fragments can also be found at archaeological sites thanks to careful sieving (usually from 1mm to 4mm mesh) and flotation processes. However, they have been typically left without further taxonomic identification due to the limitations in identification methods for eggshells (Sidell, 1993a, 1993b). These identification problems are a major contributing factor to the high rate of unidentified specimens in Anatolian avifaunal research. The analysis of ancient proteins provides a new avenue in avian zooarchaeology, enabling the refined taxonomic assignment of previously unidentified eggshell fragments and bird bones.

Eggshells

In paleoproteomics, the study of ancient proteins preserved in eggshells is a relatively new but rapidly expanding research field (Best et al., 2015; Codlin et al., 2025; Demarchi et al., 2016,

2020; Presslee et al., 2017; Stewart et al., 2013). However, working with eggshells can be challenging due to their fragile nature. Archaeological eggshells, in particular, are often highly fragmented as a result of post-depositional processes, and eggs are small, commonly ranging from about 0.5 to 5 cm in circumference[2]. To maximize the information obtained from even very small fragments, researchers typically combine morphological and proteomic methods. Therefore, in this section, we provide a brief overview of eggshells from both morphological and ancient protein perspectives.

Morphological Analysis of Eggshells

Eggshells are composed of about 95% calcium carbonate ($CaCO_3$) with only a small proportion of organic matrix (Butcher & Miles, 1990). The inorganic part of an eggshell is made up of several layers. These layers form through biomineralization while the egg is developing in the bird's oviduct. Some of the distinctive layers and morphological structures are the *cuticle* (outermost organic layer); the *palisade layer* (bulk of the eggshell); *mammillary layer* (innermost mineral layer) and *mammillary cone* (conical mineral projections in the mammillary layer) as shown in cross-section of an eggshell fragment in Figure 4 (after Hicks et al., 2023; Sidell, 1993b). Understanding how eggshell morphology develops and identifying distinctive morphological features are highly promising approaches for both taxonomic identification and assessing embryonic development. While such information is a valuable tool for biologists and ecologists in their broader research on avian biology and reproduction, it is equally important for zooarchaeologists. Detailed morphological analysis can support taxonomic identification of archaeological eggshells and provide insights into the possible domestication or management of bird species in the past.

Archaeological eggshells present several challenges for recovery and analysis. One major limitation is the taphonomic degradation they undergo after being buried in the soil for thousands of years. Another issue is the inconsistent application of recovery techniques such as fine-mesh sieving or flotation at some archaeological sites. However, when burial conditions are favorable, particularly in dry, alkaline (high pH) soils, eggshells tend to be much better preserved (Clayburn et al., 2004; Keepax, 1977). Moreover, when appropriate recovery methods are carefully implemented, including sieving with 1–4 mm mesh screens and the flotation of archaeological sediments, eggshells can be efficiently recovered. Once retrieved, they can be examined morphologically to aid in taxonomic identification, determine incubation stages, and reconstruct their taphonomic histories (Beacham & Durand, 2007; Hicks et al., 2023; Sichert et al., 2019; Sidell, 1993b; Sidell & Scudder, 2005).

2 The circumference values for the eggshell fragments are based on measurements from 50 randomly selected eggshell fragments from assemblages at Çatalhöyük, a Neolithic site in Central Anatolia.

In the morphological analysis of archaeological eggshells, one of the most informative characteristics —despite the wide range of variation— is eggshell thickness. Eggshell thickness can provide preliminary information about broad taxonomic levels (e.g., broad size range). In particular, bird species with relatively thick eggshells, such as ostriches, swans, geese, and cranes, can often be identified using catalogues from modern comparative collections, which provides average eggshell thickness values based on measurements taken from multiple individuals across different species (Keepax, 1981; Sidell, 1993). However, identifying smaller bird species with thinner eggshells is much more challenging because the thickness values of many species overlap (e.g., partridge and pheasant). Additionally, variation in thickness within a single eggshell can create additional difficulties, especially for smaller bird species that have higher overlapping rates. Nevertheless, whether thicker or thinner, morphological analysis provides the primary basis for preliminary taxonomic identification prior to paleoproteomic approaches.

Furthermore, examining the microstructure of eggshells using Scanning Electron Microscopy (SEM) is a promising approach. Some of the earliest SEM studies on modern avian eggshells focused on investigating their microstructure and comparing species from Europe and Asia (Becking, 1975; Simons, 1971). Its potential for archaeological research was soon recognized by Keepax (1977, 1981), who applied SEM to Medieval and Roman eggshell fragments. Sidell (1993b) later expanded these methods by developing broader reference collections that included biometric data and SEM images for multiple bird species. Additionally, the work of Sidell and Scudder (2005) on Çatalhöyük eggshells demonstrated the strong potential of morphological analysis for identifying archaeological avian remains.

Although still a developing method, taxonomic identification based on eggshell morphology relies on distinct structural features of the inner eggshell surface. For example, Hicks et al. (2023) describe how qualitative characteristics —such as the morphology of mammillae, membrane facets, and intermammillary spaces— can support taxonomic identification for certain bird groups (e.g., *Anser* and some Galliformes). Their findings highlight that exploring species-specific micromorphological features in archaeological eggshell fragments is a promising avenue for future research.

In addition, SEM analysis can reveal patterns of embryonic development preserved in the mammillary cone, which are also reflected in the archaeological eggshells. Although a few species, such as the Malleefowl (*Leipoa ocellata*), bury their eggs in decomposing vegetation, most bird species associated with human contexts incubate their eggs by sitting on them, a behavior referred to as the "incubation period." After approximately 15-18 days of incubation (with slight variation among species), the mammillary part of the eggshell provides sustenance to the development of the embryo. As the embryo begins to absorb calcium from the shell, it produces a characteristic pattern of cone resorption on the internal eggshell surface (see Beacham &

Durand, 2007; Simons, 1971). Building on this principle, Sidell and Scudder (2005) identified several hatched eggshells in their analysis at Çatalhöyük, which were interpreted as possible signals of intentional geese and duck breeding. Also, Beacham and Durand's work (2007) on prehistoric eggshells from northwestern New Mexico suggested the purposeful breeding of captive turkeys in the 12th century AD based on their SEM analysis, which focused on incubation stages of turkey eggs.

Paleoproteomics of Eggshells

Proteins are complex biomolecules composed of chains of 20 common amino acids, which are often referred to as the building blocks of proteins. They play vital and active roles in the metabolic processes of organisms. Based on their functions, proteins can be classified into several categories, including signaling proteins, which mediate cell communication; enzymatic proteins, which catalyze chemical reactions; and structural proteins, which contribute to the formation and mechanical stability of cells, tissues, and extracellular matrices (Barrett & Elmore, 1999; Kessel & Ben-Tal, 2018). For example, structural proteins are essential for providing shape and mechanical strength to biological tissues, such as collagen in bone and skin, keratin in hair, nails, and feathers, and elastin in connective tissue, whereas regulatory or functional proteins, such as in eggshells control calcite nucleation, crystal growth, and crystal orientation during shell formation. Proteins are often described as molecular "machines," and they contain a wealth of evolutionary and taxonomic information about the organisms to which they belong (Reynolds, 2022). Due to this informational content and their remarkable longevity, researchers have recognized their potential for ancient studies. This has led to the development of paleoproteomics, a field that investigates key zooarchaeological and paleontological questions through the study of ancient proteins found in archaeological and paleontological remains (Warinner et al., 2022).

In paleoproteomics, eggshells represent a valuable material for analysis due to their strong potential to provide insights into past human activities and ecological conditions. They comprise both organic and inorganic components, with the organic fraction containing various types of proteins. During eggshell formation, some of these proteins become encapsulated within the calcium carbonate lattice, which are known as *intracrystalline proteins* (Collins & Riley, 2000; Demarchi, 2020; Demarchi, et al., 2013). Because they are physically sealed within the mineral structure, these proteins form what is considered a closed system, meaning they are largely protected from external contamination and environmental alteration and can persist for millions of years, as demonstrated by Demarchi et al. (2016). Once they are successfully isolated and proteomically analysed, they can be identified (sometimes even to species level) because of the small differences in their amino acid sequences from one species to another (single amino acid polymorphisms - SAPs; see a discussion on avian SAPs in Codlin et al., 2025).

The proteomic analysis of archaeological eggshells is based on a methodology that was initially developed for the study of hair keratin from the clothing of the Iceman "Ötzi," discovered in the glaciers of South Tyrol, Italy (Hollemeyer et al., 2008). In this approach, proteins in hair samples are enzymatically cleaved into smaller fragments, or peptides (chains of amino acids), using trypsin, and the masses of the resulting peptides are measured via matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS), where the ionisation is achieved through MALDI, and the detection of ions through TOF-MS. The mass spectrometer generates a peptide mass fingerprint (PMF) —a pattern of peaks corresponding to the *m/z* values of the peptides. Following this initial application, the methodology and associated reference databases were further developed and extended to a wide range of proteinaceous materials. Nicknamed "ZooMS" (Zooarchaeology by Mass Spectrometry) this technique has since been successfully applied to bone, teeth, antler, ivory, leather, and parchment (some foundational studies are: Buckley et al., 2009; Coutu et al., 2016; Ebsen et al., 2019; Fiddyment et al., 2015; von Holstein et al., 2014). Using this PMF approach, researchers can identify species by comparing measured peptide mass spectra (expressed as mass-to-charge ratios (*m/z*)) with reference data from known taxa. During this development, taxon-specific marker peaks (*m/z* values characteristic of particular taxa) were identified, allowing reference libraries to be progressively refined and improved.

The first application of proteomic analysis to archaeological eggshells was carried out by Stewart et al. (2013) using a "profiling approach," in which the full peptide peak list from archaeological samples was compared against a reference database of potentially diagnostic peptide masses available at the time. Subsequent studies further demonstrated the utility of ancient protein analysis of eggshells using MALDI-TOF MS, with taxon-specific *m/z* values serving as markers for taxonomic identification (Best et al., 2015; Demarchi et al., 2020; Presslee et al., 2017; Yeomans et al., 2024). For example, the analysis of a selection of 90 eggshells from Neolithic Çatalhöyük revealed a strong dominance of waterfowl (Anseriformes), likely reflecting their use as a food resource. The same study also identified crane (*Grus*) eggshells in both burial contexts and midden deposits (Best et al., 2015; Demarchi et al., 2020). Because cranes are associated with ritual practices at the site (Russell, 2019a, 2019b), the presence of their eggshells in both mortuary and domestic refuse suggests that they played significant roles in both the worlds of the living and the dead (Demarchi et al., 2020). However, identifying eggshells based on taxon-specific *m/z* values is quite challenging for several reasons. First, eggshell proteins are highly diverse, and many different protein types must be considered due to the heterogeneous protein composition (e.g., C-type lectins such as XCA1 and XCA2, ovocleidins, ovocalyxin, osteopontin, and clusterin), most of which occur in low abundance (Codlin et al., 2025). In contrast to collagen-dominated bone proteomes, eggshell proteins do not generate the stable, abundant, and predictable peptide mass fingerprints that underpin

reliable taxonomic identification using ZooMS-based approaches (see *Bones*). To address these limitations, *de novo* sequencing using liquid chromatography tandem mass spectrometry (LC-MS/MS) is typically employed (Codlin et al., 2022; Demarchi et al., 2019; Presslee et al., 2017). LC-MS/MS enables high-resolution analysis, deep proteome coverage, and detailed sequence-level identification. After obtaining the data, they can be analysed by specific software (e.g., PEAKS) and matched to publicly available avian sequence data from NCBI (accessible at: https://www.ncbi.nlm.nih.gov). In this way, we can not only achieve more refined taxonomic identifications but also access the amino acid sequences of potential species-specific markers and confirm their suitability as unique biomarkers for further ZooMS analyses. For example, the combined use of MALDI-TOF and LC–MS/MS on eggshells from Shubayqa 6 provides strong evidence for the presence of swans (*Cygnus* spp.) and cranes (*Grus*) during the Pleistocene–Holocene transition (Yeomans et al., 2024). The study also suggests that swans may have bred at the site during the Final Natufian period, potentially indicating a southward shift in their breeding range. Furthermore, the taxonomic identification of eggshells through proteomics, together with the zooarchaeological analysis of bird remains, indicates a dominance of waterfowl and supports the interpretation of year-round water availability at the wetland during the Late Pleistocene and Early Holocene.

Bones

Bird bones are pneumatic structures that contain air sacs, allowing birds to have a lighter skeleton for flight while maintaining strength (Serjeantson, 1996). Like any other animal bones, bird bones are also composed of both inorganic and organic materials. While the inorganic part is primarily hydroxyapatite —a crystalline form of calcium phosphate that provides rigidity—, the collagen of structural proteins dominates the organic component. One of these structural proteins, called type I collagen (COL1), is the most abundant, accounting for roughly 80% of the total protein content (Buckley et al., 2009; Codlin et al., 2022; Richter et al., 2022).

When analyzing unidentified bird bones in archaeological contexts, ZooMS targets and extracts type I collagen (COL1) from the bones. The collagen is then enzymatically digested into peptides, which are chains of amino acids. As seen above for eggshell, MALDI-TOF MS is used for the analysis: the peptides are ionized, allowing them to pass through the TOF mass analyser, where their *m/z* are recorded. Because the amino acid sequence of collagen varies between species, these fingerprints can be compared to reference spectra from known species enabling accurate taxonomic identification (Buckley et al., 2009; Codlin et al., 2022; Collins et al., 2010; Eda et al., 2020; Peters et al., 2021). Although laboratory protocols may vary depending on the institution or research objective, a general ZooMS workflow is presented in Figure 5.

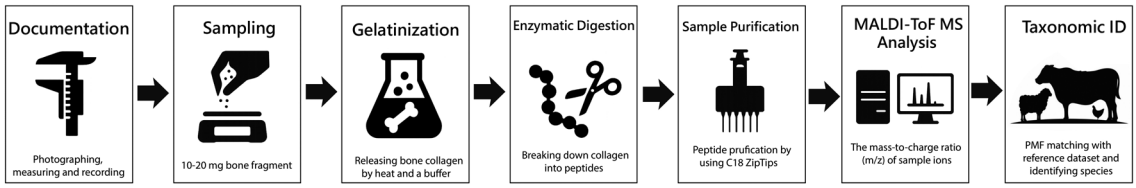

Figure 5: Diagram showing a generic workflow of Zooarchaeology by Mass Spectrometry (ZooMS) analysis on animal bones.

ZooMS has proven especially valuable for resolving long-standing challenges in taxonomic discrimination. It has been successfully applied to differentiate closely related taxa, including equids (e.g., *Equus caballus* and *Equus asinus*; Paladugu et al., 2023) and caprines (*Ovis* and *Capra*; Buckley et al., 2010; Collins & Spindler, 2016; Jeanjean et al., 2023). Furthermore, it is a powerful analytical tool for identifying unidentifiable, fragmentary animal bones, typically achieving family and genus level taxonomic resolution. Welker et al. (2015) demonstrated that ZooMS is highly effective for identifying previously unidentifiable bone fragments, achieving a 91.6% success rate at the Middle–Upper Paleolithic transitional site of Les Cottés in France. Their findings also highlighted how reconstructing faunal ecology and taxonomic composition is crucial for understanding key phases of human evolution. Additionally, studying these biomolecules is a powerful tool for gaining insight into bone manufacturing practices and the preferred faunal resources for artifact making. Several studies have shown that bone artefacts are well suited to ZooMS-based taxonomic identification, enabling researchers to determine the animal species used in tool production and to reconstruct choices of raw materials, technological behaviors, and broader subsistence strategies (Antonosyan et al., 2025; Desmond et al., 2018; McGrath et al., 2019).

Although ZooMS studies on bird bones are still limited, the available research provides valuable insights into past human–bird interactions as well as paleoenvironmental conditions. For example, applying this collagen peptide–fingerprinting approach to 295 bones from Tlajinga in Teotihuacan, Mexico, revealed extensive exploitation of aquatic species during the Classic period (ca. 100 BCE–550/600 CE) (Codlin et al., 2022). Identifying such a wide range of exploited bird species is significant because it suggests that the residents of Tlajinga employed a diversified animal exploitation strategy rather than specializing in a limited taxon or ecological niche. Moreover, it is useful for refined taxonomic identification to confirm possible domestication, as demonstrated by Choy et al. (2025), combining both ZooMS and stable isotope analysis. Choy et al. (2025) applied ZooMS to fourteen Phasianidae bones from the Gungok-ri site in southwestern Korea, dated to the 3rd century BCE–5th century AD. Due to ongoing debate about the introduction of domesticated chickens during this period, it was unclear whether the morphologically identified avian remains represented wild or domestic chickens. Using ZooMS, and specifically several diagnostic peaks at 1604.8 and 1620.8 m/z (+1), they identified five of

the fourteen Phasianidae specimens as chicken (*Gallus gallus*). They also conducted carbon and nitrogen isotope analyses and observed elevated $\delta^{15}N$ values (4–5‰) in the specimens, which they interpreted as evidence of consumption of anthropogenic food sources, supporting their domesticated status. In another example, applying ZooMS to distinguish Japanese archaeological chickens and indigenous pheasants confirmed the accuracy of earlier morphological identifications (Eda et al., 2020). This further highlights the technique's potential to achieve not only family or genus level taxonomic identifications but, in some cases, species level identifications. However, species level identification in birds remains challenging due to the slow evolutionary rate of collagen type I (COL1) and substantial intraspecies proteomic variability. Despite these limitations, ongoing efforts to better characterize avian collagen diversity show promising results (see Codlin et al., 2022; Codlin et al., 2025; Eda et al., 2020).

Conclusion & Future Notes

The study of archaeological avifauna in Türkiye offers valuable insights into both past human behavior and environmental conditions. Morphological analyses of bird bones and eggshells, combined with paleoproteomics, have the potential to significantly advance our understanding of prehistoric bird exploitation, seasonal behaviors, and ecological preferences. Our meta-data analysis highlights a persistent gap in avian identifications across Anatolian archaeological assemblages, despite the general growth of zooarchaeological research in the last decades. This gap underscores the need for increased specialization in ornithoarchaeology, more comprehensive reference collections, and the integration of novel biomolecular approaches such as ZooMS and eggshell proteomics.

Paleoproteomics, in particular, represents a transformative tool for ornithoarchaeology. Despite logistical constraints, including limited access to specialized analytical facilities and high financial costs, as well as methodological and theoretical challenges such as restricted taxonomic resolution and difficulties in achieving species-level identification due to high intraspecific protein variability, the field continues to develop rapidly and remains highly valuable. Enabling the taxonomic identification of highly fragmented and morphologically unidentifiable bird bones and eggshells, it allows researchers to recover previously inaccessible data on past bird species distribution, early bird domestication, and symbolic practices and the roles of both humans and other species in shaping their environments, as demonstrated by Yeomans et al. (2024). Furthermore, morphological analysis of eggshells and osteomorphological analysis of bird bones are already useful for the taxonomic identification of avifaunal assemblages. However, when combined with paleoproteomics, taxonomic identification becomes much more reliable. Once reliable taxonomic identification is achieved, further morphological analyses of bones and eggshells can provide insights into human social and economic preferences (e.g., the use of specific bones of specific species as tools or the identification of breeding patterns of specific

bird species based on late incubation stages inferred from their eggshell remains). Table 1 summarizes selected case studies along with their research questions and methodological approaches. In some of these cases, the studies apply combined methods, particularly paleoproteomics together with eggshell morphological analyses (e.g., SEM). As indicated by these case studies, these techniques not only complement traditional morphological approaches but also open new avenues for investigating avian contributions to past human diets, cultural practices, and paleoenvironmental reconstructions.

Table 1. Table summarizing selected studies that integrated ZooMS, morphological, and isotopic analyses to investigate key aspects of past human–bird interactions.

Research question	Case study	Methods	Material	Source
Testing the potential of methods and early bird management	Çatalhöyük (Neolithic)	ZooMS & SEM	Eggshell	Best & Demarchi, 2015
Symbolic and economic role of birds at the site	Çatalhöyük (Neolithic)	ZooMS & SEM	Eggshell	Demarchi et al., 2020
Mutual ecologies of human-bird and construction of the human niche	Shubayqa (Natufian)	ZooMS & SEM	Eggshell, Bone	Yeomans et al., 2024
Developing a database for avian biomarkers and understanding the bird exploitation at the site	Tlajinga (ca. 100 BCE–550/600 CE)	ZooMS & Zooarchaeology	Bone	Codlin et al., 2022
Domestication of chicken in the region	Gungok-ri (3rd c. BCE – 5th c. AD)	ZooMS & Isotope analysis	Bone	Choy et al., 2025
Distinguishing between Japanese archaeological chickens and indigenous pheasants	Hiroshima castle (16th century AD)	ZooMS	Bone	Eda et al., 2020

To create a more holistic picture of bird–human interactions in prehistoric Türkiye, future research should prioritize:

- Revising recovery methods to adopt more cautious techniques during excavation. For example, keeping sieving and flotation methods as high as possible, particularly for key contexts such as middens, occupation deposits, and pit fills.
- Building up an ornithological reference collection beginning with the major taxonomic groups and gradually expanding it to encompass as many bird species as possible.
- Promoting education and inspiring students to develop an interest in specialized fields such as zooarchaeology, ornithoarchaeology, paleoproteomics, and paleoecological modeling.

- Investigating the ecological and cultural significance of identified bird taxa, including their role in subsistence, ritual, and symbolic practices, and combining them with paleoclimatic and paleoecological models to better understand species-specific responses to environmental change and human impact.

To summarize, archaeological avifauna in Türkiye has great potential to shed light on historical human-bird interactions and offer a multifaceted understanding of past lifeways and paleoecology, as our meta-data analysis highlights. This study further highlights the increasing number of interdisciplinary research that integrate traditional zooarchaeological approaches with emerging methodologies such as paleoproteomic analyses of eggshells and bones, enhances taxonomic identification and expands the range of information that can be recovered from highly fragmented faunal remains. In light of Türkiye's status as a critical geographical and ecological crossroads, fostering specialized avifaunal research and incorporating rapidly evolving biomolecular approaches will not only advance reconstructions of the past but also provide deeper insights into future ecological dynamics.

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References

Akgül, H. Ç., & Dincer, B. (2021). Koskarlı Cave: The first Late Pleistocene/Early Holocene site in the eastern Black Sea region of Turkey. *Archaeological Research in Asia*, *27*, 100306. https://doi.org/10.1016/j.ara.2021.100306

Akurgal, E. (1961). *Die Kunst Anatoliens von Homer bis Alexander*. Berlin, Germany: De Gruyter.

Altınbilek-Algül, Ç., Kayci, O., & Balcı, S. (2022). A New Epipalaeolithic Site in the Central Taurus Mountains: Eşek Deresi Cave (Mersin/Turkey). *ArchéOrient-Le Blog*, *18*(2022), 1-9. https://doi.org/10.15184/aqy.2025.10170

Antonosyan, M., Mkrtchyan, S., Amano, N., Davtyan, R., Yeranyan, N., Badalyan, M., & Yepiskoposyan, L. (2025). Species identification of osseous museum artefacts through peptide mass fingerprinting illustrated by a study on objects from Neolithic to Iron Age Armenia. *Heritage Science*, *13*(1), 152. https://doi.org/10.1038/s40494-025-01763-2

Arbuckle, B. S., & Erek, C. M. (2012). Late Epipaleolithic hunters of the central taurus: Faunal remains from Direkli cave, Kahramanmaraş, Turkey. *International Journal of Osteoarchaeology*, *22*(6), 694-707. https://doi.org/10.1002/oa.1230

Arslangündoğdu, Z. (2005). İstanbul-Belgrad Ormanı'nın ornitofaunası üzerinde araştırmalar [Yayımlanmamış Doktora Tezi]. İstanbul Üniversitesi.

Atıcı, L. (2011). *Before the revolution: Epipaleolithic subsistence in the western Taurus Mountains, Turkey*. British Archaeological Reports.

Baird, D. (2012). Pınarbaşı: From Epipalaeolithic campsite to sedentarising village in central Anatolia. In M. Özdoğan, N. Başgelen, & P. Kuniholm (Eds.), *The Neolithic in Turkey, Vol. 3. New excavations and new research: Central Turkey* (pp. 181-218). Archaeology & Art Publications.

Barrett, G. C., & Elmore, D. T. (1999). *Amino Acids, Peptides and Proteins*. Cambridge University Press.

Beacham, E. B., & Durand, S. R. (2007). Eggshell and the archaeological record: new insights into turkey husbandry in the American Southwest. *Journal of Archaeological Science*, *34*(10), 1610-1621. https://doi.org/10.1016/j.jas.2006.11.015

Becking, J. H. (1975). The ultrastructure of the avian eggshell. *Ibis*, *117*(2), 143-151. https://doi.org/10.1111/j.1474-919X.1975.tb04201.x

Best, J., Presslee, S., & Demarchi, B. (2015). The avian eggshell from Çatalhöyük. In S. D. Haddow (Ed.), *Çatalhöyük 2015 Archive Report* (pp. 111-115). Çatalhöyük Research Project.

Biltekin, D., Eriş, K. K., Schachner, A., Yakupoğlu, N., & Yakupoğlu, C. (2025). Late Holocene vegetation dynamics and climate variations through pollen analysis of sediments from Lake Sülük (Çorum, Türkiye). *Review of Palaeobotany and Palynology, 334*, 105280. https://doi.org/10.1016/j.revpalbo.2025.105280

Birben, Ü., & Gençay, G. (2019). Bio-smuggling in Turkey. *Crime, Law and Social Change, 71*(4), 345–364. https://doi.org/10.1007/s10611-018-9794-7

Bochenski, Z. M., & Tomek, T. (1995). How many comparative skeletons do we need to identify a bird bone. *Courier Forschungsinstitut Senckenberg*, *181*, 357-361.

Boev, Z. (1993). Archeo-ornithology and the synanthropisation of birds: A case study for Bulgaria. *Archaeofauna, 2*, 145–153. https://doi.org/10.15366/archaeofauna1993.2.013

Boyla, K. A., Kirwan, G. M., Demirci, B., Welch, H., Özen, M., Castell, P., & Marlow, T. (2025). *Türkiye Kuşlarının Doğa Tarihi*. Retrieved December 14, 2025, from https://keremaliboyla.github.io/turkiye-kuslari/

Buckley, M., Collins, M., Thomas-Oates, J., & Wilson, J. C. (2009). Species identification by analysis of bone collagen using matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry. *Rapid Communications in Mass Spectrometry: An International Journal Devoted to the Rapid Dissemination of Up-to-the-Minute Research in Mass Spectrometry*, *23*(23), 3843-3854. https://doi.org/10.1002/rcm.4316

Buckley, M., Kansa, S. W., Howard, S., Campbell, S., Thomas-Oates, J., & Collins, M. (2010). Distinguishing between archaeological sheep and goat bones using a single collagen peptide. *Journal of Archaeological Science*, *37*(1), 13-20. https://doi.org/10.1016/j.jas.2009.08.020

Butcher, G. D., & Miles, R. (1990). Concepts of eggshell quality. *Journal International IFAS Extension. Institute of Food and Agricultural Sciences. University of Florida. Gainesville FL*, *32611*, 1-2.

Cappellini, E., Jensen, L. J., Szklarczyk, D., Ginolhac, A., da Fonseca, R. A., Stafford Jr, T. W., Holen, S. R., Collins, M. J., Orlando, L., Willerslev, E., Gilbert, M. T. P., & Olsen, J. V. (2012). Proteomic analysis of a pleistocene mammoth femur reveals more than one hundred ancient bone proteins. *Journal of proteome research*, *11*(2), 917-926. https://doi.org/10.1021/pr200721u

Carey, C. (2009). The impacts of climate change on the annual cycles of birds. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1534), 3321-3330. https://doi.org/10.1098/rstb.2009.0182.

Chen, I.-C., Hill, J. K., Ohlemüller, R., Roy, D. B., & Thomas, C. D. (2011). Rapid range shifts of species associated with high levels of climate warming. *Science, 333*(6045), 1024–1026. http://doi.org/10.1126/science.1206432

Choy, K., Songyi, B., Hyounggon C., Joo Hee, Y., Hee Young, W., & Eun, J. (2025). Biomolecular Evidence of Ancient Chickens on the Korean Peninsula: Zooms Analysis of Avian Remains from the Gungok-Ri Site, South Korea. http://dx.doi.org/10.2139/ssrn.5341940

Clayburn, J. K., Smith, D. L., & Hayward, J. L. (2004). Taphonomic effects of pH and temperature on extant avian dinosaur eggshell. *Palaios*, *19*(2), 170-177.

Clutton-Brock, J. (1992). The process of domestication. *Mammal Review*, *22*(2), 79-85.

Codlin, M. C., Douka, K., & Richter, K. K. (2022). An application of zooms to identify archaeological avian fauna from Teotihuacan, Mexico. *Journal of Archaeological Science,* 148, 105692. https://doi.org/10.1016/j.jas.2022.105692

Codlin, M., Yeomans, L., Stiller, J., & Demarchi, B. (2025). New avian protein sequences improve resolution of palaeoproteomic approaches to taxonomic identification & reveal widespread intraspecies variability. *Nature Communications 16,* 8820. https://doi.org/10.1038/s41467-025-63886-1

Collins, M., Buckley, M., Grundy, H. H., Thomas-Oates, J., Wilson, J., & van Doorn, N. (2010). ZooMS: the collagen barcode and fingerprints. *SpectroscopyEurope*, *22*(2), 6.

Collins, M. J. & Riley, M. S. (2000). Amino acid racemization in biominerals: The impact of protein degradation and loss. In G. Goodfriend, M. J. Collins, & M. Fogel (Eds.), *Perspectives in Amino Acid and Protein Geochemistry* (pp. 120–141). Oxford University Press.

Collins, M., & Spindler, L. (2016). Odense Bone and Comb Fragments. Zooarchaeology by Mass Spectrometry (ZooMS) Report: Unpublished. Report, BioArCh Report Number: KH092016. University of York.

Coutu, A. N., Whitelaw, G., Le Roux, P., & Sealy, J. (2016). Earliest evidence for the ivory trade in southern Africa: Isotopic and ZooMS analysis of seventh–tenth century AD ivory from KwaZulu-Natal. *African Archaeological Review, 33*(4), 411-435. https://doi.org/10.1007/s10437-016-9232-0

Crabbé, A., Mikeska, C. A., Pişkin, E., de Kock, W., & Çakırlar, C. (2025). Ploughing through pathologies: Traction-related bone deformations in cattle as indicators of changes in political economies in Bronze and Iron Age Anatolia. *Journal of Archaeological Science: Reports, 64*, 105100. https://doi.org/10.1016/j.jasrep.2025.105100

Çakırlar, C., Koolstra, F. J., & Ikram, S. (2021). Tracking turtles in the past: Zooarchaeological evidence for human-turtle interactions in the ancient Eastern Mediterranean. *Antiquity, 95*(379), 125–141. https://doi.org/10.15184/aqy.2020.95

Çelik, B. (2011). Karahan Tepe: a new cultural centre in the Urfa area in Turkey. *Documenta Praehistorica*, *38*, 241-254. https://doi.org/10.4312/dp.38.19

Çilingiroğlu, Ç., Kaczanowska, M., Kozłowski, J. K., Dinçer, B., Çakırlar, C., & Turan, D. (2020). Between Anatolia and the Aegean: Epipalaeolithic and Mesolithic Foragers of the Karaburun Peninsula. *Journal of Field Archaeology*, *45*(7), 479-497. https://doi.org/10.1080/00934690.2020.1786929

De Cupere, B., Thys, S., Van Neer, W., Ervynck, A., Corremans, M., & Waelkens, M. (2009). Eagle owl (Bubo bubo) pellets from Roman Sagalassos (SW Turkey): Distinguishing the prey remains from nest and roost sites. *International Journal of Osteoarchaeology, 19*(1), 1–22. https://doi.org/10.1002/oa.965

Demarchi, B. (2020). *Amino acids and proteins in fossil biominerals: an Introduction for archaeologists and palaeontologists.* New Jersey, US: John Wiley & Sons.

Demarchi, B., Collins, M. J., Tomiak, P. J., Davies, B. J., & Penkman, K. E. H. (2013). Intra-crystalline protein diagenesis (IcPD) in Patella vulgata. Part II: Breakdown and temperature sensitivity. *Quaternary Geochronol*ogy *16*, 158–172. https://doi.org/10.1016/j.quageo.2012.08.001

Demarchi, B., Hall, S., Roncal-Herrero, T., Freeman, C. L., Woolley, J., Crisp, M. K., Wilson, J., Fotakis, A., Fischer, R., Kessler, B. M., Rakownikow Jersie-Christensen, R., Olsen, J. V., Haile, J., Thomas, J., Marean, C. W., Parkington, J., Presslee, S., Lee-Thorp, J., Ditchfield, P., Hamilton, J. F., Ward, M. W., Wang, C. M., Shaw, M. D., Harrison, T., Domínguez-Rodrigo, M., MacPhee, R. D. E., Kwekason, A., Ecker, M., Kolska Horwitz, L., Chazan, M., Kröger, R., Thomas-Oates, J., Harding, J. H., Cappellini, E., Penkman, K., & Collins, M. J. (2016). Protein sequences bound to mineral surfaces persist into deep time. *eLife,* 5e17092. https://doi.org/10.7554/eLife.17092

Demarchi, B., Presslee, S., Gutierrez-Zugasti, I., Gonzalez-Morales, M., Marin-Arroyo, A. B., Straus, L. G., & Fischer, R. (2019). Birds of prey and humans in prehistoric Europe: A view from El Mirón Cave, Cantabria (Spain). *Journal of Archaeological Science: Reports*, *24*, 244-252. https://doi.org/10.1016/j.jasrep.2019.01.010

Demarchi, B., Presslee, S., Sakalauskaite, J., Fischer, R., & Best, J. (2020). The role of birds at Çatalhöyük revealed by the analysis of eggshell. *Quaternary International, 543*, 50–60. https://doi.org/10.1016/j.quaint.2020.02.009

Desmond, A., Barton, N., Bouzouggar, A., Douka, K., Fernandez, P., Humphrey, L., Morales, J., Turner, E., & Buckley, M. (2018). ZooMS identification of bone tools from the North African Later Stone Age. *Journal of Archaeological Science*, *98*, 149-157. https://doi.org/10.1016/j.jas.2018.08.012

Devictor, V., Julliard, R., Couvet, D., & Jiguet, F. (2008). Birds are tracking climate warming, but not fast enough. *Proceedings of the Royal Society B: Biological Sciences, 275*(1652), 2743–2748. https://doi.org/10.1098/rspb.2008.0878

Ebsen, J. A., Haase, K., Larsen, R., Sommer, D. V. P., & Brandt, L. Ø. (2019). Identifying archaeological leather–discussing the potential of grain pattern analysis and zooarchaeology by mass spectrometry (ZooMS) through a case study involving medieval shoe parts from Denmark. *Journal of Cultural Heritage*, *39*, 21-31. https://doi.org/10.1016/j.culher.2019.04.008

Eda, M., Morimoto, M., Mizuta, T., & Inoué, T. (2020). ZooMS for Birds: Discrimination of Japanese Archaeological Chickens and Indigenous Pheasants Using Collagen Peptide Fingerprinting. *Journal of Archaeological Science: Reports 34,* 102635. https://doi.org/10.1016/j.jasrep.2020.102635

Elvan, O. D., Arslangündoğdu, Z., & Birben, Ü. (2022). Conserving migratory birds of Turkey: Role of the international legal framework. *Environmental Monitoring and Assessment, 194*(5), 320. https://doi.org/10.1007/s10661-022-09971-0

Emra, S., Benz, M., Siddiq, A. B., & Özkaya, V. (2022). Adaptions in subsistence strategy to environmental changes across the Younger Dryas–Early Holocene boundary at Körtiktepe, Southeastern Turkey. *The Holocene, 32*(5), 390–413. https://doi.org/10.1177/09596836221074030

Fiddyment, S., Holsinger, B., Ruzzier, C., Devine, A., Binois, A., Albarella, U., Fischer, R., Nichols, E., Curtis, A., Cheese, E., Teasdale, M. D., Checkley-Scott, C., Milner, S. J., Rudy, K. M., Johnson, E. J., Vnouček, J., Garrison, M., McGrory, S., Bradley D. G., & Collins, M. J. (2015). Animal origin of 13th-century uterine vellum revealed using noninvasive peptide fingerprinting. *Proceedings of the National Academy of Sciences*, *112*(49), 15066-15071. https://doi.org/10.1073/pnas.1512264112

Gál, E. (2006). The role of archaeo-ornithology in environmental and animal history studies. In E. Jerem, Zs. Mester, & R. Benczes (Eds.), *Archaeological and cultural heritage preservation in the light of new technologies* (pp. 49–62). Budapest Archaeolingua.

Gu, Z., Dixon, A., & Zhan, X. (2024). Genetics and evolution of bird migration. *Annual Review of Animal Biosciences, 12*(1), 21–43. https://doi.org/10.1146/annurev-animal-021122-092239

Gündem, C. Y. (2024). Earliest mule remains from Early Bronze Age Central Anatolia. *Animals, 14*(10), 1397. https://doi.org/10.3390/ani14101397.

Hendy, J., Welker, F., Demarchi, B., Speller, C., Warinner, C., & Collins, M. J. (2018). A guide to ancient protein studies. *Nature ecology & evolution*, *2*(5), 791-799. https://doi.org/10.1038/s41559-018-0510-x

Hicks, M., Anamthawat-Jónsson, K., & Einarsson, Á. (2023). The identification of bird eggshell by scanning electron microscopy. *Journal of Archaeological Science*, *151*, 105712. https://doi.org/10.1016/j.jas.2022.105712

Higgins, J. (1999). Túnel: A case study of avian zooarchaeology and taphonomy. *Journal of Archaeological Science, 26*(12), 1449–1457. https://doi.org/10.1006/jasc.1999.0429

Hollemeyer, K., Altmeyer, W., Heinzle, E., & Pitra, C. (2008). Species identification of Oetzi's clothing with matrix-assisted laser desorption/ionization time-of-flight mass spectrometry based on peptide pattern similarities of hair digests. *Rapid Communications in Mass Spectrometry*, *22*(18), 2751-2767. https://doi.org/10.1002/rcm.3679

Jeanjean, M., McGrath, K., Valenzuela-Lamas, S., Nieto-Espinet, A., Schafberg, R., Parés-Casanova, P. M., Jiménez-Manchón, S., Guintard, C., Tekkouk, F., Ridouh, R., Mureau, C., & Evin, A. (2023). ZooMS confirms geometric morphometrics species identification of ancient sheep and goat. *Royal Society Open Science*, *10*(9), 230672. https://doi.org/10.1098/rsos.230672

Kabukcu, C., & Asouti, E. (2022). Early to mid-Holocene vegetation history and human settlement in Anatolia. In C. Roosevelt & J. Haldon (Eds). *Winds of Change: Environment and Society in Anatolia* (pp. 65–83). Koç University Press.

Karul, N. (2020). The beginning of the Neolithic in Southeast Anatolia: Upper Tigris Basin. *Documenta Praehistorica, 47.* https://doi.org/10.4312/dp.47.5

Keepax, C. A. (1977). Identification of avian eggshell from archaeological sites and the potential use of the scanning electron microscope. *Ancient Monuments Laboratory Report No. 2415*. England.

Keepax, C. A. (1981). Avian eggshell from archaeological sites. *Journal of Archaeological Science*, *8*(4), 315-335. https://doi.org/10.1016/0305-4403(81)90032-7

Kessel, A., & Ben-Tal, N. (2018). Introduction to proteins: structure, function, and motion. *Chapman and Hall/CRC.* https://doi.org/10.1201/9781315113876

Kirwan, G., Demirci, B., Welch, H., Boyla, K., Özen, M., Castell, P., & Marlow, T. (2008). *The birds of Turkey*. Christopher Helm London.

Kodaş, E. (2023). The younger Dryas layer at Boncuklu Tarla and the beginning of village life in the upper Tigris Basin. *Archaeological Research in Asia*, *35*, 100460. https://doi.org/10.1016/j.ara.2023.100460

Kodaş, E., Genç, B., Çiftçi, Y., Kodas, C. L., & Erdem, Ç. (2020). Çemka Höyük: A late Epipalaeolithic and pre-pottery Neolithic site on the upper Tigris, Southeast Anatolia. *NEO-LITHICS: The Newsletter of Southwest Asian Neolithic Research*, *20*, 40-46.

Kolbüken, M., Biltekin, D., Arıkan, B., & Yakupoğlu, N. (2025). Vegetation and climate patterns of western Türkiye since the late Last Glacial Period based on a new pollen record in the Aegean Sea. *Quaternary International, 742*, 109900. https://doi.org/10.1016/j.quaint.2025.109900

Kost, C., & Hussain, S. T. (2019). Archaeo-ornithology: Towards an archaeology of human–bird interfaces. *Environmental Archaeology, 24*(4), 337–358. https://doi.org/10.1080/14614103.2019.1590984

Kökten, K. (1959). Tarsus-Antalya Arası Sahil Şeridi Üzerinde ve Antalya Bölgesinde Yapılan Tarihöncesi Araştırmaları. *Türk Arkeoloji Dergisi, 11*, 10-19.

Kuzucuoğlu, C. (2013). Geomorphology of the Melendiz River in Cappadocia (Turkey): Setting of pre-pottery Neolithic sites of Aşıklı and Musular, and climate reconstruction during the onset of the Holocene. *Geografia Fisica e Dinamica Quaternaria, 36*, 95–105. https://doi.org/10.4461/GFDQ.2013.36.7

Machado, D. O. B. F., Coe, H. H. G., Bandeira, D. D. R., Souza, R., Rasbold, G. G., Chueng, K.F. & De Sá, J. C. (2025). Palaeoenvironmental reconstruction through phytolith analysis in the Casa de Pedra shell mound archaeological site, São Francisco do Sul, Santa Catarina, Brazil. *Vegetation History and Archaeobotany, 34*(2), 225–237. https://doi.org/10.21203/rs.3.rs-1633457/v1

Marston, J. M., Çakırlar, C., Luke, C., Kováčik, P., Slim, F. G., Shin, N., & Roosevelt, C. H. (2022). Agropastoral economies and land use in Bronze Age western Anatolia. *Environmental Archaeology, 27*(6), 539–553. https://doi.org/10.1080/14614103.2021.1918485

McGrath, K., Rowsell, K., Gates St-Pierre, C., Tedder, A., Foody, G., Roberts, C., Speller, C., & Collins, M. (2019). Identifying archaeological bone via non-destructive ZooMS and the materiality of symbolic expression: examples from Iroquoian bone points. *Scientific reports*, *9*(1), 11027. https://doi.org/10.1038/s41598-019-47299-x

Mellink, M. J. (1964). A votive bird from Anatolia. *Expedition, 6*(2), 28. Penn Museum.

Morales-Muñiz, A. M. (1993). Ornithoarchaeology: The various aspects of the classification of bird remains from archaeological sites. *Archaeofauna, 2,* 1–13. https://doi.org/10.15366/archaeofauna1993.2.001

Onar, V., Alpak, H., Pazvant, G., Armutak, A., & Chrószcz, A. (2012). Byzantine horse skeletons of Theodosius Harbour: 1. Paleopathology. *Revue de Médecine Vétérinaire, 163*(3), 139–146.

Onar, V., Köroğlu, G., Armutak, A., Öncü, Ö. E., Siddiq, A. B., & Chrószcz, A. (2021). A cat skeleton from the Balatlar Church excavation, Sinop, Turkey. *Animals, 11*(2), 288. https://doi.org/10.3390/ani11020288

Ökse, A. T. (2021). Ambar Dam Salvage Excavations 2018-2020: Ambar Höyük, Gre Filla, and Kendale Hecala. In Steadman, S. & McMahon, G. (Eds). *The Archaeology of Anatolia, Volume IV: Recent Discoveries (2018–2020)* (pp. 4-20). Cambridge Scholars.

Özbasaran, M., & Duru, G. (2011). Akarçay Tepe. A PPNB and PN settlement in Middle Euphrates-Urfa. In M. Özdoğan, N. Başgelen, & P. Kuniholm (Eds). *The Neolithic in Turkey*, *2* (pp. 165-202). Archaeology & Art Publications.

Özbaşaran, M., & Duru, G. (2015). The early sedentary community of Cappadocia: Aşıklı Höyük. *La Cappadoce Méridionale, de la Préhistoire à la Période Byzantine: 3e Rencontres d'archéologie de l'IFEA*, 43–51. Institut français d'études anatoliennes. https://doi.org/10.4000/books.ifeagd.3237

Özdoğan, E. (2024). Sayburç a mid-9th millennium BC site in the foothills of the Eastern Taurus. *Documenta Praehistorica*, *51*, 44-58. https://doi.org/10.4312/dp.51.23

Özdoğan, M. (2014). Anatolia: From the pre-pottery Neolithic to the end of the Early Bronze Age (10,500–2000 BCE). *The Cambridge World Prehistory*, *3*, 1508–1544. Cambridge University Press. https://doi.org/10.1017/CHO9781139017831

Özkaya, V., & Coşkun, A. (2011). Körtik Tepe. In M. Özdoğan, N. Başgelen, & P. Kuniholm (Eds.), *The Neolithic of Turkey* 1 (pp. 89–127). Archaeology & Art Publications.

Paladugu, R., Richter, K. K., Valente, M. J., Gabriel, S., Detry, C., Warinner, C., & Dias, C. B. (2023). Your horse is a donkey! Identifying domesticated equids from Western Iberia using collagen fingerprinting. *Journal of Archaeological Science*, *149*, 105696. https://doi.org/10.1016/j.jas.2022.105696

Peters, C., Richter, K. K., Manne, T., Dortch, J., Paterson, A., Travouillon, K., Louys, J., Price, G.J., Petraglia, M., Crowther, A., & Boivin, N. (2021). Species Identification of Australian Marsupials Using Collagen Fingerprinting. *Royal Society Open Science*, *8*(10), 211229. https://doi.org/10.1098/rsos.211229

Peters, J., von den Driesch, A., Pöllath, N., & Schmidt, K. (2005). Birds in the megalithic art of pre-pottery Neolithic Göbekli Tepe, Southeast Turkey. *Documenta Archaeobiologiae, 3*, 223–234.

Pöllath, N., & Peters, J. (2023). Distinct modes and intensity of bird exploitation at the dawn of agriculture in the Upper Euphrates and Tigris River basins. *Archaeological and Anthropological Sciences, 15*(10), 154. https://doi.org/10.1007/s12520-023-01841-1

Pöllath, N., & Peters, J. (2024). Early Neolithic avifaunal remains from southeast Anatolia provide insight into Early Holocene species distributions and long-term shifts in their range. *Ibis, 166*(4), 1264–1279. https://doi.org/10.1111/ibi.13341

Presslee, S., Wilson, J., Woolley, J., Best, J., Russell, D., Radini, A., Fischer, R., Kessler, B. Boano, R. Collins, M. & Demarchi, B. (2017). The identification of archaeological eggshell using peptide markers. *STAR: Science & Technology of Archaeological Research*, *3*(1), 89-99. https://doi.org/10.1080/20548923.2018.1424300

Reynolds, A. S. (2022). Proteins: Machines, Messengers, and Team Players. *Understanding Metaphors in the Life Sciences*, 48–66. Cambridge University Press. https://doi.org/10.1017/9781108938778

Richter, K. K., Codlin, M. C., Seabrook, M., & Warinner, C. (2022). A primer for ZooMS applications in archaeology. *Proceedings of the National Academy of Sciences*, *119*(20), e2109323119. https://doi.org/10.1073/pnas.2109323119

Roberts, N., Eastwood, W. J., Kuzucuoğlu, C., Fiorentino, G., & Caracuta, V. (2011). Climatic, vegetation and cultural change in the eastern Mediterranean during the mid-Holocene environmental transition. *The Holocene, 21*(1), 147–162. https://doi.org/10.1177/0959683610386819

Russell, N. (2011). *Social zooarchaeology: Humans and animals in prehistory*. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9781139019712

Russell, N. (2019a). Feathers and talons: Birds at Neolithic Çatalhöyük, Turkey. *Archaeological and Anthropological Sciences, 11*, 6393–6410. https://doi.org/10.1007/s12520-018-0681-z

Russell, N. (2019b). Spirit birds at Neolithic Çatalhöyük. *Environmental Archaeology, 24*, 377–386. https://doi.org/10.1080/14614103.2017.1422685

Russell, N. (2022). Changing use of birds across the agricultural transition at Pınarbaşı, Turkey. *Quaternary International*, 626, 43-51. https://doi.org/10.1016/j.quaint.2020.10.077

Russell, N. (2025). Duck, Duck, Goose: Varying Goose Proportions in Late Pleistocene/Early Holocene Southwest Asia. *International Journal of Osteoarchaeology*, 1–16. https://doi.org/10.1002/oa.70057

Russell, N., & McGowan, K. J. (2003). Çatalhöyük bird bones. In I. Hodder (Ed.), *Inhabiting Çatalhöyük: Reports from the 1995-1999 season* (pp. 99–110). British Institute at Ankara.

Serjeantson, D. (1996). *A manual for the identification of bird bones from archaeological sites*. Archetype Publications. https://doi.org/10.1080/00665983.1988.11077923

Serjeantson, D. (2009). *Birds*. Cambridge University Press. http://doi.org/10.1002/9781119188230.saseas0064

Sherratt, A. G. (1983). The Secondary Products Revolution of animals in the Old World. *World Archaeology*, *15,* 90–104. Taylor & Francis.

Sichert, B. M., Rentzel, P., Demarchi, B., Best, J., Negri, A., & Deschler-Erb, S. (2019). Incubated eggs in a Roman burial? A preliminary investigation on how to distinguish between the effects of incubation and taphonomy on avian eggshell from archaeological sites. *Journal of Archaeological Science: Reports*, *26*, 101845. https://doi.org/10.1016/j.jasrep.2019.05.010

Siddiq, A. B., Onar, V., Mutuş, R., & Poradowski, D. (2021). The Iron Age dogs from Alaybeyi Höyük, Eastern Anatolia. *Animals, 11*(4), 1163. https://doi.org/10.3390/ani11041163

Sidell, E.J., (1993a). A methodology for the identification of avian eggshell from archaeological sites. *Archaeofauna. 2*, 45-51. https://doi.org/10.15366/archaeofauna1993.2.005

Sidell, E.J., (1993b). *A Methodology for the Identification of Archaeological Eggshell.* Philadelphia, US: University of Pennsylvania.

Sidell, E. J., & Scudder, C. (2005). The eggshell from Çatalhöyük. In I. Hodder (Ed.), *Inhabiting Çatalhöyük: Reports from the 1995-1999 season* (pp. 99–110). British Institute at Ankara.

Simons, P. C. M. (1971). Ultrastructure of the hen eggshell and its physiological interpretation [Doktora Tezi]. Wageningen University and Research.

Slim, F., & Çakırlar, C. (2023). Pigs and polities in Iron Age and Roman Anatolia: An interregional zooarchaeological analysis. *Quaternary International, 662*, 47–62. https://doi.org/10.1016/j.quaint.2022.05.013

Spina, F., Baillie, S. R., Bairlein, F., Fiedler, W., & Thorup, K. (Eds.). (2022). *The Eurasian African Bird Migration Atlas*. EURING/CMS. https://migrationatlas.org

Starkovich, B. M., & Stiner, M. C. (2009). Hallan Çemi Tepesi: High-ranked game exploitation alongside intensive seed processing at the Epipaleolithic-Neolithic transition in southeastern Turkey. *Anthropozoologica*, *44*(1), 41-61. https://doi.org/10.5252/az2009n1a2.

Stewart, J. R., Allen, R. B., Jones, A. K., Penkman, K. E., & Collins, M. J. (2013). ZooMS: making eggshell visible in the archaeological record. *Journal of Archaeological Science*, *40*(4), 1797-1804. https://doi.org/10.1016/j.jas.2012.11.007

Stiner, M. C., Buitenhuis, H., Duru, G., Kuhn, S. L., Mentzer, S. M., Munro, N. D. & Özbaşaran, M. (2014). A forager–herder trade-off, from broad-spectrum hunting to sheep management at Aşıklı Höyük, Turkey. *Proceedings of the National Academy of Sciences, 111*(23), 8404–8409. https://doi.org/10.1073/pnas.132272311

Urquiza, S. V., & Echevarria, A. L. (2018). Zooarchaeology of flight: Avifauna resource from the southern Argentine Puna. *Journal of Archaeological Science: Reports, 18*, 516–534. https://doi.org/10.1016/j.jasrep.2017.12.046

Üner, Ö., Boyla, K. A., Bacak, E., Birel, E., Çelikoba, I., Dalyan, C., Tabur, E. & Yardim, Ü., (2010). Spring migration of soaring birds over the Bosphorus, Turkey, in 2006. *Sandgrouse*, *32*(1), 20-33. OSME.

Van Neer, W., Fuller, B. T., Fahy, G. E., De Cupere, B., Bouillon, S., Uytterhoeven, I., & Richards, M. P. (2024). Early Byzantine fish consumption and trade revealed by archaeoichthyology and isotopic analysis at Sagalassos, Turkey. *Journal of Archaeological Science: Reports*, *53*, 104322. https://doi.org/10.1016/j.jasrep.2023.104322

Van Tuinen, M., Gourichon, L., Carter, A. L., Yener, K. A., Bulu, M., Akar, M., & Çakırlar, C. (2025). Human–bird interactions across time and space in a Bronze Age city: The case of Tell Atchana, Alalakh (Amuq Valley, Turkey). *International Journal of Osteoarchaeology*, 1–15. https://doi.org/10.1002/oa.70047

Von Holstein, I. C., Ashby, S. P., Van Doorn, N. L., Sachs, S. M., Buckley, M., Meiri, M., Barnes, I., Brundle, A., & Collins, M. J. (2014). Searching for Scandinavians in pre-Viking Scotland: molecular fingerprinting of Early Medieval combs. *Journal of Archaeological Science*, *41,* 1-6. https://doi.org/10.1016/j.jas.2013.07.026

Warinner, C., Korzow Richter, K., & Collins, M. J. (2022). Paleoproteomics. *Chemical reviews*, *122*(16), 13401-13446. https://doi.org/10.1021/acs.chemrev.1c00703

Welker, F., Soressi, M., Rendu, W., Hublin, J. J., & Collins, M. (2015). Using ZooMS to identify fragmentary bone from the late Middle/Early Upper Palaeolithic sequence of Les Cottés, France. *Journal of Archaeological Science*, *54*, 279-286. https://doi.org/10.1016/j.jas.2014.12.010

Yeomans, L. (2025). Zooarchaeology of Managed, Captive, Tame, and Domestic Birds: Shifts in Human–Avian Relationships. *Journal of Archaeological Research, 33,* 587–628. https://doi.org/10.1007/s10814-024-09206-5

Yeomans, L., Codlin, M. C., Mazzucato, C., Dal Bello, F., & Demarchi, B. (2024). Waterfowl eggshell refines palaeoenvironmental reconstruction and supports multi-species niche construction at the Pleistocene-Holocene transition in the Levant. J*ournal of Archaeological Method and Theory*, *31*(3), 1383-1429. https://doi.org/10.1007/s10816-024-09641-0

Zeder, M. A., & Spitzer, M. D. (2016). New insights into broad spectrum communities of the Early Holocene Near East: The birds of Hallan Çemi. *Quaternary Science Reviews, 151*, 140–159. https://doi.org/10.1016/j.quascirev.2016.08.024

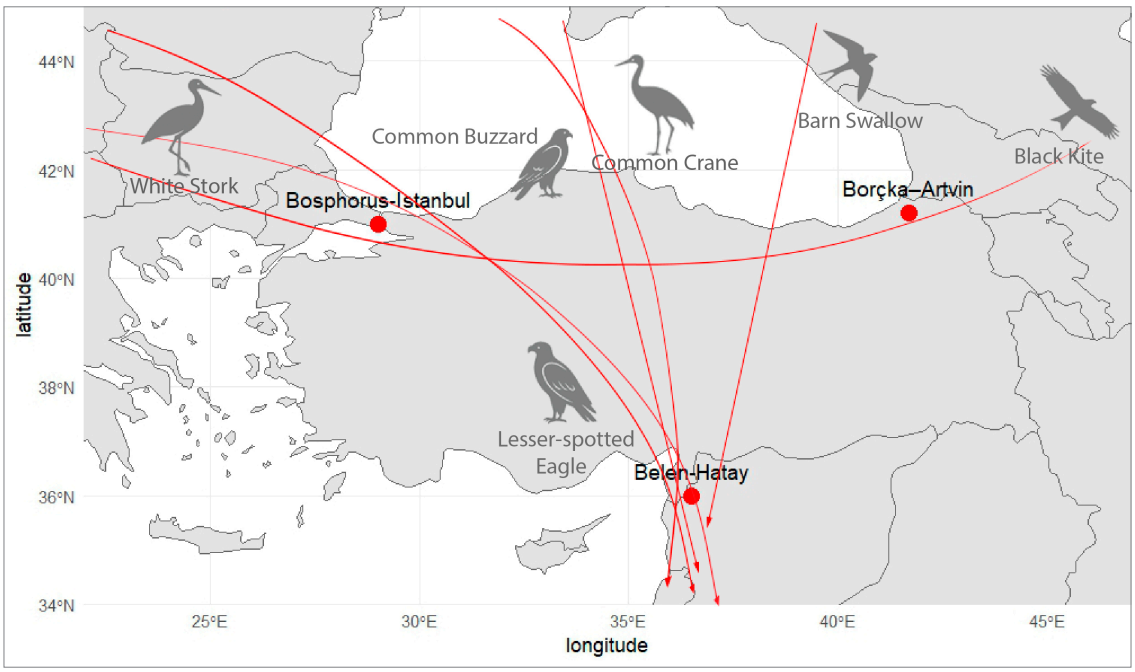

Figure 1: The illustrated map shows some of the migrant bird species and their migration routes across the main migration corridors in Türkiye (after Arslangündoğdu, 2005; Elvan et al., 2022; Spina et al., 2022; Üner et al., 2010).

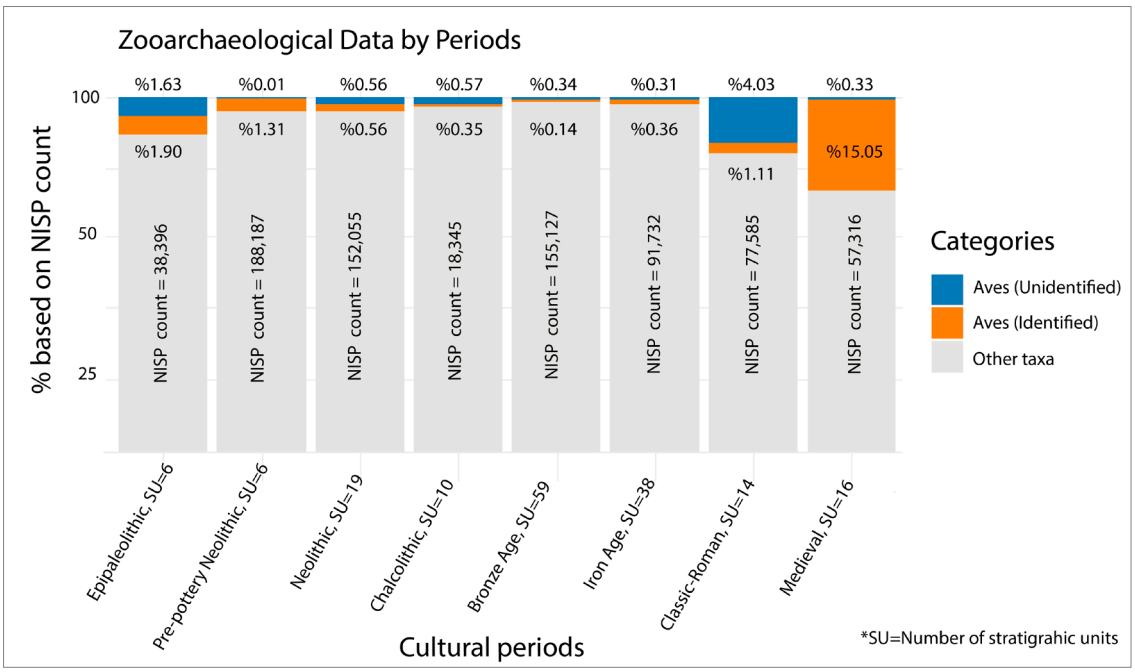

Figure 2: The relative abundance of identified (to family level and below) and unidentified bird species, and other species based on NISP counts.

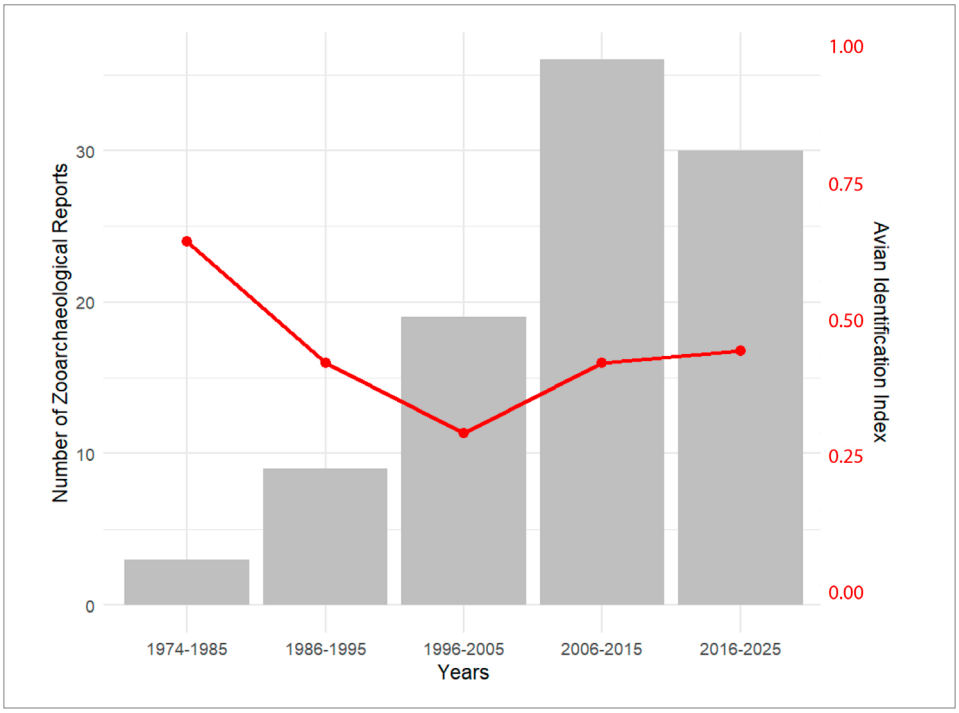

Figure 3: The number of zooarchaeological studies by decade is shown in the gray columns, while the Avian Identification Index (AII) across decades is represented by the red line.

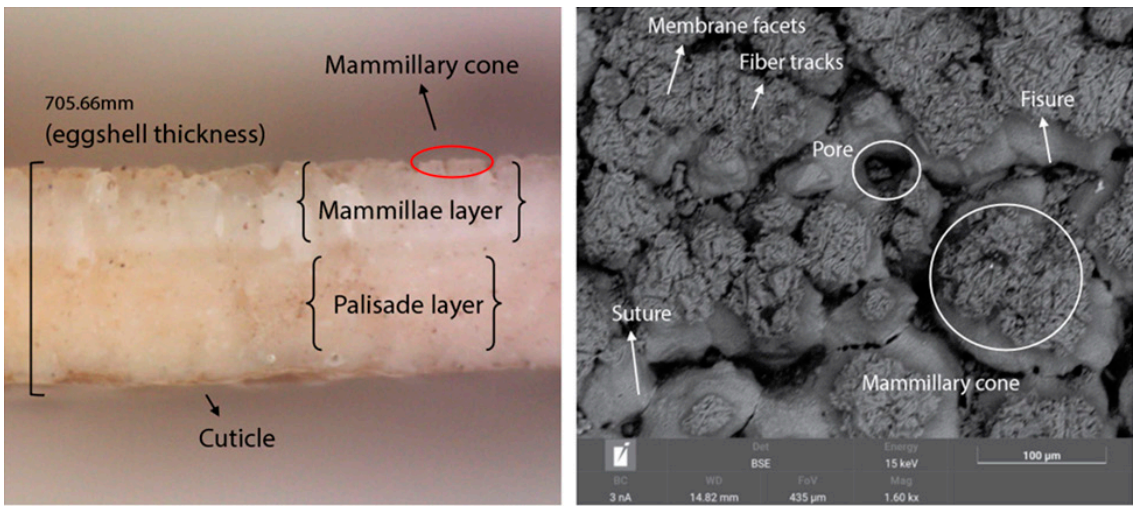

Figure 4: Digital microscopy image of an eggshell fragment from Neolithic Çatalhöyük showing the main morphological components in cross-section *(left)*. Scanning Electron Microscopy (SEM) image showing the same fragment from top view *(right)*. The sample was morphologically identified as *Anser*, ID: PALTO 3718A.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Amaç & Kapsam

Arkeoloji bir süredir geçmişin yorumlanmasında teknoloji ve doğa bilimleri, mühendislik ve bilgisayar teknolojileri ile yoğun iş birliği içinde yeni bir anlayışa evrilmektedir. Üniversiteler, ilgili kurum ya da enstitülerde yeni açılmakta olan "Arkeoloji Bilimleri" bölümleri ve programları, geleneksel anlayışı terk ederek değişen yeni bilim iklimine adapte olmaya çalışmaktadır. Bilimsel analizlerden elde edilen sonuçların arkeolojik bağlam ile birlikte ele alınması, arkeolojik materyallerin, yerleşmelerin ve çevrenin yorumlanmasında yeni bakış açıları doğurmaktadır.

Türkiye'de de doğa bilimleriyle iş birliği içindeki çalışmaların olduğu kazı ve araştırma projelerinin sayısı her geçen gün artmakta, yeni uzmanlar yetişmektedir. Bu nedenle Arkeoloji Bilimleri Dergisi (ABD), Türkiye'de arkeolojinin bu yeni ivmenin bir parçası olmasına ve arkeoloji içindeki arkeobotanik, arkeozooloji, alet teknolojileri, tarihlendirme, mikromorfoloji, biyoarkeoloji, jeokimyasal ve spektroskopik analizler, Coğrafi Bilgi Sistemleri, iklim ve çevre modellemeleri gibi uzmanlık alanlarının çeşitlenerek yaygınlaşmasına katkı sağlamayı amaçlamaktadır. Derginin ana çizgisi arkeolojik yorumlamaya katkı sağlayan yeni anlayışlara, disiplinlerarası yaklaşımlara, yeni metot ve kuram önerilerine, analiz sonuçlarına öncelik vermek olarak planlanmıştır. Kazı raporlarına, tasnif ve tanıma dayalı çalışmalara, buluntu katalogları ve özgün olmayan derleme yazılarına öncelik verilmeyecektir.

Arkeoloji Bilimleri Dergisi açık erişimli, uluslararası hakemli bir dergidir. Araştırma ve yayın etiğine uygun bulunan makaleler çift taraflı kör hakem değerlendirme sürecinden geçtikten sonra yayınlanır. Dergi, Ege Yayınları tarafından çevrimiçi olarak yayınlanmaktadır.

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ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Aims & Scope

Archaeology is being transformed by integrating innovative methodologies and scientific analyses into archaeological research. With new departments, institutes, and programs focusing on "Archaeological Sciences", archaeology has moved beyond the traditional approaches of the discipline. When placed within their archaeological context, scientific analyses can provide novel insights and new interpretive perspectives to study archaeological materials, settlements and landscapes.

In Türkiye, the number of interdisciplinary excavation and research projects incorporating scientific techniques is on the rise. A growing number of researchers are being trained in a broad range of scientific fields, including but not limited to archaeobotany, archaeozoology, tool technologies, dating methods, micromorphology, bioarchaeology, geochemical and spectroscopic analysis, Geographical Information Systems, and climate and environmental modeling. The Turkish Journal of Archaeological Sciences (TJAS) aims to situate Turkish archaeology within this new paradigm and to diversify and disseminate scientific research in archaeology. New methods, analytical techniques and interdisciplinary initiatives that contribute to archaeological interpretations and theoretical perspectives fall within the scope of the journal. Excavation reports and manuscripts focusing on the description, classification, and cataloging of finds do not fall within the scope of the journal.

The Turkish Journal of Archaeological Sciences is an open access, international, double-blind peer-reviewed yearly publication. Articles that comply with publication and research ethics are published after the reviewing process. The journal is published online by Ege Yayınları in Türkiye.

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ARKEOLOJİ BİLİMLERİ DERGİSİ
TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Makale Değerlendirme Politikası (Çift Taraflı Kör Hakemlik) ve Yayın Süreci

Arkeoloji Bilimleri Dergisi, Türkçe veya İngilizce özgün araştırma makaleleri yayımlamaktadır.

1. Daha önce yayımlanmamış veya başka bir dergide değerlendirme sürecinde bulunmayan ve tüm yazarlar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir.
2. Gönderilen makaleler, ön inceleme, intihal taraması, hakem değerlendirmesi ve dil düzenlemesi aşamalarından geçirilir.
3. Ön inceleme aşamasını geçemeyen makaleler, yazar(lar)a iade edilir ve aynı yayın döneminde tekrar değerlendirmeye alınmaz. Ön incelemeyi geçen makaleler, en az iki hakemin değerlendirdiği çift taraflı kör hakem sürecine tabi tutulur.
4. İntihal kontrolünden geçen makaleler, Editör tarafından bilimsel içerik, yöntem, ele alınan konunun önemi ve derginin kapsamına uygunluk açısından değerlendirilir. Editör, makalelerin ön değerlendirmesini yapmak üzere editör yardımcılarına yönlendirir.
5. Editör yardımcıları, her bir makaleyi son gönderim tarihinden önce inceleyerek Arkeoloji Bilimleri Dergisi yayın ilkelerine uygunluğunu değerlendirir. Bu aşamada intihal taraması yapılır ve dergi yazım kurallarına uygunluk kontrol edilir.
6. Editörler ve editör yardımcıları, makalenin etik standartlara, konuya uygunluğa, metin düzenine, dipnotlar ve kaynakçaya, görsel kalitesine ve gerekli telif hakkı izinlerine uyup uymadığını değerlendirir. Bu kriterleri karşılayan makaleler, çift taraflı kör hakemlik süreci korunarak en az iki ulusal/uluslararası hakeme gönderilir.
7. Derginin hakem değerlendirme süreci ve editoryal etik kuralları, değerlendirmelerin milliyet, cinsiyet veya diğer herhangi bir faktöre dayalı önyargılardan arındırılmış olmasını sağlar. Makaleler, doktora derecesine sahip ve güçlü bir araştırma geçmişi bulunan en az iki uzman tarafından değerlendirilir.

8. Hakemler, makalenin yayınlanmaya uygunluğunu değerlendiren bir form doldurur ve gerekli revizyonlara yönelik önerilerde bulunur. Hakemler makaleyi değişiklik yapmadan kabul edebilir, küçük değişikliklerle kabul edebilir, büyük değişiklikler ve yeniden gönderim talep edebilir veya makaleyi reddedebilir. Her iki hakem de küçük değişiklikleri kabul ederse ve revize edilen versiyon onaylanırsa makale kabul edilir. Büyük değişiklikler gerektiğinde, makale Editörler tarafından yeniden değerlendirilir ve gerekli düzeltmeler yapıldıktan sonra hakemlere geri gönderilebilir. Revizyonlar yeterli bulunduğunda makale yayımlanmak üzere kabul edilir. Eğer bir hakem makaleyi reddeder veya biri olumlu, diğeri olumsuz görüş bildirirse, makale üçüncü bir hakeme gönderilir. Ancak iki hakemin olumlu görüş bildirmesi durumunda, son yayın kararı Editör Kurulu tarafından verilir. Editoryal kararlar nihaidir ve yalnızca istisnai durumlarda ilgili *COPE* yönergelerine göre itiraz edilebilir.
9. Hakemlerden, değerlendirmelerinde nazik, saygılı ve bilimsel bir dil kullanmaları beklenir. Saldırgan, saygısız veya kişisel yorumlardan kaçınmaları gerekmektedir. Bilimsel olmayan yorumlar tespit edildiğinde, dergi yönetimi hakemden raporunu gözden geçirmesini ve düzeltmesini talep eder. Hakemlerin değerlendirmelerini belirtilen süre içinde tamamlaması ve burada açıklanan etik sorumluluklara uyması gerekmektedir.
10. Dil düzenlemesi tamamlandıktan sonra, kabul edilen makaleler ilgili dergi sayısında tematik veya kronolojik sıraya göre düzenlenir.
11. Makalelerin mizanpajı, dergi tasarımına uygun olarak yapılır ve ardından Editörler tarafından gözden geçirilir.
12. Makalelerin son PDF versiyonu, nihai kontrol ve onay için yazarlara gönderilir. Yazarlar, makalenin derginin etik standartlarına uygun olduğunu ve çalışmalarının tüm sorumluluğunu kabul ettiklerini teyit etmelidir.
13. Hakemlerin talepleri doğrultusunda yazarlar tarafından yapılan düzenlemeler incelendikten sonra, nihai yayın kararı Yayın Kurulu tarafından verilir.
14. Yukarıda belirtilen süreçler tamamlandıktan sonra ilgili dergi sayısı son haline getirilir ve makalelere DOI numaraları atanır.
15. DOI numaraları atandıktan sonra baskı süreci başlar ve yayın süreci tamamlanır.

Editör Sorumlulukları

1. Editör, makaleleri yalnızca bilimsel içerik temelinde değerlendirir; yazarların etnik kökeni, cinsiyeti, cinsel yönelimi, milliyeti, dini inançları veya siyasi görüşleri dikkate alınmaz.
2. Editör, gönderilen makalelerin tarafsız bir şekilde çift taraflı kör hakem değerlendirmesine tabi tutulmasını sağlar ve yayınlanmadan önce gizliliği korur.

3. Editör, hakemlere makalelerin gizli bilgi içerdiğini ve değerlendirmenin ayrıcalıklı bir etkileşim olduğunu bildirir. Hakemler ve yayın kurulu üyeleri, makaleleri üçüncü şahıslarla tartışamaz. Belirli durumlarda, Editör belirli bir noktayı netleştirmek amacıyla bir hakemin değerlendirmesini diğer hakemlerle paylaşabilir.
4. Editör, derginin içeriği ve genel kalitesinden sorumludur; gerektiğinde düzeltme notu yayımlamak veya geri çekme işlemi yapmak editörün sorumlulukları arasındadır.
5. Editör, yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkilidir ve makalelerin yayımlanmasına ilişkin nihai karardan sorumludur.

Hakem Sorumlulukları

1. Hakemler, araştırma, yazarlar ve/veya finansman sağlayıcıları ile herhangi bir çıkar çatışması içinde olmamalıdır. Değerlendirmeleri objektif olmalıdır.
2. Hakemler, gönderilen makalelerle ilgili tüm bilgilerin gizli kalmasını sağlamalı ve telif hakkı ihlali veya intihal tespit etmeleri durumunda Editöre bildirmelidir.
3. Kendini makaleyi değerlendirmede yetersiz hisseden veya incelemeyi belirtilen süre içinde tamamlayamayacağı kanısına varan hakem, Editöre haber vermeli ve değerlendirme sürecinden çekilmelidir.

Yazar Sorumlulukları

1. Yazar olarak belirtilen kişiler, makalenin kavramsallaştırılması, tasarımı, veri toplama ve yorumlama, veri analizi veya araştırma ve yazım süreçlerine önemli katkıda bulunmuş olmalıdır. Tüm ortak yazarlar, makalenin son sürümünü onaylamalı ve içeriğinden eşit derecede sorumlu olmalıdır.
2. Yazarlar, görsellerin (fotoğraf veya şekiller) telif hakkı düzenlemelerine uygun olmasını sağlamalı veya gerekli izinleri almalıdır. Eğer etik veya telif hakkı ihlali tespit edilirse, dergi ilgili makaleyi geri çekme veya erişimini engelleme hakkını saklı tutar.
3. Yazarlar, dergi editörleri ile iletişim kurmaktan, düzeltmeleri yapmaktan, makaleyi belirtilen sürede yeniden göndermekten ve etik ile telif hakkı kurallarına uygunluğu onaylamaktan sorumludur. İlk gönderimden sonra yazar isim değişiklikleri dikkate alınmaz.

Düzeltme Süreci

Hakemler tarafından revizyon talep edilmesi durumunda, ilgili raporlar yazara iletilir ve yazarın en kısa sürede gerekli düzeltmeleri yapması beklenir. Yazar, yaptığı düzeltmeleri işaretleyerek güncellenmiş makaleyi Editörlere sunmalıdır.

Türkçe Dil Düzenlemesi: Hakem sürecinden geçen Türkçe makaleler, Türkçe Dil Editörü tarafından incelenir ve gerekli görüldüğünde yazardan tashih istenebilir.

Yabancı Dil Düzenlemesi: Hakem sürecinden geçen İngilizce makaleler, Yabancı Dil Editörü tarafından gözden geçirilir ve gerekli görüldüğünde yazardan ek düzeltmeler yapması istenebilir.

Dizgi, Mizanpaj ve Son Okuma Süreci

Yayın Kurulu tarafından yayımlanması onaylanan makaleler, nihai yayına hazırlanmak üzere dizgi ve mizanpaj işlemlerine tabi tutulur. Mizanpaj işlemi tamamlandıktan sonra, yayınlanmadan önce makaleler için son okuma süreci gerçekleştirilir.

DOI Atama

Dijital Nesne Tanımlayıcısı (DOI), elektronik ortamda yayımlanan bir makalenin resmi ve orijinal versiyonuna kalıcı bir bağlantı sağlayan benzersiz bir kimlik numarasıdır. Arkeoloji Bilimleri Dergisi, yayın sürecinin tamamlanmasının ardından kabul edilen tüm bilimsel makalelere DOI numarası atayarak, makalenin dijital ortamda resmi kaydını güvence altına alır.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Article Evaluation Policy (Double-Blind Peer Review) and Publication Process

The Turkish Journal of Archaeological Sciences publishes original research articles in Turkish or English.

1. Manuscripts must be original, unpublished, and not under review elsewhere. All authors must approve the submission.
2. Submitted manuscripts undergo preliminary review, plagiarism screening, peer review, and language editing.
3. Manuscripts that do not pass the preliminary review are returned to the author(s) and are not reconsidered within the same publication period. Those that pass proceed to the double-blind peer review, evaluated by at least two reviewers.
4. The Editors evaluate manuscripts based on scientific content, methodology, significance, and the journal scope. Manuscripts passing this stage are assigned to associate editors for preliminary assessment.
5. Associate editors ensure manuscripts comply with journal principles, including plagiarism screening and adherence to formatting guidelines.
6. Editors and associate editors verify compliance with ethical standards, subject relevance, formatting, references, image quality, and copyright permissions. Approved manuscripts are sent for double-blind peer review.
7. The journal's peer review process maintains fairness and objectivity, free from biases based on nationality, gender, or other factors. Reviewers must have a doctoral degree and a strong research background.
8. The reviewers complete evaluation forms and provide recommendations: accept without changes, accept with minor revisions, request major revisions and resubmission, or reject. If both reviewers recommend minor revisions, and the revised version is approved, the

manuscript is accepted. If major revisions are required, the manuscript may be reassessed before final decision. If there is one positive and one negative review, a third reviewer is consulted. The final decision rests with the Editors. Editorial decisions are final and can only be appealed under *COPE* guidelines.

9. Reviewers must use respectful, professional, and scientific language. Disrespectful or unscientific comments will prompt a revision request. Reviews must be completed within the assigned timeframe.
10. After final editing, accepted manuscripts undergo thematic or chronological organization before inclusion in the journal.
11. Typesetting is conducted according to journal layout guidelines.
12. The final PDF version is sent to the authors for review and approval. Authors must confirm that the manuscript adheres to the journal's ethical standards and accept full responsibility for their work.
13. The Editorial Board makes the final publication decision after reviewing revisions.
14. Once this process is finalized, DOI numbers are assigned to the articles.
15. Following DOI assignment, the printing stage begins, completing the publication process.

Editor Responsibilities

1. The Editor evaluates manuscripts based solely on scientific merit, without bias toward authors' ethnicity, gender, nationality, or beliefs.
2. The Editor ensures a fair, confidential double-blind peer review process.
3. Manuscripts remain confidential before publication. Reviewers and editorial board members must not discuss them with third parties. If necessary, reviewer evaluations may be shared between reviewers by the Editor for clarification.
4. The Editor ensures journal quality, including corrections and retractions when necessary.
5. The Editor prevents conflicts of interest and has full authority in reviewer assignments and publication decisions.

Reviewer Responsibilities

1. Reviewers must disclose any conflicts of interest regarding the research, authors, or funding sources. Reviews must be objective.
2. Reviewers must maintain confidentiality and report any copyright infringement or plagiarism to the Editor.
3. Reviewers who feel unqualified to evaluate a manuscript or unable to complete their evaluation on time should notify the Editor and withdraw.

Author Responsibilities

1. All authors must have made significant contributions to the manuscript in terms of conceptualization, design, data collection and interpretation, data analysis, or research and writing. All co-authors must approve the final version and share responsibility for its content.
2. Authors must ensure that all images comply with copyright regulations or obtain necessary permissions. The journal reserves the right to retract or restrict access to articles with unresolved copyright or ethical issues. Any such actions will follow COPE guidelines.
3. The corresponding author is responsible for journal communication, revisions, post-publication inquiries, and compliance with the journal's ethical and copyright policies. Changes to authorship after submission will not be considered.

Revision Process

If revisions are requested, the review reports are sent to the authors. The authors must make necessary revisions promptly, highlighting them for clarity, and submit the updated manuscript to the Editors.

Turkish Language Editing: Turkish manuscripts passing peer review are reviewed by the Turkish Language Editor, who may request corrections.

Foreign Language Editing: English manuscripts passing peer review are reviewed by the English Language Editor, who may request corrections.

Typesetting, Layout, and Proofreading Process

Approved manuscripts undergo typesetting and layout formatting, followed by a final proofreading before final publication.

DOI Assignment

Digital Object Identifier (DOI) is a unique identifier that provides a permanent link to the official and original version of an electronically published article. The Turkish Journal of Archaeological Sciences assigns DOI numbers to all accepted scientific articles at the end of the publication process, ensuring the article's official recording in the digital environment.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Arkeoloji Bilimleri Dergisi Yayın Etiği ve Yayın Politikası

Yayın Etiği

Arkeoloji Bilimleri Dergisi, yürütülen tüm süreçlerde; Yazar, Hakem, Editör, Yayıncı ve Okuyucu sorumlulukları bağlamında yayın etiğine ilişkin uluslararası bir standart olarak kabul gören *Committee on Publication Ethics* (COPE) politikalarını benimsemekte ve yönergelerini takip etmektedir.

Editörler için: Editörler kurulunda yer alan araştırmacıların göndermiş olduğu makalelerle ilgili olarak makale hakem sürecindeyken makale sahibi editörlerin editör rolleri askıya alınır ve hakem sürecini görmemeleri sağlanır, böylece çift taraflı kör hakemlik korunur.

Hakemler için: Arkeoloji Bilimleri Dergisi, önyargısız ve en iyi etik standartlara göre çift taraflı kör hakem değerlendirmesi sistemi işletir ve COPE'nin Akran Hakemleri için Etik İlkelerinde belirtilen akran hakemlerine yönelik kılavuzunu dikkate alır. Hakemlerin, incelemelerini kendilerine ayrılan süre içinde tamamlamaları beklenir. Hakemlerimizin gizliliğine saygı duyuyor, yazarların ve hakemlerin de aynı gizliliğe uymasını bekliyoruz. Hakemlerin önyargısız ve saygılı bir dil kullanarak rapor vermeleri beklenir. Agresif dil veya yazarlar hakkında kişisel görüşler içeren yorumlar dikkate alınmaz. Bir hakem, gönderiyi incelemeye başlamadan önce varsa konuya istinaden veya olası herhangi bir çıkar çatışması hakkında editörleri bilgilendirmelidir.

Yazarlar için: Arkeoloji Bilimleri Dergisi, bilim dünyasına özgün çalışmalar sunmayı amaçlamaktadır. Makaleler özgün bilimsel araştırma olmalıdır. Dergiye çalışmalarını gönderen yazar(-lar) söz konusu yazının daha önce başka bir yerde yayımlanmadığını ya da yayımlanmak üzere bir başka yere gönderilmemiş olduğunu kabul etmiş sayılırlar. Yazarlar, araştırma ve yayın etiğine uyduklarını kabul ederler. Yazar/lar etik izin gerektiren çalışmalar için Etik Kurul İzni sunmalıdır. Yazar/lar araştırma sürecinde araştırmaları için mali destek almışlarsa bu desteği makale metninde belirtmelidir. Yayın sonrası hata tespit edilmesi durumunda yazar/lar, hatalı makaleyi geri çekmek ve düzeltmekle yükümlüdür. Dergi ilkelerine uymayan makaleler dergiye kabul edilmezler. Ön değerlendirme ve intihal denetimini başarıyla geçen makaleler hakem değerlendirme süreci için en az iki hakeme gönderilir.

Telif Hakkı

Arkeoloji Bilimleri Dergisi'nde yayımlanan tüm özgün makaleler, Creative Commons Atıf-GayriTicari 4.0 International (*CC BY-NC 4.0*) lisansına tabidir. Bu lisans ile taraflar, Arkeoloji Bilimleri Dergisi'nde yayımlanan tüm makaleleri ve görselleri; atıfta bulunarak dağıtabilir, kopyalayabilir, üzerine çalışma yapabilir, yine sahibine atıfta bulunarak türevi çalışmalar yapabilir. Arkeoloji Bilimleri Dergisi tarafından yayınlanan makalelerin telif hakları *CC BY-NC 4.0* lisansı kapsamında yazarlara aittir. Yayınlanan tüm telif hakları yazarın/yazarların sorumluluğundadır. Dergide yayınlamayı kabul ederek, yazarlar bu telif hakkı şartlarına uymayı da kabul ederler. Dergide yayımlanan eserlerin sorumluluğu yazarlarına aittir. Yazarların yayımlanmış olan makalelerine ait PDF dosyaları, kendi kurumsal arşivleri ile başka makale platformlarında ve sosyal medya hesaplarında açık erişim politikası gereği paylaşılabilir. Arkeoloji Bilimleri Dergisi hiçbir çıkar gözetmez.

İntihal

Arkeoloji Bilimleri Dergisi, intihal tespit yazılımı (*iThenticate* veya benzeri) kullanarak metinleri kontrol etme hakkını saklı tutar. İntihal, başkalarına ait çalışmaların (fikirlerin, verilerin, kelimelerin, görüntülerin vb. her türlü medyatik formun) kaynak göstermeden veya gerekli olduğunda izin veya onay alınmadan kullanılmasıdır. Bu tanım çerçevesinde yazar(lar)ın gerekli referanslar veya izinler olmadan kendi çalışmalarını yeniden üretmeleri, kendinden kendine intihali içerir. İntihal materyali içeren gönderiler otomatik olarak reddedilecektir. Yayınlanmış ise yayınlandıktan sonra dahi, ilgili eyleme karar verilerek COPE'nin Akran Hakemleri için Etik İlkelerine göre sürdürülür.

Makale Geri Çekme Politikası

Bünyesinde özgün makalelere yer veren Arkeoloji Bilimleri Dergisi yayın yönetimi, yayın politikası gereği henüz değerlendirme aşamasında veya dergide yayımlanmış bir makaleye dair etik olmayan bir durum şüphesinin oluşması veya telif hakkı ihlali halinde, söz konusu çalışma hakkında incelemelerde bulunabilir. Yapılan incelemeler sonucunda bu amaçla değerlendirilen makale için COPE'nin makale geri çekme süreçleri uygulanır.

Eğer dergi editörleriyle iletişime geçen çalışma sahibinin kendisinden henüz yayımlanmış, hakem sürecinden geçerek kabul edilmiş ya da değerlendirme aşamasındaki çalışmalarıyla ilgili bir geri çekme talebi gelirse Arkeoloji Bilimleri Dergisi Yayın Kurulu bunu ivedilikle işleme alır. Bu işlemin yapılabilmesi için yazar(lar)ın geri çekme isteklerini kaleme aldıkları bir belge hazırlayıp her bir yazarın ıslak imzasıyla imzalayarak Arkeoloji Bilimleri Dergisi e-posta adresine (editor@arkeolojibilimleridergisi.org) iletmesi gereklidir. Bu süreç COPE'nin Akran Hakemleri için Etik İlkelerine göre sürdürülür. Arkeoloji Bilimleri Dergisi Yayın Kurulu, başvuruyu inceleyip karar vermeden önce yazarların çalışmasını başka bir dergiye yayınlanmak üzere göndermesini katiyetle etik bir davranış olarak kabul görmez.

Finansman

Yayında sunulan çalışmanın tamamlanması için alınan fon ve benzeri araştırma desteği, uygun olduğunda hibe numaraları ve/veya bilimsel proje numaraları da dahil olmak üzere beyan edilmelidir. Arkeoloji Bilimleri Dergisi'nde uygulanan yayın süreçleri, bilginin tarafsız ve saygın bir şekilde gelişimine ve dağıtımına temel oluşturmaktadır. Hakemli çalışmalar bilimsel yöntemi somutlaştıran ve destekleyen çalışmalardır. Bu noktada sürecin bütün paydaşlarının—yazarlar, okuyucular ve araştırmacılar, yayıncı, hakemler ve editörler—etik ilkelere yönelik standartlara uyması önem taşımaktadır. Makalelerde cinsiyetçi, ırkçı veya kültürel ayrım yapmayan, kapsayıcı bir dil kullanmalıdır ("insanoğlu" yerine "insan"; "bilim adamı" yerine "bilim insanı" gibi). Arkeoloji Bilimleri Dergisi yayın etiği kapsamında tüm paydaşların bu etik sorumlulukları taşımasını beklenmektedir. Burada belirtilen etik görev ve sorumluluklar, *Committee on Publication Ethics* (COPE) tarafından açık erişimli olarak yayınlanan rehberler ve politikalar dikkate alınarak hazırlanmıştır. Bkz.: COPE İş Akış Diyagramları.

Kişisel Verilerin Korunması

Arkeoloji Bilimleri Dergisi'nde değerlendirilen çalışmalarda gerçek kişilere ait kişisel veriler Kişisel Verilerin Korunması Hakkında Kanun kapsamında koruma altındadır. Yazara ait hiçbir bilgi üçüncü kişi ve kurumlarla paylaşılmaz.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Turkish Journal of Archaeological Sciences Publication Ethics and Policies

Publication Ethics

The Turkish Journal of Archaeological Sciences adheres to the ethical standards set by the Committee on Publication Ethics (COPE), ensuring integrity in all aspects of the publication process for authors, reviewers, editors, publishers, and readers. The journal follows COPE guidelines to uphold ethical publishing practices.

For Editors: If a member of the editorial board submits an article to the journal, their editorial role is suspended during the peer review process to prevent any access to or influence over the review. This measure safeguards the integrity of the double-blind peer review system.

For Reviewers: The Turkish Journal of Archaeological Sciences employs an unbiased and ethical double-blind peer review system in accordance with COPE's Ethical Guidelines for Peer Reviewers. Reviewers are expected to complete their assessments within the assigned timeframe. The journal maintains the confidentiality of reviewers and expects both authors and reviewers to do the same. Reviewers must provide objective cand respectful evaluations. Comments containing aggressive language or personal opinions about the authors will not be considered. Before commencing a review, reviewers must disclose any potential conflicts of interest to the editors.

For Authors: The Turkish Journal of Archaeological Sciences aims to contribute original research to the scientific community. Submitted manuscripts must be original and based on scientific research. By submitting a manuscript to the journal, authors confirm that the work has not been published elsewhere and is not under consideration for publication in another journal. Authors must comply with research and publication ethics. If the research requires ethical approval, authors must provide an Ethics Committee Approval. If financial support was received for the research, authors must declare this in the manuscript. Authors are responsible for correcting any errors discovered post-publication. Manuscripts that do not adhere to the journal's ethical principles will be rejected. Following a preliminary evaluation and plagiarism check, manuscripts undergo peer review by at least two independent reviewers.

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Plagiarism Policy

The Turkish Journal of Archaeological Sciences reserves the right to check submitted manuscripts using plagiarism detection software (*iThenticate* or similar). Plagiarism includes the use of another's work—whether ideas, data, text, images, or other media—without proper citation or required permission. This also applies to self-plagiarism, where authors reuse their own previously published material without appropriate citation. Manuscripts found to contain plagiarism will be rejected. If plagiarism is identified post-publication, corrective measures will be taken under COPE's Ethical Guidelines for Peer Reviewers

Article Retraction Policy

The Turkish Journal of Archaeological Sciences is committed to academic integrity and will investigate ethical concerns regarding submitted or published articles. If ethical violations or copyright infringements are suspected, the journal will initiate a review process and follow COPE's retraction procedures as necessary.

If an author wishes to withdraw their manuscript after submission, acceptance, or publication, the Editorial Board will process the request promptly. Authors must submit a signed withdrawal request, endorsed by all co-authors, to the journal's official email address (editor@arkeolojibilimleridergisi.org). Manuscripts must not be submitted to another journal before receiving formal withdrawal confirmation, as this is considered unethical.

Funding Disclosure

If the research was supported by a grant or other financial resources, authors must disclose this in the manuscript, including relevant grant numbers and project identifiers where applicable.

Ethical Standards and Responsibilities

The Turkish Journal of Archaeological Sciences aims to support the objective and reputable dissemination of knowledge. Peer-reviewed publications represent the application of scientific

methodology, and all stakeholders—authors, readers, researchers, publishers, reviewers, and editors—must adhere to ethical standards. Manuscripts should use inclusive language that is free from bias based on sex, race or ethnicity, etc. (e.g., "he or she" or "his/her/their" instead of "he" or "his") and avoid terms that imply stereotypes (e.g., "humankind" instead of "mankind"). The ethical duties and responsibilities outlined herein align with open-access policies and the Committee on Publication Ethics (COPE) guidelines.

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Personal data of individuals involved in research published in the Turkish Journal of Archaeological Sciences is protected under the *Law on the Protection of Personal Data*. No personal information of authors will be shared with third parties or external institutions.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Makale Gönderimi ve Yazım Kılavuzu

* *Please see below for English*

Makale Kabul Kriterleri

Makalelerin konu aldığı çalışmalar, Arkeoloji Bilimleri Dergisi'nin amaçları ve kapsamı ile uyumlu olmalıdır (bkz.: Amaç ve Kapsam). Buna göre yayım önceliği, makalelerin arkeolojik yorumlamaya katkı sağlayan yeni anlayışlar, disiplinler arası yaklaşımlar, yeni metot ve kuram önerileri ile analiz sonuçlarındadır.

Makaleler Türkçe veya İngilizce olarak yazılmalıdır. Makalelerin yayın diline çevirisi yazar(lar)ın sorumluluğundadır. Eğer yazar(lar) makale dilinde akıcı değilse, metin gönderilmeden önce anadili Türkçe ya da İngilizce olan kişilerce kontrol edilmelidir.

Yazarın Türkçesi veya İngilizcesi akıcı değilse, özet ve anahtar kelimelerin Türkçe veya İngilizce çevirisi editör kurulu tarafından üstlenilebilir.

Her makale, 4000-10.000 sözcük arasında olmalıdır. Metne, 200 kelimeyi aşmayacak uzunlukta Türkçe ve İngilizce yazılmış özet ve beş anahtar kelime eklenmelidir. Özete referans eklenmemelidir.

Metin, figürler ve diğer dosyalar e-posta veya wetransfer yoluyla **archaeologicalsciences@gmail.com** adresine gönderilmelidir.

Makale Kontrol Listesi

Lütfen makalenizin aşağıdaki bilgileri içerdiğinden emin olun:

- Yazarlar (yazarların adı-soyadı ve iletişim bilgileri buradaki sırayla makale başlığının hemen altında paylaşılmalıdır)
- Çalışılan kurum (varsa)
- E-mail adresi
- ORCID ID

Makalenin içermesi gerekenler:

- Başlık
- Özet (Türkçe ve İngilizce)
- Anahtar kelimeler (Türkçe ve İngilizce)
- Metin
- Kaynakça
- • Şekiller, tablolar, vb.
- • Ekler (varsa)

Yazım Kuralları

Metin ve Başlıkların Yazımı

- Times New Roman karakterinde yazılan metin 12 punto büyüklüğünde, iki yana yaslı ve tek satır aralıklı yazılmalıdır. Makale Word formatında gönderilmelidir.
- Yabancı ve eski dillerdeki kelimeler italik olmalıdır.
- Ana başlık 14 punto ve bold; sırasıyla alt başlık 12 punto ve bold; bir alt başlık ise 12 punto ve italik yazılmalıdır.
- Başlıklar numaralandırılmamalı, altları çizilmemelidir.
- Başlık ve alt başlıklarda her kelimenin ilk harfi büyük olmalıdır.

Referans Yazımı

Ayrıca bkz.: Metin içi Atıflar ve Kaynakça Yazımı

- Referanslar metin içinde (Yazar, yıl, sayfa numarası) şeklinde verilmelidir.
- Metin içinde aynı parantezdeki çoklu referanslar alfabetik sıraya göre dizilmelidir.
- Referanslar için dipnot ve son not kullanımından kaçınılmalıdır. Bir konuda not düşme amacıyla gerektiği taktirde dipnot tercih edilmelidir.
- Dipnotlar Times New Roman karakterinde, 10 punto büyüklüğünde, iki yana yaslı, tek satır aralıklı yazılmalı ve her sayfa sonuna süreklilik izleyecek şekilde eklenmelidir.

Şekiller ve Tablolar

- Makalenin altına şekiller ve tablolar için bir başlık listesi eklenmelidir. Görsellerde gerektiği takdirde kaynak belirtilmelidir. Her şekil ve tabloya metin içerisinde gönderme yapılmalıdır (Şekil 1 veya Tablo 1).
- Görseller Word dokümanının içerisine yerleştirilmemeli, jpg veya tiff formatında, ayrı olarak gönderilmelidir.
- Görüntü çözünürlüğü basılması istenen boyutta ve 300 dpi'nin üzerinde olmalıdır.
- Görseller Photoshop ve benzeri programlar ile müdahale edilmeden olabildiğince ham haliyle gönderilmelidir.
- Excel'de hazırlanmış tablolar ve grafikler var ise mutlaka bunların PDF ve Excel dokümanları da gönderilmelidir.

Sayıların Yazımı

- MÖ ve MS kısaltmalarını harflerin arasına nokta koymadan kullanınız (örn.: M.Ö. yerine MÖ).
- "Bin yıl" ya da "bin yıl" yerine "... binyıl" kullanınız (örn.: MÖ 9. binyıl).
- "Yüzyıl", "yüz yıl" ya da "yy" yerine "yüzyıl" kullanınız (örn.: MÖ 7. yüzyıl).
- Beş veya daha fazla basamaklı tarihler için sondan sayarak üçlü gruplara ayırmak suretiyle sayı gruplarının arasına nokta koyunuz (örn.: MÖ 10.500).
- Dört veya daha az basamaklı tarihlerde nokta kullanmayınız (örn.: MÖ 8700).
- 0-10 arasındaki sayıları rakamla değil yazıyla yazınız (örn.: "8 kez yenilenmiş taban" yerine "sekiz kez yenilenmiş taban").

Noktalama ve İşaret Kullanımı

- Ara cümleleri lütfen iki çizgi ile ayırınız (—). Çizgi öncesi ve sonrasında boşluk bırakmayınız.
- Sayfa numaraları, tarih ve yer aralıklarını lütfen tek çizgi (-) ile ayırınız: 1989-2006; İstanbul-Kütahya.

Kısaltmaların Yazımı

- Sık kullanılan bazı kısaltmalar için bkz.:

Yaklaşık:	yak.	Circa:	ca.
Bakınız:	bkz.	Kalibre:	kal.
Örneğin:	örn.	ve diğerleri:	vd.

Özel Fontlar

- Makalede özel bir font kullanıldıysa (Yunanca, Arapça, hiyeroglif vb.) bu font ve orijinal metnin PDF versiyonu da gönderilen dosyalar içerisine eklenmelidir.

Metin içi Atıflar ve Kaynakça Yazımı

- Her makale, metin içinde atıfta bulunulan çalışmalardan oluşan ve "Kaynakça" başlığı altında düzenlenmiş bir referans listesi içermelidir.
- Metinde atıfta bulunulan tüm çalışmalar "Kaynakça" başlığı altında listelenmelidir.
- Eğer mevcutsa, dergi makaleleri için mutlaka DOI numarası eklenmelidir.
- Metin içi atıf ve kaynakça yazımında APA 7 kuralları geçerlidir:
  - https://apastyle.apa.org/style-grammar-guidelines/citations
  - https://apastyle.apa.org/style-grammar-guidelines/references

Teşekkürler

Varsa teşekkür edilecek kişi ve kurumlar, ana metnin hemen arkasında, Kaynakça'dan önce, Teşekkürler başlığı altında verilmelidir.

Ekler

Arkeoloji Bilimleri Dergisi çalışmayı destekleyici veri setleri, tablo ve şekilleri ek materyal olarak kabul etmektedir. Lütfen çalışmanızı destekleyici ekleri XLSX (veri setleri ve tablolar için), veya Word (şekil ve görseller için) formatında gönderiniz.

ARKEOLOJİ BİLİMLERİ DERGİSİ

TURKISH JOURNAL OF ARCHAEOLOGICAL SCIENCES

Article Submission and Author Guidelines

Article Acceptance Criteria

Submitted articles must fall within the aims and scope of the Turkish Journal of Archaeological Sciences (see: Aims and Scope). Priority in publication is given to articles that contribute new insights to archaeological interpretation, present interdisciplinary approaches, propose new methods and theories, and report analytical results.

Articles must be written in Turkish or English. The author(s) are responsible for translating the manuscript into the language of publication. If the author(s) are not fluent in the manuscript's language, the text should be reviewed by a native speaker of Turkish or English before submission.

If the author(s) are not fluent in Turkish or English, the editorial board may undertake the translation of the abstract and keywords into Turkish or English.

Each article should be between 4,000 and 10,000 words. The manuscript must include an abstract in both Turkish and English, not exceeding 200 words, and five keywords. The abstract should not include references.

The text, figures, and other files should be submitted via e-mail or WeTransfer to:
archaeologicalsciences@gmail.com

Article Checklist

Please ensure your manuscript includes the following information:

- Authors (the authors' full names and contact details should be provided in this order directly below the article title)
- Affiliation (if applicable)
- E-mail address
- ORCID ID

The manuscript must include the following components:

- Title
- Abstract (in Turkish and English)
- Keywords (in Turkish and English)
- Main text
- References
- Figures, tables, etc.
- Supplementary materials (if any)

Formatting Guidelines

Text and Headings

- The text must be written in Times New Roman, 12-point font, justified alignment, and single-line spacing. The article must be submitted in Word format.
- Words in foreign and ancient languages should be written in italics.
- The main title should be 14-point and in bold; subheadings should be 12-point and in bold; lower-level subheadings should be 12-point and italic.
- Headings should not be numbered or underlined.
- The first letter of each word in titles and subtitles should be capitalized.

Referencing Guidelines

See also: In-Text Citations and Reference List Formatting

- References must be cited in the text using the following format (Author, year, page number).
- Multiple references within the same parentheses should be listed in alphabetical order.
- The use of footnotes and endnotes for references should be avoided. If necessary, footnotes may be used for explanatory notes.
- Footnotes must be written in Times New Roman, 10-point font, justified alignment, and single-line spacing, and should be added at the bottom of each page, numbered continuously.

Figures and Tables

- A list of figure and table captions must be included at the end of the article. Sources for images should be cited when necessary. Each figure and table must be referenced in the text (e.g., Figure 1 or Table 1).
- Images must not be embedded in the Word document; they should be submitted separately in JPG or TIFF format.
- Image resolution must be at least 300 dpi at the intended print size.
- Images should be submitted in their original, unaltered form, without manipulation in Photoshop or similar software whenever possible.
- If tables or graphs have been prepared in Excel, both the PDF and the original Excel files must also be submitted.

Writing of Numbers

- Please use the abbreviation BCE without periods (e.g., BCE, not B.C.E.).
- Please use "… millennium" rather than variations such as "thousand years" (e.g., 9th millennium BCE).
- Please use "century" instead of other abbreviations (e.g., 7th century BCE).
- For dates with five or more digits, please use a dot to separate groups of three digits counting from the right (e.g., 10.500 BCE).
- Please do not use a dot in dates with four or fewer digits (e.g., 8700 BCE).
- Please write out numbers between zero and ten in words rather than numerals (e.g., "eight renewed floors" instead of "8 renewed floors").

Punctuation and Use of Symbols

- Please prefer em dashes (—) for parenthetical sentences. Do not leave a space before or after the dash.
- Please use a hyphen (-) to separate page numbers, dates, and place ranges: 1989-2006; Istanbul-Kütahya.

Abbreviations

- Commonly used abbreviations:

Approximately:	approx.	Circa:	ca.
See:	see	Calibrated:	cal.
For example:	e.g.	And others:	et al.

Special Fonts

If a special font has been used in the article (Greek, Arabic, hieroglyphic, etc.), the font file and a PDF of the original text must also be included among the submitted files.

In-Text Citations and Reference List Formatting

- Each article must include a reference list under the heading "References," consisting only of works cited in the text.
- All works cited in the text must be listed under the "References" heading.
- Where available, a DOI number must be included for journal articles.
- APA 7 guidelines apply to both in-text citations and the reference list:
  - https://apastyle.apa.org/style-grammar-guidelines/citations
  - https://apastyle.apa.org/style-grammar-guidelines/references

Acknowledgements

If applicable, individuals and institutions to be acknowledged should be listed immediately after the main text and before the References under the heading "Acknowledgements."

Supplementary Materials

We accept supporting datasets, tables, and figures as supplementary materials. Please submit supplementary materials in XLSX format for datasets and tables, or in Word format for figures and images.